

**Utrecht University
Graduate School Natural Sciences**

**Programme Annex to the
Education and Examination Regulations 2010-2011**

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Applied Computing Science

Admissions Criteria

Admission to this programme is no longer possible from September 2010 onwards. Students who enrolled before this date, will obtain a degree in Computer Science under the programme name Computing Science. This programme fully covers the Applied Computing Science curriculum. The underlying learning outcomes and courses of the Applied Computing Science programme will appear on the graduate's Diplome Supplement.

Learning outcomes

The successful candidate will satisfy the following learning outcomes:

Graduates have:

- theoretical and practical knowledge of advanced general subjects such as: the algorithmics of complex information systems involving concepts like data analysis, probabilistic networks and evolutionary techniques, graph-based modeling and complexity, planning and scheduling and/or simulation;
- a specialization within the field of Applied Computing Science, or alternatively a specialization at the interface between Applied Computing Science and a concrete application domain in data mining, decision-support systems or logistics;
- solid basic knowledge of computer science, viz. of algorithm design and problem complexity;

Graduates have the skills to:

- identify, formulate, analyse and suggest possible solutions to problems independently in the field of applied computing science;
- conduct research in the field of applied computing science under supervision of a scientific staff member and report on it in a manner that meets the customary standards of the discipline;
- the ability to analyze and model computer science problems algorithmically;
- communicate facts and findings verbally and in writing, also using information and communication technology and audio-visual means.

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 backgrounds;
- be capable of working independently and of taking initiatives where necessary;
- enrol in a PhD programme in the field of applied computing science;
- continue in organisations or companies such as IT companies (large and small), companies in the creative sector (software design and development), and companies with ICT divisions (banks, insurance companies, etc).

Astrophysics and Space Research

Admission's 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

[see 3.6.1 & 4.2]

Mandatory courses	37.5 ects
Optional courses	22.5 ects
Research part	<u>60 ects</u>
	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.

Optional courses

- Binaries (NS-AP438M)
- Nucleosynthesis (NS-AP437M)
- IAC (NS-AP428M)
- Solar Physics
- Large-Scale Structures in the Universe
- High-Energy Astrophysics
- General Relativity (Either NS-TP428 or NS-AP431M)

Any additional NS-AP courses announced on the website of the programme. Approved Astrophysics courses from other NOVA Master's programmes. Approved MSc courses offered by the Graduate School of Natural Sciences.

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 coordinator - an external staff member in any research institute in the Netherlands or abroad. In this case, a staff member of the Utrecht Astronomy Institute is responsible for quality control and the assigning of a grade.

Business Informatics

Admission's 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 program, 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	22.5 ects
Optional courses	52.5 ects
Research part	<u>45 ects</u>
	120 ects

Mandatory courses

- Enterprise Architecture
- Method Engineering
- Knowledge Management

Optional courses

1. Advanced Research Methods
2. Business Informatics Summer School
3. Business Process Management
4. Chain-Computarisation/Informatiestrategie
5. Design of Interactive Content
6. Development of knowledge Systems
7. Financial Management
8. ICT entrepreneurship
9. IT Business Models
10. Seminar Advanced Method Engineering
11. Seminar Medical Informatics
12. Seminar Software Eco Systems
13. Software Product Management
14. Supply Chain Management
15. Using Interactive Systems

Plus:

- Any MSc course from the Computer Science curriculum
- Any related MSc course offered by Utrecht University
- Capita Selecta

Research part

Research Part: 45 ects
 Thesis Project: 40 ects
 MBI Colloquium :5 ects

The Research Part or Thesis Project include participation in the bi-weekly MBI Colloquium (at the end of the master programme), and the Introduction to MBI course (at the start of the master's 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

Computing science

Admissions Criteria

Admission to the degree Computer Science

[See 2.1.a]

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;

[See 2.1.b]

