

**Utrecht University
Graduate School Natural Sciences**

**Programme Annex
to the
Education and Examination Regulations 2011-2012**

Contents

Astrophysics and Space Research.....	3
Business Informatics	5
Computing Science	8
Energy Science	12
Game and Media Technology.....	15
History and philosophy of Science.....	17
Mathematical Sciences.....	19
Meteorology, Physical Oceanography and Climate (MPOC)	22
Nanomaterials: Chemistry & Physics.....	25
Particle Physics	28
Science and Business Management	31
Science Education and Communication*	33
Technical Artificial Intelligence	36
Theoretical Physics	39
Honours programme Mathematical Sciences and Theoretical Physics	42

Astrophysics and Space Research

Admission Criteria

Admission to the degree in Astrophysics and Space Research

At the start of their Master's studies, students should possess:

1. Solid basic knowledge in classical physics, quantum mechanics, electrodynamics, thermal physics and astrophysics as well as in the mathematics required for the study of such topics at an advanced level.
2. The ability to work independently as well as in groups on solving physical problems, present the results of solving problems and to read (English) physics literature at the level of graduate textbooks.
3. Intermediate problem-solving skills in the main fields of physics and/or their applications.

Applicants are therefore expected to have

- A Bachelor's of Science degree with a strong component in physics and/or astronomy and
- 30 ECTS of BSc courses in astrophysics, astronomy, space research or space sciences.

Applicants holding a BSc in Physics and Astronomy of Utrecht University have a legal right under Dutch Law (doorstroomrecht) to be admitted to the program in Astrophysics and Space Research

Admission to the programme Astrophysics and Space Research

Applicants with a BSc in physics and/or astronomy and at least a minor in astrophysics or astronomy are automatically admitted to the programme.

Applicants with a BSc and background in related fields can be admitted if their background level in physics, mathematics, and astrophysics is sufficient. The admittance committee of the programme will evaluate these candidates. This also applies to for students from the University College Utrecht with a Science major.

Learning outcomes

Graduates have a profound knowledge of and insights into:

- the theoretical and observational aspects of the physics of stars, galaxies and the universe
- at least one area in the field of astrophysics or space research such that they can understand the international research literature

Graduates have the skills to:

- give a concise summary of the relevant observations, the observational techniques used and the relevant theories used to explain the observations;
- execute a research project under the supervision of a staff member and present the results of this project both in an oral presentation and in writing in English;
- independently formulate a scientific hypothesis, or develop a consistent model, as an explanation of an observed phenomenon or result of a numerical model;
- develop a sound judgment of and a critical attitude toward the interpretation of observational and model-based data in terms of fundamental physical principles, statistical and numerical approaches.
- design, perform and analyze astronomical observations;
- apply theoretical concepts that allow a quantification of astrophysical processes and phenomena;
- develop a (simple) numerical model of the observed objects;
- recognise and be aware of recent scientific developments in the field of astrophysics and space research.

Graduates display attitudes that enable them to

- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
- work together in a team of experts with different nationalities and backgrounds;
- work independently and take initiatives where necessary;
- enrol in a PhD programme in the field of astrophysics or space research
- continue their careers in research-oriented organizations or industrial research and development.

Contents

Mandatory courses	37.5 ECTS
Primary electives	15 ECTS
Secondary electives	7,5 ECTS
Research part	60 ECTS
Total	120 ECTS

Mandatory courses

1. Stellar evolution (NS-AP434M)
2. Galaxies (NS-AP432M)
3. Astronomical Data Analysis (NS-AP433M)
4. Stellar atmospheres (NS-AP426M)
5. Theoretical astrophysics (NS-AP402M)

The courses on Stellar Evolution and Galaxies may be followed by students during the 3rd year of their Bachelor studies. For those student courses 3. to 5. remain mandatory (22.5 ECTS), and optional courses adding up to 37.5 ECTS are required.

Primary Electives

1. Astronomical Telescopes and Instruments (NS-AP443M)
2. Nucleosynthesis (NS-AP437M)
3. IAC (NS-AP428M)
4. Solar Physics (NS-AP439M)

Secondary Electives

Astrophysics courses from other NOVA Master's programmes and MSc courses offered by the Graduate School of Natural Sciences when approved in advance by the programme coordinator.

Research part

Research Part:	60 ECTS
Thesis & Seminar in Astrophysics	60 ECTS

The research part of the Master's programme in Astrophysics consists of a full year of research under the supervision of a staff member of the *Astronomical Institute Utrecht* or - after approval by the programme coordinator - an external staff member in any research institute in the Netherlands or abroad.

Business Informatics

Admission Criteria

Admission to the degree information science

Applicants should possess:

- solid basic knowledge in the field of information and computing sciences (including programming languages, data models, exchange languages and object-oriented modeling)
- solid basic knowledge of research methods
- solid basic knowledge of cognitive and communication science
- solid basic knowledge of organization science
- the ability to communicate facts and findings verbally and in writing, also using information and communication technology and audio-visual means.

Applicants are therefore expected to hold one of the following degrees:

- a BSc in Information Science
- a BSc in Computer Science
- a BSc in other Science (with specific prerequisites)
- a professional Bachelor in ICT, or an HBO-(Bedrijfskundige) Informatica or a HIO diploma.

Applicants holding one of the following degrees of Utrecht University:

- A major in Information Science;
- A major in Computer Science, mathematics, artificial intelligence with a minor in information science

have a legal right under Dutch Law (doorstroomrecht) to be admitted to the Information Science degree.

Admission to the programme

Students admitted to the degree in Information Science qualify for admission to this programme if they satisfy the following skills and knowledge:

- Basic knowledge of product software development, delivery, implementation and use
- Basic knowledge of design methods and modeling.

Students with a HBO-background need an average score of at least 7 for their professional bachelor programme, and a score of at least 7 for their thesis project as well.

There is room in the MBI programme (max. 15 ECTS) to remedy possible deficiencies of the student in the above mentioned areas.

Learning outcomes

Graduates:

- have theoretical and practical knowledge of advanced general subJECTS such as Methodology of development, implementation and entrepreneurship of software products; ICT entrepreneurship.
- have in-depth knowledge of at least one area in the field of software product development methodology; implementation and adoption of systems; ICT entrepreneurship in such a way that that the international research literature can be understood.
- have an overview of the area of scientific research and development concerned;

Graduates have the skills to:

- identify, formulate, analyse and suggest possible solutions to problems independently in the field of Business Informatics;
- conduct research in the field of Business Informatics under the supervision of a scientific staff member and report on it in a manner that meets the customary standards of the discipline;

- communicate conclusions both written and orally, as well as the underlying knowledge, grounds and considerations, to an audience composed of specialists or non-specialists in English

Graduates display attitudes that enable them to:

- have an integer constructive-critical attitude towards own and other one's plans, visions and research results
- work together in a (possibly interdisciplinary) team of experts with different nationalities and backgrounds
- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
- work independently and taking initiatives where necessary.
- enrol in a PhD programme in the field of Business Informatics
- start his/her own company in product software or IT services

Contents

Mandatory courses	23.5 ECTS
Primary electives	15-52.5 ECTS
Secondary electives	0-37.5 ECTS
Research part	44 ECTS
Total	120 ECTS

Mandatory courses

- Enterprise Architecture
- Method Engineering
- Knowledge Management
- Introduction to Business Informatics

Primary electives

- Advanced Research Methods
- Business Informatics Summer School
- E-Business and ICT-alignment
- Financial Management
- ICT entrepreneurship
- Seminar Medical Informatics
- Seminar Software Eco Systems
- Seminar Intelligent User Interfaces
- Software Product Management

Secondary electives

- Possible deficiencies (at most 15 ECTS): Deficiency courses will be defined by the programme coordinator.
- Any MSc course from the Computer Science curriculum
- Any related MSc course offered by Utrecht University when approved in advance by the programme director
- Capita Selecta

Research part

- Thesis Project: 40 ECTS
- MBI Colloquium: 4 ECTS

The Research Part or Thesis Project includes participation in the bi-weekly MBI Colloquium (at the end of the master programme).

Research can be done in the following directions:

All subjects related to the list of mandatory courses for example:

- Product software development, deployment and requirement management
- The management of product software companies and markets

- Adoption, implementation and use of IS/IT
- Enterprise architecture and IS/IT architecture
- IT management and IT governance
- Business/IT alignment and IT maturity

Special provisions for students enrolled in the programme Content and Knowledge Engineering in the year 2010-2011

Due to the admission stop as of September 2010, students that have chosen the CKE master programme (possible until September 2010) are subject to the following rules concerning the courses.

Mandatory courses

- Introduction to Business Informatics

Primary elective courses (you have to choose *at least three* of this list)

- Advanced Research Methods
- Semantic Web
- Knowledge Management
- Enterprise Architecture
- Method Engineering
- Software Product Management.

Secondary elective courses

- Seminar Intelligent User Interfaces
- Seminar Medical Informatics

Research part

- Thesis Project: 40 ECTS
- MBI Colloquium: 4 ECTS

Computing Science

Admission Criteria

Admission to the degree Computer Science

Applicants should possess:

- solid basic knowledge of computer science and logic;
- the ability to analyze and model computer science problems.
- the ability to communicate facts and findings verbally and in writing, also using information and communication technology and audio-visual means.