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 program 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 program 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, program generation, program analysis and program transformation, large scale software architectures
 - the algorithmics of complex information systems involving concepts like data analysis, probabilistic networks and evolutionary techniques, graph-based modeling 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 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 program;
- 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	37.5 ects
Optional courses	37.5 ects
Research part	45 ects
	120 ects

Format

Study paths

Students follow individual study paths. The following study paths are pre-defined and set the standard for the program, with options depending on the specific research orientation of the student:

- Software design
- Formal methods and program analysis
- Algorithm design and analysis
- Advanced planning and decision making
- Design of decision processes ('Engineering Bayes')
- Big data

Mandatory courses

Up to 5 courses per study path (guideline):

- Software design
Programming language concepts, software engineering, advanced functional programming, compiler construction, software architecture
- Formal methods and program analysis
Programming language concepts, advanced functional programming, model checking, generic programming, automatic program 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, decision theory, scheduling and time-tabling, simulation
- Design of decision processes ('Engineering Bayes')
Programming language concepts, probabilistic reasoning, advanced functional programming, decision theory, software architecture
- Big data
Advanced data mining, multimedia retrieval, learning from data, queries and retrieval

together with (at least one) research seminar and participation in one of the colloquium series of the master program that fits the study path.

Optional courses

- All courses listed under mandatory courses that have not been taken as mandatory course.
- Extra experimentation project: a student may do 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 (maximum 15 ECTS)

Mandatory Research part

The research part consists of a MSc thesis project of 45 ECTS (including 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.

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

Students enrolled in the MSc programs 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 the their diploma supplement.

Content and Knowledge Engineering

Admissions Criteria

Last scheduled admission date into this programme is September 2010. There will be no admissions anymore after this due date.

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 human computer interaction, and cognitive and communication science
- Basic knowledge of knowledge representation and elicitation methods and languages
- Basic knowledge of empirical research methods and statistics and exchange languages

In addition to the degrees mentioned above, a HBO-degree in Human Computer Interaction should in all probability satisfy such qualifications.

There is room in the programme (max. 15 erts) to remedy possible deficiencies of the student in the above mentioned areas. Deficiency courses will be fixed at the beginning of the study by the programme coordinator.

Learning outcomes

The successful candidate will satisfy the following learning outcomes:

Graduates:

- have theoretical and practical knowledge of advanced general subjects such as the design, development and presentation of media and virtual environments, system usability and research methods;
- have in-depth knowledge of at least one area in the field of document engineering, knowledge engineering and human media interaction in such a way 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 content and knowledge engineering;
- conduct research in the field of content and knowledge engineering and report on it in a manner that meets the customary standards of the discipline;
- communicate conclusions both orally and written, 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

- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
- 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;
- enrol in a PhD programme in the field of content and knowledge engineering or a research position in a company
- obtain positions as project manager, content manager, knowledge engineer, Human Factors engineer or business consultant with a specialization towards knowledge management or content architectures.

Contents

Mandatory courses	22,5 ects
Optional courses	52,5 ects
Research part	45 ects
	120 ects

Mandatory courses

Students must take at least **three** from the following courses for a total of 22,5 ECTS:

- Design of Interactive Content (formerly known as Content Design. Students that have successfully completed Content Design cannot take the course Design of Interactive Content.)
- Using Interactive Systems (formerly known as Use of Knowledge and Content Systems (INFOUCKS). Students that have successfully completed INFOUCKS cannot take the course Using Interactive Systems.)
- Usability for Interactive Systems (formerly known as Usability Evaluation Methods (UEM). Students that have successfully completed UEM, cannot take the course Usability for Interactive Systems).
- Advanced Research Methods
- Game Design
- Knowledge Management
- Enterprise Architecture
- Method Engineering
- Software Product Management.