Degrees in all probability meeting these requirements are:

- A BSc with a major in Computer Science or Artificial Intelligence;
- A BSc with a science major and (a) a minor in Computer Science or (b) a minor in Technical Artificial Intelligence or (c) a comparable use of the non-major part ('profielingsruimte') of the bachelor programme;
- A HBO-diploma 'Hogere Informatica Opleiding' (HIO) or (Technical) Computer Science;

Applicants holding one of the following degrees of Utrecht University: A BSc in Computer Science or Artificial Intelligence have a legal right under Dutch Law (doorstroomrecht) to be admitted to the computer science degree.

Admission to the programme

Students admitted to the computer science degree qualify for admission to this programme if they possess the following skills and knowledge:

- have a reasonable experience in the use of several programming languages (amongst which functional and object-oriented languages)
- have a basic knowledge of modern software construction
- have a basic knowledge of algorithms and data structures, their design and analysis
- have adequate knowledge of the working of computer systems and information networks
- have a basic knowledge of computer science and logic
- be able to reason formally, and
- be able to communicate facts and findings verbally and in writing, including using information and communication technology and audio-visual means.

The following BSc degrees should satisfy these qualifications:

- UU BSc degree in Informatics

This degree is the standard for the programme ('doorstroom'), but the BSc degrees in Informatics (Computer Science) at many regular universities in the Netherlands and abroad are nowadays equivalent to it to the extent that is needed for entry in the master's programme 'Computing Science'. Suitable standards must be achieved in basic backgrounds, as in the UU major, in the domains of programming (Java, C#, Haskell, software engineering) and algorithmic and formal methods (datastructures, discrete mathematical methods, complexity). *Other* BSc programmes that likely satisfy the entrance requirements include:

- a BSc in Mathematics (with a minor in informatics) or Artificial Intelligence,
- a HBO-bachelor in the 'HBO-opleiding Informatica',
- a HBO-bachelor in Informatics/Information Technology other than the 'HBO-opleiding Informatica',

in all cases depending on the particular programme followed.

Small deficiencies (less than 15 ECTS) are facilitated in the 'homologatie' in the first period of the programme. If the entrance requirements are not fully met by a student and the deficiency is larger, but motivation and other indicators are convincing, the Admissions Committee may allow a student to prepare for entrance by means of an individual pre-master programme of at most three (bachelor-level) courses which must be passed before qualifying for entrance in the master programme. With HBO's whose bachelor programme(s) in informatics do not meet the entrance requirements fully as a rule, a standard pre-master package can be agreed which students can embed in their individual study programme in the HBO if they wish to qualify for entrance beforehand.

Learning outcomes

The successful candidate will satisfy the following learning outcomes:

Graduates have theoretical and practical knowledge:

- of advanced general subjects in computing science such as:
 - the design and implementation of advanced software systems involving e.g. programming language concepts, design and implementation, programme generation, programme analysis and programme transformation, large scale software architectures
 - the algorithmics of complex information systems involving concepts like data analysis, probabilistic networks and evolutionary techniques, network-based algorithms and complexity, planning and scheduling and/or simulation;
- of a specialization within the field of Computing Science, or alternatively a specialization at the interface between Computing Science and a concrete application domain in software technology, algorithmic data analysis, algorithmic systems, or decision-support systems;
- of computer science research, viz. in software-, data analysis-, algorithm- and decision process design and problem complexity, to the extent that the international research literature in one of the aforementioned areas can be followed;

Graduates have the skills to:

- to model and analyze computing science problems algorithmically;
- identify, formulate, analyse and suggest possible solutions to complex problems in the field of computing science independently;
- apply acquired knowledge in the construction of software systems and implement technical designs in the aforementioned areas in the form of a computer programme;
- conduct research in the field of computing science under supervision of a scientific staff member and report on it in a manner that meets the customary standards of the discipline;
- communicate facts and findings verbally and in writing, also using information and communication technology and audio-visual means.
- recognise and asses new developments in the aforementioned areas;

Graduates display attitudes that enable them to

- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
- have an honest constructive-critical attitude towards own and other one's plans, visions and research results
- be able to work together in a (possibly interdisciplinary) team of experts with different nationalities and/or backgrounds;
- be capable of working independently and of taking initiatives where necessary;
- enrol in a PhD programme in the field of computing science;

- continue in organisations or companies in the field such as IT companies (large and small), companies in the IT creative and IT applications sector (software design and development), and companies with ICT divisions (banks, insurance companies, etc).

Contents

Mandatory courses	0 ects
Primary electives	37.5 ects
Secondary electives	37.5 ects
Research part	45 ects
Total	120 ects

Format

Study paths

Students follow individual study paths, under approval of the programme coordinator(s). The following study paths are pre-defined and set the standard for the programme, with options depending on the specific research orientation of the student:

- Programming technology
- Algorithm design and analysis
- Advanced planning and decision making
- Algorithmic data analysis (‘Big data’)

Primary Electives

Up to 5 courses per study path (guideline):

- Programming technology
Advanced functional programming, compiler construction, programme verification, generic programming, automatic programme analysis
- Algorithm design and analysis
Intelligent agents, algorithms and networks, scheduling and time tabling, algorithmic mechanism design, simulation
- Advanced planning and decision making
Probabilistic reasoning, algorithms and networks, evolutionary computing, scheduling and time-tabling, simulation
- Algorithmic data analysis (‘Big data’)
Advanced data mining, multimedia retrieval, geographic data processing, pattern recognition, queries and retrieval

together with at least one research seminar and participation in the Computing Science colloquium series of the master programme (at least 30 sessions).

Secondary Electives

To be chosen in agreement with the chosen study path from the following list:

- Courses listed under mandatory courses that are not part of the mandatory courses in the chosen study path.
- Extra experimentation project(s): a student may take up to 15 ECTS worth of experimentation projects in total.
- Literature study under supervision of an ACS staff member
- Any MSc course from the Computer Science curriculum
- Any MSc course offered by Universiteit Utrecht: a student may take up to 15 ECTS worth of

relevant courses outside of the regular Computer Science curriculum upon approval in advance of the programme director

Mandatory Research part

The research part consists of a MSc thesis project of 45 ECTS (including the Colloquium requirement). Research can be done in the following directions: all subjects related to the research programmes of the Software Technology chair, the Algorithmic Data Analysis chair, the Algorithmic Systems chair, or the Decision Support Systems chair (internally or externally). In particular, all subjects related to the list of mandatory courses.

Core courses in the Computing Science programme

All courses are 7.5 ECTS

Advanced data mining (INFOADM)
Advanced functional programming (INFOAFP)
Algorithmic mechanism design (INFOMAMD)
Algorithms and networks (INFOAN)
Automatic programme analysis (INFOAPA)
Compiler construction (INFOMCCO)
Evolutionary computing (INFOEA)
Generic programming (INFOGP)
Geographic data processing (INFOMGEODP)
Intelligent agents (INFOIAG)
Multimedia retrieval (INFOMR)
Pattern recognition (INFOMPR)
Probabilistic reasoning (INFOPROB)
Programme verification (INFOPV)
Queries and retrieval (INFOMQR)
Scheduling and time tabling (INFOSTT)
Simulation (INFOSIM)

Special provision for students enrolled in the programmes Applied Computing Science and Software technology during 2009-2010

Students enrolled in the MSc programmes Applied Computing Science (ACS) and Software Technology (ST) during 2009-2010 and earlier continue under the fully compatible terms of the new programme Computing Science. Courses and learning outcomes of the ACS and ST programmes will appear on their diploma supplement.

Energy Science

Starting moments

The programme starts three times per year, on September 1st, November 15th (only for Dutch students) and February 1st. Enrolment in the programme in September is recommended.

Admission Criteria

Admission to the degree in Science and Business

Applicants are eligible for admission when holding one the following degrees:

- Bachelor degree in one of the natural sciences
- Bachelor degree in one of the life sciences

Admission to the programme Energy Science

Students admitted to the Science and Business degree qualify for admission to this programme when they possess the following skills and knowledge:

- Solid knowledge of chemistry and/or physics;
- Knowledge of energy analysis;
- Academic skills at the level of a Dutch university Bachelor of Science degree.

Bachelor degree's that satisfy these requirements on knowledge and skills are:

- Bachelor degree in Chemistry;
- Bachelor degree in Physics;
- Bachelor degree in Engineering
- Or a similar degree.

Learning outcomes

Graduates have

- profound knowledge and insights into: theory and practice of the field of Energy Science. This means mastery of a number of basic and advanced general subjects such as Energy Analysis, Energy Modelling, Energy Conversion Technologies, Energy Economics, Energy Policy, Sustainability issues;
- an overview of the area of scientific research and development concerned;
- at least one specialization, within the field of Energy Science , or alternatively of a specialization at the interface between Energy Science and another related field in the Natural Sciences.