Optional courses

Apart from the three mandatory courses taken, students must take at least **three** from the following courses for a total of 22,5 ECTS

- Design of Interactive Content (formerly known as Content Design. Students that have successfully completed Content Design cannot take the course Design of Interactive Content.)
- Using Interactive Systems (formerly known as Use of Knowledge and Content Systems (INFOUCKS). Students that have successfully completed INFOUCKS cannot take the course Using Interactive Systems.)
- Usability for Interactive Systems (formerly known as Usability Evaluation Methods (UEM). Students that have successfully completed UEM, cannot take the course Usability for Interactive Systems).
- Advanced Research Methods
- Game Design
- Knowledge Management
- Enterprise Architecture
- Method Engineering
- Software Product Management
- Seminar CKE
- Seminar Intelligent User Interfaces
- Seminar Multimodal Perception and Interaction
- Seminar Medical Informatics.

The rest of the course credits can be filled by many different courses (typically those offered by the department of ICS, but possibly by other departments, faculties or even universities). The programme is determined uniquely for each student under the final decision of the programme coordinator and programme leader. At most 7.5 ECTS can be used for an individual experimentation project or capita selecta.

Research part

Research Part, 45 ects

Thesis Project, 40 ects

MBI Colloquium, 5 ects

The Research Part includes participation in the bi-weekly MBI Colloquium (at the end of the master programme), and in the Introduction to MBI course (at the start of the master's programme).

Research can be done in the following directions:

- Document Engineering (Interactive Content Design & Management)
- Human Media Interaction (Cognition & Communication)
- Knowledge Engineering (Knowledge Systems, Knowledge Management & Sharing)

Research projects can be carried out internally at the Department, at a company, or at a research institution, and must be supervised by at least one staff member of the group Business Informatics of the Department of Information and Computing Sciences.

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's Criteria

Admission to the degree in Science and Business

[See 2.1.a]

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

[see 2.3]

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 (see incidental courses);
- 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 an 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

[see 3.6.1 & 4.2]

Two variants exist: Systems Analysis and Natural Science

	Systems Analysis	Natural Science
Mandatory courses	37.5 ECTS	45 ECTS
Optional courses	15 ECTS	3.75-15 ECTS
Research/internship	67.5 ECTS	60 -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

Optional courses

- 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 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
• Energy Economics**	3.75
• Energy Modelling**	3.75
• Energy Policies**	3.75
• Advanced Energy Analysis	7.5
• 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*

Optional courses

- 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 optional courses, thesis and internship should be at least equal to 63.75 ECTS*

Game and Media Technology

Admissions 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 program if they possess (in addition to the degree criteria) the following skills and knowledge:

- the ability to make a computer program 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 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 computer science in general, and game technology and multimedia in particular.

Contents

Mandatory courses	45 ects
Optional courses	30 ects
Research part	<u>45 ects</u>
	120 ects

Mandatory courses

Five out of the following list (7.5 ECTS each) of

- courses: multimedia retrieval, motion and manipulation, geometric algorithms, game design, 3D modelling, computer vision, game engine programming, geographic data processing, pattern recognition;
- seminars: computer animation, advanced multimedia systems, crowd simulation, multimodal perception and interaction.

An experimentation project of 7.5 or 15 ECTS.

Colloquium of the programme.

Optional courses

Additional courses from the course list above and additional seminars from the seminar list may be elected.

Courses from other master programmes (external courses) and capita selecta may -if approved by the programme coordinator- be elected.

The programme offers room to take deficiency courses.

Research part

Thesis project (45 ECTS).

Constraints

The maximum number of credits allowed for seminars is 22.5 ECTS.

The combined number of credits for external courses, capita selecta en deficiency courses cannot exceed 15 ECTS.

History and philosophy of Science

Admission's Criteria

Admission to the degree in History and Philosophy of Science

[See 2.1.a]

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

NB 2.1.b

There is no automatic admission into this degree.

Admission to the programme

There is no automatic admission into this programme.

Learning outcomes

[3.2.1]

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
Optional courses	45 ects
Research part	60 ects

	120 ects
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Mandatory courses and primary optional courses 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

Optional courses

Primary courses (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, WBFAI
- Applied Philosophy of Science
- History of Mathematics, WISB281
- Seminar History of Mathematics, WISM481
- Historical Aspects of Classroom Mathematics, WISM482
- Foundations of Mathematics, WISB323

Secondary Courses (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's Criteria

Admission to the degree in Mathematical Sciences

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

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
- 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

NB 2.1.b

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.