Graduates have the skills to:

- identify, formulate, analyse and suggest possible solutions to problems independently in the field of Energy Science;
- conduct research in the field of Energy Science and report on it in a manner that meets the customary standards of the discipline under the supervision of a member of the scientific staff;
- communicate conclusions, as well as the underlying knowledge, grounds and considerations, to an audience composed of specialists or non-specialists in English;
- to defend opinions in the area of energy science

Graduates display attitudes that enable them to

- have a conscientious and constructive-critical attitude towards own and other one's plans, visions and research results;
- act in a professional and academic way, in particular with respect to the field of Energy Science;
- collaborate in a (possibly interdisciplinary) team of experts with different nationalities and backgrounds
- enrol in a Ph.D. programme in the field of Energy Science

Contents

Two variants exist: Systems Analysis and Natural Science

	Systems Analysis	Natural Science
Mandatory courses	37.5 ECTS	26,25 ECTS
Primary electives	0 ECTS	18,75 ECTS
Secondary electives	15 ECTS	3.75-15 ECTS
Research/internship	67.5 ECTS	63,75-71.25 ECTS
Total	120 ECTS	120 ECTS

Systems analysis variant

Mandatory courses

Courses	ECTS
• Energy and Sustainable Development	3.75
• Energy Economics	3.75
• Energy Conversion Technologies I (thermal/chemical)	7.5
• Energy Conversion Technologies II (physical/mechanical)	7.5
• Energy Modelling	3.75
• Energy Policies	3.75
• Advanced Energy Analysis	7.5

Secondary electives

- Students should select courses for a total of 15 ECTS. The level of the courses must be at least 3rd year Bachelor and they can be chosen from university Bachelor's or Master's degree natural science programmes, as far as they do not belong to the obligatory components of the Master's programme in Energy Science.

Research/internship

- | | |
|--------------------------------------|----------------|
| • Research project / Master's thesis | 30-41.25* ECTS |
| • Consultancy Project | 11.25 ECTS |
| • Internship | 15-26.25* ECTS |

**total amount of credits for thesis and internship together should be at least equal to 56.25 ECTS*

Natural Science variant

Mandatory courses

Courses	ECTS
• Energy and Sustainable Development	3.75
• Energy Conversion Technologies I (thermal/chemical)	7.5
• Energy Conversion Technologies II (physical/mechanical)	7.5
• Advanced Energy Analysis	7.5

Primary electives

- | | |
|--|------|
| • Energy Economics** | 3.75 |
| • Energy Modelling** | 3.75 |
| • Energy Policies** | 3.75 |
| • Two of the following courses from the Natural Sciences Master Curriculum: Device Physics, Adsorption, Kinetics and Catalysis, Synthesis of Complex Nanostructures, Solids and Surfaces | 15 |

***students should choose one of these three courses*

Secondary electives

- Students should select courses for a total of 3.75-15 ECTS. The level of the courses must be at least 3rd year Bachelor and they can be chosen from university Bachelor's or Master's degree natural science programmes, as far as they do not belong to the obligatory components of the Master's programme in Energy Science.

Research/internship

- | | |
|-----------------------------------|------------------|
| • Research in the Science Faculty | 22.5–37.5 * ECTS |
| • Consultancy Project | 11.25 ECTS |
| • Energy Science Research | 22.5–37.5 * ECTS |

**total amount of credits for consultancy project, thesis and internship together should be at least equal to 63.75 ECTS*

Game and Media Technology

Admission Criteria

Admission to the degree computer science

At the start of their master studies, students should possess:

- Solid basic knowledge of computer science and logic;
- The ability to analyze and model computer science problems;
- The ability to communicate facts and findings verbally and in writing, also using information and communication technology and audio-visual means.

Degrees in all probability meeting these requirements are:

- A BSc with a major in Computer Science or Artificial Intelligence;
- A BSc with a science major and (a) a minor in Computer Science or (b) a minor in Technical Artificial Intelligence or (c) a comparable use of the non-major part ('profielingsruimte') of the bachelor programme;
- A HBO-diploma 'Hogere Informatica Opleiding' (HIO) or (Technical) Computer Science;

Applicants holding one of the following degrees of Utrecht University:

- A BSc in Computer Science or Artificial Intelligence;
have a legal right under Dutch Law (doorstroomrecht) to be admitted to the computer science degree.

Admission to the programme

Students admitted to the computer science degree qualify for admission to this programme if they possess (in addition to the degree criteria) the following skills and knowledge:

- the ability to make a computer programme of reasonable complexity and size, in an object-oriented programming language such as Java or C++;
- knowledge of data structures, algorithms and related concepts of reasonable complexity, such as sorting algorithms, $O(\cdot)$ -notation, balanced binary search trees, etc.;
- knowledge of basic computer-graphics techniques;
- have a good level of English understanding, speaking and writing.

Bachelor programmes that in all probability satisfy those knowledge and skill requirements are

- BSc programmes with a major in computer science
- BSc with a major in science and a minor (or comparable) in computer science
- A HBO BSc programme in HIO or technical computer science

Learning outcomes

The successful candidate will satisfy the following learning outcomes.

Graduates:

- possess advanced knowledge on and skills in a substantial number of the following areas: game design, motion and manipulation, graphical and physical modeling, computer vision, pattern recognition and multimedia retrieval, virtual worlds, and geometric computing,
- have in-depth knowledge of at least one area in the field of game technology and multimedia in such that the international research literature can be understood,
- have an overview of the area of scientific research and development concerned.

Graduates have the skills to:

- identify, formulate, analyse and suggest possible solutions to problems independently in the field of Game and Media Technology,

- conduct research in the field of Game and Media Technology under supervision of a scientific staff member and report on it in a manner that meets the customary standards of the discipline,
- communicate conclusions both written and orally, as well as the underlying knowledge, grounds and considerations, to an audience composed of specialists or non-specialists in English.

Graduates display attitudes that enable them to:

- have an honest constructive-critical attitude towards own and other one's plans, visions and research results,
- work together in a (possibly interdisciplinary) team of experts with different nationalities and backgrounds,
- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession,
- work independently and taking initiatives where necessary,
- enrol in a PhD programme in the field of computer science in general, and game technology and multimedia in particular.

Contents

Mandatory courses	0 ECTS
Primary electives	37.5 - 45 ECTS
Secondary electives	15 ECTS
Research part	60 - 67.5 ECTS
Total	120 ECTS

Primary electives

If a 15 ECTS experimentation project is chosen, select *five* out of the following list of courses (7.5 ECTS each): computer animation, computer vision, game engine programming, game physics, geographic data processing, geometric algorithms, motion and manipulation, multimedia retrieval, multimodal interaction, pattern recognition.

If a 7.5 ECTS experimentation project is chosen, select *six* out of the following list of courses (7.5 ECTS each): computer animation, computer vision, game engine programming, game physics, geographic data processing, geometric algorithms, motion and manipulation, multimedia retrieval, multimodal interaction, pattern recognition.

Secondary electives

- Any master's course offered by the UU (including the unchosen primary electives), pending approval by the programme coordinator.
- At most one *capita selecta*, on an approved subject.
- Courses that remove deficiencies, as recommended by the programme coordinator.

Research part

- A thesis project of 45 ECTS.
- A literature study of 7.5 ECTS, preferably on the anticipated subject of the thesis project.
- An experimentation project of 7.5 or 15 ECTS.

History and philosophy of Science

Admission Criteria

Admission to the degree in History and Philosophy of Science

Applicants are expected to hold one of the following bachelor degrees

- a Bachelor's degree of Science with a major in Physics
- a Bachelor's degree of any of the Sciences with preferably a minor in History and/or Philosophy
- a Bachelor's degree with a major in History and/or Philosophy, and a minor in one of the Sciences.
- a Bachelor's degree in any of the Humanities with preferably a minor in one of the Natural or Life Sciences

There is no automatic admission into this degree.

Admission to the programme

There is no automatic admission into this programme.

Learning outcomes

Graduates have obtained a profound knowledge of, and insights into:

- the historical and/or philosophical methods which are used in the study of history and philosophy of science (HPS);
- at least one specialised area in the field of history of science, history of natural philosophy, philosophy of science, foundations of physics, and history or philosophy of logic.

Graduates have obtained the skills that enable them to:

- give a concise summary of the outcomes of their research in one of the fields of HPS;
- execute a research project under the supervision of a staff member and present the results of this project both in an oral presentation and in writing in English;
- independently formulate a historical or philosophical hypothesis on the basis of their research;
- develop sound judgement and a critical attitude with respect to historical or philosophical theories.

Graduates display attitudes that enable them to:

- apply knowledge and insight in a way that demonstrates a professional approach to their work and profession;
- work independently and take initiatives where necessary;
- enrol in a PhD programme in the field of HPS;
- start a career in e.g. science journalism, science communication, science centres and museums, science policy or science management.

Contents

Mandatory courses	15	ECTS
Primary electives	30-45	ECTS
Secondary electives	0-15	ECTS
Research part	60	ECTS
Total	120	ECTS

Mandatory courses and primary electives reflect the body of knowledge in which a student must be sufficiently prepared to successfully engage in research. At least 30 ECTS of the primary courses need to be taken. Secondary optional courses are considered to be pure electives but may also be used for further specialization. A maximum of 15 ECTS can be taken from the underlying list.

Mandatory courses

- History, role and impact of the natural sciences, NS-HP401M
- Philosophy of Science, NS-HP402M

Primary Electives (30-45 ECTS)

- Foundations of Quantum Mechanics, NS-HP428M
- Foundations of Statistical Physics, NS-HP429M
- History and Philosophy of Space and Time, NS-HP430M
- History and Philosophy of Experimentation, NS-HP431M
- Science and the Public, NS-HP436M
- Science and the Dilemmas of Modernity (Part I and II), NS-HP438M
- History of modern Biology, NS-HP433M
- CS Mental Representation, WBMA0903
- Kennis en Wetenschap, WBMD5005
- CS Philosophy of Nature and History of Science, WBMA4002
- Philosophy of Mind, CKWM4051
- Philosophy of AI, WBF AI
- Applied Philosophy of Science
- History of Mathematics, WISB281
- Seminar History of Mathematics, WISM481
- Historical Aspects of Classroom Mathematics, WISM482
- Foundations of Mathematics, WISB323

Secondary Electives (0-15 ECTS)

- Any MSc course offered by the Graduate School of Natural Sciences
- Suggestions for other courses can be found on www.phil.uu.nl/HPS
- Any other choice has to be approved by the Exam Committee

Research part

Research Part:	60 ECTS
Research Seminar	7.5 ECTS
Thesis	52.5 ECTS

Mathematical Sciences

Admission Criteria

Admission to the degree in Mathematical Sciences

At the start of their master studies, students should possess solid knowledge in mathematics.

Applicants are therefore expected to hold one of the following degrees:

- A BSc with a major in Mathematics
- A BSc with a major in Physics with a strong component in mathematics
- A BSc with a major in Computer Science with a strong component in mathematics
- A BSc with a major in Science with a strong component in mathematics

Applicants holding a BSc in Mathematics of Utrecht University have a legal right under Dutch Law (doorstroomrecht) to be admitted to the degree in Mathematical Sciences.

Learning outcomes

Graduates:

- have theoretical and practical knowledge of advanced general concepts, principles and techniques of fundamental and applied mathematics;
- have in-depth knowledge of at least one area in the field of fundamental or applied mathematics in such that the international research literature can be understood;
- have an overview of the area of scientific research and development concerned;

Graduates have the skills to:

1. assimilate complex mathematical ideas and arguments;
2. identify, formulate, analyse and suggest independently possible solutions to problems in the field of mathematical sciences;
3. conduct research in the field of mathematical sciences and report on it in a manner that meets the customary standards of the discipline (including correct referencing, appropriate layout and style);
4. work together in a (possibly interdisciplinary) team of experts with different backgrounds;
5. communicate conclusions both written and orally, as well as the underlying knowledge, grounds and considerations, to an audience composed of specialists or non-specialists in English.

Graduates should be able to:

- enrol in a PhD programme in mathematics, or begin a career as a professional mathematician.

Contents

Mandatory courses	0 ects
Primary electives	58 ects
Secondary electives	15 ects
Research part	47 ects
total	120 ects

Primary Electives

Primary elective courses are chosen from the course list given below. Students must choose their courses in consultation and agreement with their tutor, so as to create a coherent course load, usually aiming for one of eight possible specializations:

- Algebraic Geometry and Number Theory
- Applied Analysis
- Differential Geometry and Topology

- History of Mathematics
- Logic
- Probability and Statistics
- Pure Analysis
- Scientific Computing

Secondary Electives

The secondary elective courses can be any course from the course list below or other courses on the master level, if approved by the programme coordinator. Courses to remedy deficiencies are also counted in this category.

Research part

Thesis research work for 47 ECTS.

Course list

The course list is made up of local courses, courses that are part of the national Mastermath Programme, and courses that are part of Stochastics and Financial Mathematics (SFM) Programme, which is offered by the University of Amsterdam (UvA), the Free University (VU), the University of Leiden (RUL) and the University of Utrecht (UU). The courses that are part of the national Mastermath programme, as listed on <http://www.mastermath.nl>, form the core part of the master's programme Mathematical Sciences. Examination takes place according to general rules of Mastermath, to be found at <http://www.mastermath.nl>.

Mastermath courses 2011-2012

Introduction to Stochastic Processes (WISL102, 4 ECTS)
 Continuous Optimization (WISL103, 6 ECTS)
 Systems and Control (WISL20, 6 ECTS)
 Discrete Optimization (WISL101, 6 ECTS)
 Heuristic Methods in Operations Research (WISL110, 6 ECTS)
 Functional Analysis (WISL401, 8 ECTS)
 Dynamical Systems (WISL404, 8 ECTS)
 Elliptic Curves (WISL303, 8 ECTS)
 Measure-theoretical Probability (WISL701, 8 ECTS)
 Asymptotic Statistics (WISL702, 8 ECTS)
 Parallel Algorithms (WISL603, 8 ECTS)
 Numerical Linear Algebra (WISL601, 8 ECTS)
 Stochastic Differential Equations (WISL108, 6 ECTS)
 Advanced Modelling in Science (WISL203, 6 ECTS)
 Applied Statistics (WISL106, 6 ECTS)
 Applied Finite Elements (WISL204, 6 ECTS)
 Nonlinear Systems Theory (WISL202, 6 ECTS)
 Advanced Linear Programming (WISL105, 6 ECTS)
 Scheduling (WISL107, 6 ECTS)
 Queuing Theory (WISL108, 6 ECTS)
 Intuitionistic Mathematics (WISL318, 8 ECTS)
 Lambda Calculus as Formalism for Computations and Proofs (WISL317, 8 ECTS)
 Semidefinite Optimization (WISL111, 8 ECTS)
 Algebraic Geometry (WISL509, 8 ECTS)
 Variational Methods (WISL408, 8 ECTS)
 Mathematical Biology (WISL411, 8 ECTS)
 Partial Differential Equations (WISL402, 8 ECTS)
 Lie Groups (WISL500, 8 ECTS)
 Riemann Surfaces (WISL514, 8 ECTS)
 Stochastic Processes (WISL703, 8 ECTS)
 Numerical Methods for stationary PDEs (WISL604, 8 ECTS)
 Time Series (WISL704, 8 ECTS)
 Historical Aspects of Classroom Mathematics (WISL909, 8 ECTS)
 Operator Algebra (WISL517, 8 ECTS)
 Differential Geometry (WISL503, 8 ECTS)
 Automatic Sequences (WISL318, 8 ECTS)

SFM courses 2011-2012

see also <http://www.math.vu.nl/sto/onderwijs/sfm/index.html>.

Stochastic Optimization (WISS101-09, 6 ECTS)
Stochastic Processes for Finance (WISS102, 6 ECTS)
Ergodic Theory (WISS122, 7.5 ECTS)
Stochastic Models for telecommunication Systems (WISS103, 4 ECTS)
Semiparametric Statistics (WISS112, 6 ECTS)
Bayesian Statistics (WISS114, 6 ECTS)
Stochastic Integration (WISS105, 8 ECTS)
Financial Mathematics: A Levy Process Perspective (WISS126, 8 ECTS)
Information Theoretic Learning (WISS119, 8 ECTS)
Modern Theory of Markov Chains (WISS123, 7.5 ECTS)
Topics in Discrete Probability (WISS118, 6 ECTS)
Simulation Methods in Statistics (WISS11-09, 8 ECTS)
Portfolio Theory (WISS104, 6 ECTS)
Financial Stochastics (WISS106, 8 ECTS)
First Passage Percolation (WISS115, 8 ECTS)
Mathematical Statistical Mechanics (WISS121, 7.5 ECTS)
Stochastic Models for Genetic Evolutionary (WISS111, 8 ECTS)
Statistical Genetics (WISS124, 8 ECTS)
Fluctuation Theory for Levy Processes (WISS125, 8 ECTS)

Local courses 2011-2012

Laboratory Class Scientific Computing (WISM454, 7.5 ECTS)
Characteristic classes of Vector Bundles (WISM442, 7.5 ECTS)
Computability Theory (WISM430, 7.5 ECTS)
Seminar Spatio-Temporal Patterns (WISM418, 7.5 ECTS)
Modular forms (WISM425, 7.5 ECTS)
Science in Islamic Civilization (WISM483, 7.5 ECTS)
Wavelets- and Fouriertransforms (WISM453, 7.5 ECTS)

Honours programme

Students who are registered (1) for both the master's programme in Theoretical physics and the Master's programme in Mathematical Sciences, and (2) are registered for the Honours programme in Theoretical Physics and Mathematics and (3) fulfill all of the other requirements to successfully complete the honours programme, can do a thesis project of 60 ECTS, co-supervised by staff members of the ITP and the Mathematics Institute. Such a thesis has to contain sufficient mathematics and theoretical physics, such that it has to meet the standard of both programmes. The extra 13 credits of the thesis project exceeding the research part of the programme may be counted towards the secondary electives credit load.

Special provision for students enrolled in the programmes Scientific Computing and Stochastics and Financial Mathematics during 2010-2011 and earlier

Students enrolled in the MSc programmes Scientific Programming and Stochastics and Financial Mathematics during 2010-2011 and earlier continue under the fully compatible terms of the programme Mathematical Sciences.

Meteorology, Physical Oceanography and Climate (MPOC)

Admission Criteria

Admission to the degree Physics and Climate Science

At the start of their master studies, students should possess:

- Solid basic knowledge in classical physics, quantum mechanics, electrodynamics and thermal physics, as well as in the mathematics required for the study of such topics at an advanced level.
- The ability to work independently as well as in groups on solving physical problems, present the results of solving problems and to read (English) physics literature at the level of graduate textbooks.
- Intermediate problem-solving skills in the main fields of physics and/or their applications.

Applicants are therefore expected to hold one of the following degrees

- a completed Bachelor's of Science with a major in physics,
- a major in Science with strong component in physics

Applicants holding a BSc in Physics and Astronomy of Utrecht University have a legal right under Dutch Law (doorstroomrecht) to be admitted to the degree in Physics and Climate Science

Admission to the programme MPOC

Applicants with a Bsc and a minor "meteorologie, fysische oceanografie and climate" are automatically admitted to the programme.

Applicants with a BSc and background in related fields like chemistry, earth sciences, geophysics, mathematics can be admitted if their background level in physics and mathematics, fluid dynamics is sufficient.