Admission to the programme

Students admitted to the mathematical sciences degree qualify for admission to this program if they possess the following skills and knowledge:

- solid basic knowledge in Mathematics.

Applicants are therefore expected to hold a Bachelor's of Science with a major in mathematics.

Learning outcomes

Knowledge:

Successful 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 a research-type experience that will aid them in their approach to further research activity.

Skills:

Graduates have the skills to:

- assimilate complex mathematical ideas and arguments;
- identify, formulate, analyse and suggest independently possible solutions to problems in the field of mathematical sciences;
- conduct research in the field of mathematical sciences under supervision of a scientific staff member and report on it in a manner that meets the customary standards of the discipline (including correct referencing, appropriate layout and style);
- 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.

Assessment Methods

The level of attainment of these skills is assessed through coursework, examinations, essays, presentations during seminars, and review and defense of the research project (Master thesis).

Contents

Mandatory courses	0 ects
Optional courses	73 ects
Research part	<u>47 ects</u>
	120 ects

Optional courses

This master's programma participates in the Dutch Masters Programme in Mathematics (Mastermath). Therefore every student has to follow 4 courses out of this Programme. Students should choose their courses in consultation and agreement with their tutor.

Local Courses:

Courses which are part of neither national Mastermath Programme nor MRI Masterclasses and are given in Utrecht and listed in the Study Guide (Studiegids).

Other courses:

Courses that are part of the national Mastermath Programme and courses that are part of the MRI Masterclasses.

Research part:

The most of the second year is devoted to doing a supervised research project. Areas of mathematics that are represented within the Programme Mathematical Sciences are: Applied Mathematics: Applied Analysis, Bifurcation Theory, Dynamical Systems, Econometrics, Financial Mathematics, Mathematical Biology, and Numerical Analysis. Fundamental Mathematics: Algebra, Analysis, Geometry, Stochastics, Logic and Foundations of Mathematics, and History of Mathematics.

It is expected that each programme's participant writes a Master Thesis where results of the research project are reported. The thesis should satisfy the usual standards of survey or original publications.

During the work on the Master Thesis the student is supervised by at least one staff member of the Mathematical Institute. This main supervisor invites a second reader of the thesis. Before a final grade can be given, the student must publicly defend his or her thesis in a 45 minute presentation. The main supervisor gives a final grade for the Master thesis, after consulting with the second reader.

After completion, the student should send a .pdf file of the thesis to the library.

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 [13 for mathematical sciences] credits of the thesis project exceeding the research part of the programme may be counted towards "the optional courses" credit load.

External or incidental Courses

The courses that are part of the national Mastermath programme, listed on <http://www.mastermath.nl/courses/>, are the essential part of the master programme Mathematical Sciences. Examination takes place according to general rules of Mastermath to be found at http://www.mastermath.nl/courses/Regels_en_richtlijnen_final.pdf

Mastermath courses 2010-2011

Introduction to Stochastic Processes
Continuous Optimization
Systems and Control
Discrete Optimization
Heuristic Methods in Operations Research
Functional Analysis
Introduction to Numerical Bifurcation Analysis of ODE's and Maps
Conservative Dynamical Systems
Algebraic Number Theory
Representation Theory
Algebraic Topology
Symplectic Geometry
Measure-theoretic Probability
Asymptotic Statistics
Parallel Algorithms
Numerical Linear Algebra
Number Theory and Cryptology
Stochastic Differential Equations
Advanced Modelling in Science
Applied Statistics
Applied Finite Elements
Nonlinear Systems Theory
Advanced Linear Programming
Scheduling
Queueing Theory
Complexity Theory
Diophantine Equations
Asymptotic Methods for differential equations
Partial Differential Equations
Semisimple Lie Algebras
Algebraic Geometry
Proof Theory
Set Theory
Stochastic Processes
Numerical Methods for Time-dependent PDEs
Empirical Processes and Statistical Learning
Geometry