Learning outcomes

Graduates have profound knowledge of, and insights into:

- the dynamical, physical and chemical processes that determine the state of the atmosphere, ocean and cryosphere.
- have in-depth knowledge of at least one area in the field of meteorology, oceanography and climate science, such that the international research literature can be understood.
- understand connections and interactions between different components of the climate system.

Graduates have the skills to:

- give a concise summary of the relevant observations, the observational techniques used and the theoretical challenges posed by these observations.
- execute a research project under the supervision of a staff member and present the results of this project both in an oral presentation and in writing in English.
- independently formulate a scientific hypothesis, or develop a consistent model, as an explanation of an observed phenomenon or result of a numerical model.
- develop a sound judgement and a critical attitude on the interpretation of observational and model data based on fundamental chemical and physical principles, and statistical and numerical skills.
- be able to design, perform and analyze (statistically and deterministically) field and laboratory experiments.
- be able to apply theoretical concepts that allow a quantification of oceanographic, atmospheric and climatic processes and phenomena.
- be able to develop a numerical model of the observed systems.

- recognise and be aware of recent scientific developments in the field of meteorology, oceanography and climate science.

Graduates display attitudes that enable them to

- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
- work together in a (possibly interdisciplinary) team of experts with different nationalities and backgrounds;
- work independently and take initiatives where necessary
- enrol in a PhD programme in the field of meteorology, oceanography and climate sciences
- continue in research oriented organisations.
- continue in positions in public service (in organisations related to weather, climate, air quality, hydrology etc.)

Contents

Mandatory courses	37,5ECTS
Primary Electives	22,5-37,5 ECTS
Secondary Electives	0-15 ECTS
Research part	45 ECTS
Total	120 ECTS

Mandatory courses

- Dynamical Oceanography (NS-MO401M, 7.5 ECTS)
- Dynamical Meteorology (NS-MO402M, 7.5 ECTS)
- Atmospheric Composition and Chemical Processes (NS-MO405M, 7.5 ECTS)
- Simulation of Ocean, Atmosphere and Climate (NS-MO501M, 7.5 ECTS)
- Making, analyzing and Interpreting Observations (NS-MO502M, 7.5 ECTS)

Primary Electives

At least 22,5 ECTS has to be chosen from the underlying list of courses

- Turbulence, mixing (NS-MO406M, 3.75 ECTS)
- Boundary Layer Meteorology (NS-MO407M, 3.75 ECTS)
- Ocean Waves (NS-MO428M, 7.5 ECTS)
- Physics of Coastal Systems (NS-MO426M, 7.5 ECTS)
- Ice and Climate (NS-MO427M, 7.5 ECTS)
- Current Themes in Climate Change (NS-MO434M, 7.5 ECTS)
- Topics in Climate Science (NS-MO44xM see study guide for course contents)
- Any other NS-MO graduate courses announced on the IMAU website or through the study guide.

Secondary electives

- At most 15 ECTS may be chosen from all MSc course offered by the Graduate School of Natural Sciences
- For other courses approval of the examination committee is required

Research part

The research part of the Master's programme will consist of 9 months of research under the supervision of a staff member of the Institute for Marine and Atmospheric Research or adjoint faculty. This research is concluded with a written Master's thesis, which is graded by the supervisor, together with another independent staff member.

Research can be done in the following directions:

- Ice and Climate
- Ocean Circulation and Climate
- Atmospheric Physics and Chemistry
- Atmospheric Dynamics and Boundary Layer Meteorology
- Coastal and shelf seas

Nanomaterials: Chemistry & Physics

Admission Criteria

This programme can be completed within the framework of two degrees:

- 1) Chemical Sciences
- 2) Physics & Climate Science

Admission to the degree in Chemical Sciences

At the start of their master studies, students should possess a sound basic knowledge of physical, inorganic and organic chemistry.

Applicants are therefore expected to hold one of the following academic degrees:

- A BSc degree with a major in chemistry or materials science
- A major in science with a strong component in chemistry.

Admission to the degree in Physics and Climate Science

At the start of their master studies, students should possess:

- Solid basic knowledge in classical physics, quantum mechanics, electrodynamics and thermal physics, as well as in the mathematics required for the study of such topics at an advanced level.
- The ability to work independently as well as in groups on solving physical problems, present the results of solving problems and to read (English) physics literature at the level of graduate textbooks.
- Intermediate problem-solving skills in the main fields of physics and/or their applications.

Applicants are therefore expected to hold one of the following academic degrees

- A BSc degree with a major in physics,
- A major in science with a strong component in physics

Applicants holding a BSc degree in Physics and Astronomy from Utrecht University or a BSc degree in Chemical Sciences from Utrecht University are legally entitled under Dutch Law (doorstroomrecht) to be admitted to the degree in Physics and Climate Science or the degree in Chemical Sciences respectively.

Admission to the programme

Students admitted to the Chemical Sciences degree qualify for admission to this programme if they possess the following skills and knowledge:

The student must have successfully completed at least three subjects out of the following five: 1) Physical Chemistry (classic and principles of statistical thermodynamics), 2) Inorganic and Solid State Chemistry, 3) Knowledge on several spectroscopic and analytical techniques (MS, IR/VIS, NMR, ESR, RDX, SAXS/SANS, CSLM,...4) Quantum chemistry (insight in several theoretical models based on more electron wave functions) and 5) Advanced organic chemistry. For Utrecht bachelor students, the following courses represent the above mentioned subjects. Three of these courses must have been completed:

- a. Physical Chemistry 2 (SK-BFYCH)
- b. Inorganic and Solid State Chemistry (SK-BANVA)
- c. Advanced (Super)Structures: Scattering and Microscopy (SK-BASSM)

- d. Quantum Chemistry 2 (SK-BKWCH)
- e. Organic Chemistry 3 (SK-BORC3)

-Prospective students must have acquired practical skills in the field of physical, inorganic and organic chemistry. Experience in writing a research report, such as a bachelor thesis, is a prerequisite.

-Degrees mentioned in the paragraph *Admission to the degree of chemical sciences* normally satisfy these conditions.

b) Students admitted to the Physics & Climate Science degree qualify for admission to this programme if they possess the following skills and knowledge:

- The student must have successfully completed at least two subjects out of the following five at a level corresponding to second to third year Utrecht physics bachelor courses: 1) quantum mechanics (Hilbert space, angular momentum, spin, charged particles in a e-m field, perturbation theory, variation techniques, WKB method, many-body systems, scattering theory), 2) statistical physics (ensemble, Boltzmann distribution, quantum statistics, bosons, fermions, Bose-Einstein condensation, phase transitions, etc.), 3) condensed matter physics (crystal structure, phonons, electrons, plasmons, dielectrics, magnetism, superconductivity, Bose-Einstein condensation, quantum dots, photonic crystals), 4) electrodynamics (electrostatics, magnetism, electrodynamics, Maxwell equations, electromagnetic waves, radiation), and 5) mechanics (Newton's laws, Hamilton Lagrange formalism, oscillations, Coriolis force, Kepler's laws, rotation and translation). For Utrecht students, the following courses represent the above mentioned subjects; two of these courses must have been completed:

- a. Kwantummechanica 2 (NS-356B)
- b. Thermische Fysica 2 (NS-355B)
- c. Moderne Gecondenseerde Materie (NS-352B)
- d. Electrodynamica 2 (NS251B)
- e. Mechanica 2 (NS-350B)

-Prospective students must have acquired practical skills in the field of experimental physics, electronics and computer techniques. Experience in writing a research report such as a bachelor thesis and in presenting scientific results is a prerequisite.

-Degrees mentioned in in the paragraph *Admission to the degree of Physics and Climate Science* normally satisfy these conditions.

Learning outcomes

Graduates have knowledge of, and insights into:

- the physics and/or chemistry of hard and soft condensed matter with an emphasis on nanomaterials.
- fields such as photonics, colloid science, catalysis or functional materials in such a way that the international research literature can be understood.

Graduates have the skills to:

- develop and apply original ideas within the research context in fields such as photonics, colloid science, catalysis or functional materials
- be able to plan and carry out experiments under the supervision of a scientific staff member
- be able to communicate conclusions, written and orally, in English, as well as the underlying knowledge, background and considerations, to an audience composed of specialists or non-specialists

Graduates display attitudes that enable them to

- have an integer constructive-critical attitude towards own and other one's plans, visions and research results

- work together in a (possibly interdisciplinary) team of experts with different nationalities and backgrounds
- Work independently and of taking initiatives where necessary
- continue in research oriented companies, the public sector, patent agencies, etc.
- enrol in a PhD program in one of the research groups of the Debye Institute for Nanomaterials Science or other related research institutes
- act in a professional and academic way in the field of Chemistry or Physics.

Contents

Mandatory courses	7,5 ects
Primary electives	22,5 ects
Secondary electives	30 ects
Research part	60 ects
Total	120 ects

Mandatory course

Topics in Nanoscience (SK-MTOPICS).

Primary electives

Chemical Sciences students must take 3 courses irrespective their signature, while **Physics and Climate Science students** must take 3 courses with a Physical Sciences (P) or a combined C/P signature. All courses have a study load of 7,5 ECTS.

Chemical science courses	Physical science courses
Kinetics & Diffusion (SK-MKIDI) (C/P)	Device Physics (NS-NM426M)(P)
Advanced Organic Synthesis (SK-MOSS)	Nanophotonics (NS-NM428M)(P)*
Advanced Spectroscopy of Nanomaterials (SK-MASPN)	Photon Physics (NS-NM427M)(P)
Solids & Surfaces (SK-MSOLS)	Soft Condensed Matter (NS-NM429M) (C/P)
Synthesis of Complex Nanostructures (SK-MSYNA)	Computational Materials Science (NS-CP432M) (C/P)
Advanced Physical Chemistry (SK-MPC3) (C/P)	Plasma Physics (NS-NM434M)(P)
Adsorption, Kinetics and Catalysis (SK-MAKC)	Soft Condensed Matter Theory (NS-TP453M)(P)*
Organometallic Chemistry and Homogeneous Catalysis (SK-MOCHC)(C)	

*only taught every two year (2010-2011, 2012-2013, etc)

Secondary electives

For the remaining 30 ECTS, several options are possible such as any MSc course offered by the Graduate Schools of Natural and Life Sciences or other courses, such as 3rd year bachelorcourses, with permission from the programme directors or a 15 to 30 ECTS internship outside Utrecht University. Internships can only start as soon as the mandatory and primary elective courses and the research project of 60 ECTS have been finished.

Secondary electives can also be those courses required to fulfill the admission requirements in the case of deficiencies. The programme director decides which courses need to be followed during the master's programme. Deficiencies will be stated in the Letter of Admission.

Research part

The student may start with his/her research project before the completion of the mandatory course with the permission of his/her supervisor.

Particle Physics

Admission Criteria

Admission to the degree Physics and Climate Science

At the start of their master studies, students should possess:

- Solid basic knowledge in classical physics, quantum mechanics, electrodynamics and thermal physics, as well as in the mathematics required for the study of such topics at an advanced level.
- The ability to work independently as well as in groups on solving physical problems, present the results of solving problems and to read (English) physics literature at the level of graduate textbooks.
- Intermediate problem-solving skills in the main fields of physics and/or their applications.

Applicants are therefore expected to hold one of the following degrees

- a completed Bachelor's of Science with a major in physics,
- a major in Science with strong component in physics

Applicants holding a BSc in Physics and Astronomy of Utrecht University have a legal right under Dutch Law (doorstroomrecht) to be admitted to the degree in Physics and Climate Science.

Admission to the programme

Students admitted to the Physics and Climate degree qualify for admission to this programme, if they possess skills and knowledge in Quantum Mechanics, Thermal Physics at an advanced bachelor level and have general knowledge in Subatomic Physics and in Classical Field Theory.

For students who have a bachelor's degree of Utrecht University: *at least one each of the following two groups of courses* must have been completed:

One course of

- Quantum mechanics 2 (NS-356B) or
- Thermal physics 2 (NS-355B),

and one course of

- Particle Physics (NS-262B) or
- Subatomic Physics (NS-369B)

In case a student has not taken two of these courses, one of them can be taken as part of the MSC programme to remedy this deficiency.

Learning outcomes

Graduates have knowledge of, and insights into:

- modern particle physics with an emphasis on the Standard Model, and
- profound knowledge of the physics of strong interactions and/or another special subtopic of relevance in current particle physics research such that the international research literature can be understood.
- They further have knowledge on experimental techniques of particle detection and data analysis in high-energy physics.

Graduates have the skills to:

- identify, formulate, analyse and suggest possible solutions to problems independently in the field of particle physics;
- conduct research in the field of particle physics under supervision of a scientific staff member and report on it in a manner that meets the customary standards of the discipline;
- apply knowledge and insight in original research projects in the area of particle physics, at the level of international scientific journals.

- communicate both orally and written conclusions, as well as the underlying knowledge, grounds and considerations, to an audience composed of specialists or non-specialists in English

Graduates display attitudes that enable them to

- work together constructively critical in an international team of experts and use modern means of scientific communication
- work independently and take initiatives where necessary
- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession
- enrol in a PhD programme in the field of particle physics

Contents

Mandatory courses	18 ECTS
Primary electives	24 ECTS
Secondary electives	13-23 ECTS
Research part	65-55 ECTS
Total	120 ECTS

Mandatory courses

1. NS-PP 401M Particle Physics (12 ECTS)
2. NS-PP 402M Strong Interactions (6 ECTS)

Primary electives

A choice of 24 ECTS from:

- the following courses from the NIKHEF Particle & Astroparticle Physics programme
 - Astroparticle Physics (6 ECTS)
 - Particle Detection (6 ECTS)
 - NIKHEF Project (6 ECTS)
 - Statistical Data Analysis (6 ECTS)
- CERN Summer Student programme (6 ECTS)
- NS-TP401M Quantum Field Theory (10 ECTS)
- NS-EP438M Modeling & Simulation (7.5 ECTS)
- pending approval from the programme coordinator the following courses may also be included :
 - a Quantum Field Theory course from a partner university in the NIKHEF Particle & Astroparticle Physics programme (e.g. UvA)
 - course on C++ programming

Secondary electives

For the remaining ECTS a choice of:

- master's courses offered by the Graduate School of Natural Sciences
- other master's courses offered by the UU or by UvA or VU pending approval from the programme coordinator

Any courses mentioned as primary electives and not used in that category can be used as secondary electives. The surplus of credits from primary electives beyond the requested 24 ECTS can also be counted towards the required credits in the secondary electives. One of the following courses used to compensate deficiencies as mentioned above can be included in the secondary electives:

- Quantum mechanics 2 (NS-356B)
- Thermal physics 2 (NS-355B)
- Particle Physics (NS-262B)
- Subatomic Physics (NS-369B)

Research part

The research part consists of a thesis project of 55-65 ECTS. Research is usually done at the corresponding Institute at UU in the field of high-energy nuclear collisions as studied in the ALICE experiment at CERN. Projects are also possible in other subfields of Sub Atomic Physics according to agreements with the programme director.

Science and Business Management

Admission Criteria

Admission to the degree in Science and Business

Applicants are eligible for admission when holding one the following degrees:

- Bachelor degree in one of the natural sciences
- Bachelor degree in one of the life sciences

Admission to the programme Science and Business Management

Students admitted to the Science and Business degree qualify for admission to this programme when they possess the following skills and knowledge:

- Solid knowledge of one of the natural or life sciences;
- An interest in the application of science must be demonstrated;
- Academic skills at the level of a Dutch university Bachelor of science degree.

Bachelor degree's that satisfy these requirements on knowledge and skills are:

- Bachelor degree in Biology;
- Bachelor degree in Biomedical Sciences;
- Bachelor degree in Chemistry;
- Bachelor degree in Informatics;
- Bachelor degree in Mathematics;
- Bachelor degree in Pharmacy;
- Bachelor degree in Physics;
- Or a similar degree.

Learning outcomes

Graduates have:

- profound knowledge of, and insights into theory and practice in one of the disciplines of Science, namely an area in one of the disciplines of Biology, Biomedical Sciences, Chemistry, Informatics, Mathematics, Pharmacy or Physics and have an overview of the area of scientific research and development concerned
- profound knowledge of, and insights into at least one specialization (of applied nature) within one of the disciplines of Biology, Biomedical Sciences, Chemistry, Informatics, Mathematics, Pharmacy or Physics
- knowledge of, and insights into the fundamentals of Business and Economics, the fundamentals of Finance and Management accounting and the fundamentals of entrepreneurship

Graduates have skills to:

- identify, formulate, analyse and suggest possible solutions to problems independently in the field of Science and Business Management
- conduct research with an applied component within one of the disciplines of Biology, Biomedical Sciences, Chemistry, Informatics, Mathematics, Pharmacy or Physics and report on it in a manner that meets the customary standards of the discipline under the supervision of a scientific staff member.
- communicate conclusions orally and written, as well as the underlying knowledge, grounds and considerations, to an audience composed of specialists or non-specialists in English.
- apply knowledge and problem solving capacities in new and unknown situations in a broader (or multidisciplinary) context related to the field of specialisation, can integrate knowledge and handle complex matters
- transform a scientific idea into a product and direct the development of this product
- optimize a part of an industrial process from the Research & Development perspective
- speak the professional language of both science and business
- identify if new findings can be patented

Graduates display attitudes that enable them to

- act in a professional and academic way, in particular with respect to the field of Science and Business Management
- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession
- be able to work together in a (possibly interdisciplinary) team of experts with different nationalities and backgrounds
- enrol in a PhD programme
- continue in organisations or companies
- start up his/her own company

Contents

Mandatory courses/internship	64 ECTS
Primary electives	5 ECTS
Secondary electives	18 ECTS
Research	33 ECTS
Total	120 ECTS

Mandatory courses

Courses	ECTS
• Introduction, return meetings and essay (AS-SP401M)	4
• Course Fundamentals of Business and Economics (AS-SP501M7)	15
• Finance and management accounting (AS-SP511M)	7.5
• Idea and start (AS-SP403M)	7.5
Internship	30

Primary Electives

- Theoretical science course(s)* 5

**This course may be chosen from the Utrecht University Master's degree science programmes (Graduate School of Life Sciences or Graduate School of Natural Sciences) pending approval by the programme director or programme coördinator.*

Secondary Electives

- Students should select one or more science courses with a total academic load of at least 18 ects. The level of the optional courses must be at least 3rd year Bachelor (for a maximum of 15 ECTS) and they can be chosen from university Bachelor's or Master's degree science programmes;
or
- up to 18 ects can be used to extend the research project.

Research/internship

- Research project 33* ects

** (Part of the) secondary electives may be used to extend the research project to a maximum of 51 ects*

Science Education and Communication*

Degree Science Communication and Education

And

Degree Teacher Education - Computer Science

*These regulations also apply to students from the former programmes Science Teacher Education, Science teacher education-Computer Science and Research and Development in Science Education.

Note: the two degree programmes described here are identical, except for the teacher education components:

- The degree Science Education and Communication provides the opportunity to qualify for a teacher degree in biology, chemistry, physics, mathematics, or astronomy as part of the programme.
- The degree Science Teacher Education – Computer Science provides the opportunity to qualify for a teacher degree in computer science as part of the programme.

Admissions Criteria

Applicants who are eligible for admission to the programme Science Education and Communication have:

- Solid knowledge of one of the natural or life sciences at the level of a Dutch university Bachelor of science degree;
- Academic skills at the level of a Dutch university Bachelor of science degree;
- English language proficiency at a level as specified in article 2.2.1. a-c.

Bachelor degrees that satisfy these requirements are:

- Bachelor of Science (BSc) degree in one of the natural sciences;
- Bachelor of Science (BSc) degree in one of the life sciences.

In order to qualify for the teacher education components of the programme, there are additional requirements upon the student's prior education. Bachelor degree's that satisfy these requirements are:

- BSc degree in Biology (teacher certificate biology);
- BSc degree in Chemistry (teacher certificate chemistry);
- BSc degree in Physics (teacher certificate physics);
- BSc degree in Mathematics (teacher certificate mathematics);
- BSc degree in Astronomy (teacher certificate astronomy);
- BSc degree in Computer Science or Information Science (teacher certificate computer science).

Students who get admitted on different, but related, degrees may have to take prescribed courses within and beyond the programme in order to qualify for a teacher degree. These prescribed courses will be determined by the Admissions Committee upon recommendation by the programme coordinator such that the specifications of the Interdisciplinary Committee on Teacher Education of the VSNU (see brochure *Universitaire lerarenopleidingen Vakinhoudelijk masterniveau*) will be met at the end of the master's programme. Prescribed courses that are specific to the aim of obtaining a teacher degree will only be regarded as 'deficiencies' according to EER 3.6.3, as long as the student pursues a teacher degree within the programme. If a student, who initially did not pursue a teaching degree, switches to pursue a teacher degree within the programme, the Letter of Acceptance will be revised if necessary.

The regular version of the teacher education components is in Dutch. Students may take the English language version of the teacher education (U-Teach) instead, but U-Teach will have its own, competitive, application procedure, and admission to the programme Science Education and Communication does not imply admission to the U-Teach programme.

Learning outcomes

Graduates of this programme have knowledge of:

- a broad range of science subjects, with an in-depth knowledge of at least one area in the natural sciences or in the life sciences, at such a level that they can understand the international research literature;
- the learning, teaching and communication processes that play a role in formal and informal science education and communication, and the factors that influence those processes, at such a level that this knowledge can inform their teaching and design activities;
- the current state of scientific research and development in Science Education and Communication, at such a level that they can understand the international research literature.

Graduates have the skills to:

- acquire and integrate new knowledge in their disciplinary field;
- identify, formulate, analyse and solve problems independently in the field of Science Education and Communication;
- conduct research in the field of Science Education and Communication, or in one of the Sciences, under supervision of a scientific staff member, at a level that enables them to enter a PhD-programme.
- communicate conclusions both orally and written, as well as the underlying knowledge, grounds and considerations, to various audiences, both specialist and non-specialist in English (and for Dutch natives also in Dutch).
- form well-founded judgement, also if only limited information is available, and to act in accordance with these judgements, taking into account the ethical and societal responsibilities associated with Science Education and Communication practices.

Graduates display attitudes that enable them to

- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
- provide constructive feedback towards own and other one's plans, visions and research results;
- be able to work together in a (possibly interdisciplinary) team of experts with different nationalities and backgrounds;
- work independently and take initiatives where necessary

In order to qualify for a teacher degree within this programme, students will acquire additional qualifications, according to the specifications of the Interdisciplinary Committee on Teacher Education of the VSNU (see the brochure "Competentieprofiel van leraren die aan een ULO zijn opgeleid" at www.universitairelerenopleiding.nl).

Contents

Curriculum requirements vary dependent on whether the student takes the full teacher education component, so as to obtain a teacher certificate in one of the school subjects, and whether the student's research project is in Science or in Science Education and Communication. Within the programme, the following three combinations will occur:

- A. Teacher degree + Science research
- B. Teacher degree + Science Education and Communication research
- C. No Teacher degree + Science Education and Communication research

The following table presents the curriculum requirements for each of these combinations:

Mandatory courses AS-SEC410- Introduction to Science Education and Communication AS-SEC412- Designing Science Education and Communication	7,5 ECTS 3,75 ECTS 3,75 ECTS
Primary electives <i>Select one of the clusters below:</i>	37,5 – 63,75 ECTS
<u>Cluster A</u> Teacher Training (regular or U-Teach) ¹	60 ECTS
<u>Cluster B</u> AS-SEC414 - Research Methods Science Education and Communication Teacher Training (regular 52,5 ECTS ² or U-Teach 60 ECTS)	3,75 ECTS 52,5 - 60 ECTS
<u>Cluster C</u> AS-SEC411 - Public Science Communication with Multi Media AS-SEC413 - Innovation and Dissemination AS-SEC414 - Research Methods Science Education and Communication AS-SEC415 - Advanced Topics in Science Education and Communication AS-SEC420 - Professional Practice Internship	3,75 ECTS 3,75 ECTS 3,75 ECTS 3,75 ECTS 22,5 ECTS
Secondary electives A coherent set of master's courses offered by the UU faculty of science, pending prior approval by the programme coordinator. i. Up to 15 ECTS ³ can be taken at Bachelor level 3. ii. If specific level 1 or 2 courses have been prescribed upon the student's admission in accordance with EER art. 3.6.3, these courses can also be taken here, but the total of i and ii will not exceed 15 ECTS. As a global criterion, the set of secondary electives will be regarded coherent if at least half of the course credits will be obtained from a single science master's programme. Acceptable choices include • Courses in the field of Science Education and Communication, including non-selected primary elective courses • Courses directly relevant to the student's research project • Courses relevant to a teacher's professional practice, including courses required to meet the requirements for a teacher degree (see brochure <i>Universitaire lerarenopleidingen Vakinhoudelijk masterniveau</i>) • An extension of the research project up to a maximum project size of 45 ECTS. Electives from outside the UU faculty of science that contribute towards the above criteria will be accepted if the faculty of science does not offer a comparable course.	18,75 - 30 ECTS
Research part <i>Select one of the following options:</i>	30 - 45 ECTS
Research Project Science (in combination with cluster A)	30 - 45
Research Project Science Education and Communication • (in combination with cluster B) • (in combination with cluster C)	30 - 45 45
Total	120 ECTS

¹Detailed programme for Teacher Training/UTeach is published by COLUU.

²As part of cluster B the regular teacher training does not include PGO.

³ The maximum of 15 ECTS (conditions i and ii) does not apply for students who started their master programme before September 2011, provided that they graduate no later than October 1, 2014.

Technical Artificial Intelligence

Admission Criteria

Admission to the degree Computer Science

Applicants should possess:

- solid basic knowledge of computer science and logic;
- the ability to analyze and model computer science problems.
- the ability to communicate facts and findings verbally and in writing, also using information and communication technology and audio-visual means.

Degrees in all probability meeting these requirements are:

- A BSc with a major in Computer Science or Artificial Intelligence;
- A BSc with a science major and (a) a minor in Computer Science or (b) a minor in Technical Artificial Intelligence or (c) a comparable use of the non-major part ('profielingsruimte') of the bachelor programme;
- A HBO-diploma 'Hogere Informatica Opleiding' (HIO) or (Technical) Computer Science;

Applicants holding a BSc in Computer Science or Artificial Intelligence of Utrecht University have a legal right under Dutch Law (doorstroomrecht) to be admitted to the computer science degree.

Admission to the programme

No further knowledge and skills are required in addition to those required for admission to the degree Computer Science.

In addition to the degrees mentioned above, the following degrees also in all probability meet the requirements for admission to this master's programme:

- A UU-BSc in Information Science with a Minor in Technical Artificial Intelligence (TKI).

Learning Outcomes

The Master's programme in Technical Artificial Intelligence has the following exit qualifications:

1. Mastery of technical artificial intelligence at an advanced academic level. This means mastery of a number of advanced general subjects in the areas of agent technology, AI techniques and agent-oriented software engineering, in depth-knowledge and ability in at least one advanced subject (such as agent design, agent programming, multi-agent communication, (multi-) agent logics, argumentation, adaptive agents and games and agents), mastery of the necessary logical and computational tools, and skills in theoretical analysis, modelling and experimentation. This knowledge and these skills should be mastered at a level that is considered equal to that of other comparable Master degrees at international, top-quality, educational institutions.
2. In-depth knowledge of at least one area within technical artificial intelligence, such that the international research literature can be understood.
3. Thorough experience with research in (pure or applied) technical artificial intelligence and complete awareness of the applicability of research in technological developments and organisational contexts.
4. Capable of understanding a wide variety of different problems and being able to formulate these at an abstract level. To see, from the abstract level, the relation

- between diverse problems and to contribute creatively to their solution focused on practical applications.
5. Capable of creating innovative software and information system designs, taking account of feasibility issues.
 6. Capable of working in a (possibly interdisciplinary) team of experts performing the aforementioned activities and communicating easily in both written and oral English.
 7. Capable of working independently and of taking initiatives where necessary. Identifying areas where expertise is lacking and remedying the situation.
 8. Capable of making English language presentations orally or in writing of one's own research activities to diverse audiences. Being able to adapt to the background and interest of the audience.

Contents

Mandatory courses	0 ECTS
Primary electives	15-37,5 ECTS
Secondary electives	37,5-60 ECTS
Research part	45 ECTS
Total	120 ECTS

Format

Students follow study lines. Students can design their own study line subject to approval of the TAI programme leader or select one of three currently approved studylines:

- Agent Technology
- AI Techniques
- Agent-Oriented Software Engineering.

Mandatory courses

None.

Primary electives – mandatory per studyline (all 7,5 ects)

Up to three courses per studyline:

- Agent Technology:
 - Intelligent Agents (INFOIAG), Multi-Agent Systems (INFOMAS), Multi-Agent Programming (INFOMAP).
- AI Techniques:
 - None.
- Agent-Oriented Software Engineering:
 - Intelligent Agents (INFOIAG), Multi-Agent Systems (INFOMAS), Multi-Agent Programming (INFOMAP)

Primary electives - optional per study line (all 7,5 ects)

Up to five courses per study line, with some bounded-choice options:

- Agent Technology:
 - Choice of two courses from: Multi-agent Learning (INFOMAA), Commonsense Reasoning (INFOCR), Games and Agents (INFOMGMAG), Philosophy of AI (WBFAI).
- AI Techniques:
 - Choice of one course from: Intelligent Agents (INFOIAG), Multi-Agent Systems (INFOMAS).
 - Choice of two courses from: Adaptive Agents (INFOMAA), Commonsense Reasoning (INFOCR), Philosophy of AI (WBFAI).

- Choice of two courses from: Advanced Datamining (INFOADM), Evolutionary Computing (INFOEA), Probabilistic Reasoning (INFOPROB).
- Agent-Oriented Software Engineering:
 - Choice of one course from: Program Verification, Automatic Programme Analysis (INFOAPA).

Secondary electives (all 7,5 ects)

- Free choice from the Computer Science curriculum designated at <http://www.cs.uu.nl/education/> unless marked with a cross under "TAI".

Students who do not fully possess the prerequisite knowledge for TAI can select at most two deficiency courses from the [UU Bsc programme in Computer Science](#) (max 15 ects). The student's choice of deficiency course(s) is subject to approval of the TAI programme leader. If the student has chosen a currently approved study line, then the chosen deficiency courses are part of the study line's secondary electives.

As part of an own-designed programme or the secondary electives of a study line students can do one or two [experimentation projects](#) (INFOEPAT (7,5 ects, INFOEPAT1, 15 ects), to a maximum of 15 ects, either alone or with another student.

Subject to approval of the TAI programme leader, students can also select courses from outside the UU Computer Science master programmes, including courses from other universities in the Netherlands or other countries. If made in the context of one of the currently approved study lines, they are part of the secondary electives. Courses from other universities in the Netherlands or other countries must also be approved by the Examination Committee.

Research part

In the research part the student carries out a research project under the supervision of one of the staff members of the research groups within the Department of Information and Computing Sciences offering the programme. The project is normally performed within the Department but can also be done in a research-and-development department of a company or institution.

Special provision for students enrolled in the programme Agent Technology during 2009-2010 or earlier.

Students enrolled in the MSc programme Agent Technology during 2009-2010 or earlier continue under the fully compatible terms of the renamed programme Technical Artificial Intelligence.

Theoretical Physics

Starting Moments

The preferred starting moment for this programme is Sept. 1. Starting at another moment (Feb. 1) is not ruled out, but will usually cause study delay.

Admission Criteria

Admission to the degree Physics and Climate Science

At the start of their master studies, students should possess:

1. Solid basic knowledge in classical physics, quantum mechanics, electrodynamics and thermal physics, as well as in the mathematics required for the study of such topics at an advanced level.
2. The ability to work independently as well as in groups on solving physical problems, present the results of solving problems and to read (English) physics literature at the level of graduate textbooks.
3. Intermediate problem-solving skills in the main fields of physics and/or their applications.

Applicants are therefore expected to hold one of the following degrees

- A BSc degree with a major in physics,
- A major in Science with strong component in physics

Applicants holding a BSc degree in Physics and Astronomy from Utrecht University are legally entitled under Dutch Law (doorstroomrecht) to be admitted to the degree in Physics and Climate Science.

Admission to the programme

Students admitted to the Physics and Climate Science degree qualify for admission to this Master's programme if they have successfully completed courses in quantum mechanics, thermal physics, and electrodynamics, at an advanced level (typically the second courses on these topics in a physics curriculum). Within the Utrecht BSc programme, these courses are:

- Quantum mechanics 2 (NS-356B)
- Thermal physics 2 (NS-355B)
- Classical field theory (NS-364B).

Students who did not pass these courses with high grades (above average) are advised not to choose this Master's programme. Note that there is no automatic admission to this programme.

Learning outcomes

Students should acquire the amount of knowledge, insight and technical skills in the field of theoretical physics and related disciplines required to work independently at a professional academic level, or to continue their education in a PhD programme.

A successful graduate student:

- has a thorough knowledge of modern theoretical physics
- has a thorough knowledge of the methods of theoretical physics and will have research experience in at least one area of theoretical physics
- is able to familiarize him or herself with other areas of theoretical physics in a reasonable amount of time
- is able to develop a research plan given a realistic and well-defined problem within theoretical physics
- Is capable of properly formulating the conclusions of a research project, analyze them, drawing conclusions from them and putting them in the context of research done by others
- is capable of writing a scientific report or paper
- can participate in discussions in certain areas of physics

- knows how to access and use international scientific literature and publications
- can collaborate with other people, transmit knowledge to others and is capable of explaining results to both a general as well as a more specialized audience (in English).

Contents

Mandatory courses	30 ects
Primary electives	30 ects
Secondary electives	15 ects
Research part	45 ects
Total	120 ects

Mandatory courses (Each 10 ECTS)

- Quantum Field Theory NS-TP401M
- Statistical Field Theory NS-TP402M
- Student seminar in Theoretical Physics

Participation in 18 sessions of the Theoretical physics colloquium is required.

Electives

Primary Electives: 22,5 ECTS to choose out of the following list	Secondary Electives: 15 ECTS to choose out of the following list
<ul style="list-style-type: none"> - A Master level course in Mathematics* -General Relativity -Cosmology -String Theory -Modelling and Simulation -Field Theory in Condensed Matter -Kramers course -Soft Condensed Matter theory -Field Theory in Particle Physics 	<ul style="list-style-type: none"> -Any MSc course offered by the Graduate School of Natural Sciences. -With the consent of the study advisor (an academic staff member of the programme) also other master level courses may be selected.

*Some mathematics courses offered in the third year of the bachelor programme in mathematics can replace the mandatory master level course in Mathematics. These courses are:

- Differentieerbare variëteiten
- Complexe functies
- Topologie en Meetkunde
- Maat en Integratie
- Stochastische processen
- Distributies
- Functionaalanalyse.

Note that at most one of these courses can be selected as part of the Master's programme, that the official language of education in these courses is Dutch, and that courses which are listed on the Bachelor's degree cannot be used for the Master's degree.

Research part

Research Part:	45 ECTS
Thesis	45 ECTS

Research can be done in any area of theoretical physics, provided that a staff member of the ITP is willing to act as the primary responsible supervisor.

Honours Programme

Students who are registered (1) for both the master's programme in Theoretical physics and the Master's programme in Mathematical Sciences, and (2) are registered for the Honours programme in Theoretical Physics and Mathematics and (3) fulfill all of the other requirements to successfully complete the honours programme, can do a thesis project of 60 ECTS, co-supervised by staff members of the ITP and the Mathematics Institute. Such a thesis has to contain sufficient mathematics and theoretical physics, such that it has to meet the standard of both programmes. The extra 15 credits of the thesis project exceeding the research part of the programme may be counted towards secondary electives credit load.

Honours programme Mathematical Sciences and Theoretical Physics

Starting Moments

The starting moment of the honours programme is September 1.

Admission's criteria

The applicant should satisfy the admissions criteria for the master programmes Theoretical Physics and Mathematical Sciences, which are stated in the corresponding programme descriptions.

Moreover, the application will be reviewed by a selection-committee, consisting of representatives of the two master programmes. The selection committee will base its decision on previous study results, motivation and the CV of the applicant.

Typically, an applicant will have completed a bachelor degree in Physics and one in Mathematics, both with high grades.

Contents

Mandatory Physics courses	30 ects
Optional Physics courses	22,5 ects
Optional Mathematics courses	52,5 ects
Thesis	60 ects
Total	165 ects

Mandatory Physics courses

Quantum Field Theory	10 ects
Statistical Field Theory	10 ects
Student seminar in Theoretical Physics	10 ects

Optional Physics courses (7,5 ects each)

General Relativity Cosmology, String Theory, Modelling and Simulation, Field Theory in Condensed Matter, Field Theory in Particle Physics, Soft Condensed Matter theory.

Optional Mathematics courses

See the programme appendix of Mathematical Sciences.

Thesis

The thesis must be co-supervised by a staff member of the ITP and one from the Mathematical Institute. It must meet the requirements of both master programmes.