The courses that are given as part of the MRI Master class (<http://mri.math.uu.nl/>):

MRI Masterclass courses 2010-2011: Moduli spaces

Riemann surfaces
Jacobians and theta-functions
Introduction to conformal field theory
Introduction to stacks
The moduli space of abelian varieties
The moduli space of curves: geometric aspects
The moduli space of curves: combinatorial aspects
Research Seminar

Local courses 2010-2011

Seminar Models in Epidemiology
Seminar History of Mathematics

Meteorology, Physical Oceanography and Climate (MPOC)

Admission's 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 Climate and 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. The admittance committee of the programme will evaluate these candidates. This holds also for students from the University College Utrecht with a Science major.

Learning outcomes

[see 3.1.2]

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

[see 3.6.1 & 4.2]

Mandatory courses	22.5 ects
Optional courses	37.5 ects
Research part	60 ects
	120 ects

Mandatory courses

- Dynamical Oceanography (NS-MO401M)
- Dynamical Meteorology (NS-MO402M)
- Atmospheric Composition and Chemical Processes (NS-MO405M)

Optional courses

- Turbulence, mixing (NS-MO406M)
- Boundary Layer Meteorology (NS-MO407M)
- Ocean Waves (NS-MO428M)
- Physics of Coastal Systems (NS-MO426M)
- Ice and Climate (NS-MO427M)
- Current Themes in Climate Change (NS-MO434M)
- 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.
- Any MSc course offered by the Graduate School of Natural Sciences

Research part

The research part of the Masters program 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 Masters thesis which is graded by the supervisor, together with another independent staff member

Research Part:	60 ECTS
Research Seminar: -Simulation of Ocean, Atmosphere and Climate (NS-MO501M) -Making, analyzing and Interpreting Observations (NS-MO502M)	15 ECTS
Thesis	45 ECTS

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
- Physical Geography and Oceanography of the Coastal Zone

Nanomaterials: Chemistry & Physics

Admission to the degree in Physics and Climate Science or the degree in Chemical Sciences

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

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

[See 2.1.a.]

a) within the degree of 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 degrees:

- A BSc degree with a major in physics, chemistry or materials science
- A major in science and a strong component in physics and/or chemistry.

b) within the degree of 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 BSc degree with a major in physics,
- A major in Science with strong component in physics

The admission committee decides for Utrecht University Bachelor students who do not fulfill the above mentioned requirements and based on their file, if admission under certain conditions can be permitted.

[See 2.1.b.]

Applicants holding a BSc degree in Physics and Astronomy from Utrecht University or a BSc degree in Chemical Sciences 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

[see 2.3]

a) 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 at a level corresponding to second to third year Utrecht chemistry bachelor courses: 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 2.1.a. 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 2.1.a. normally satisfy these conditions

Learning outcomes

[see 3.1.2]

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

[see 3.6.1 & 4.2]

Mandatory courses	30 ects
Optional courses	30 ects
Research part	<u>60 ects</u>
	120 ects

Mandatory courses

4 courses to be chosen from the list below are required, including the mandatory 'Topics in Nanoscience (SK-MTOPICS)'.

The remaining mandatory courses, corresponding to 22,5 ECTS, differentiate between Chemical Sciences and Physics & Climate Science degree. **Chemical Sciences** students must take 3 courses irrespective their signature, while **Physics and Climate Science** take 3 courses with a Physical Sciences (P) or a combined C/P signature. All courses have a study load of 7,5 ECTS.

Topics in nanoscience (SK-MTOPIC)	
Chemical science courses	Physical science courses
Kinetics & Diffusion (SK-MKIDI) (C/P)	Device Physics (NS-CP426M)(P)
Advanced Organic Synthesis (SK-MOSS)	Nanophotonics (NS-CP428M)(P)
Advanced Spectroscopy of Nanomaterials (SK-MASPN)	Photon Physics (NS-CP427M)(P)
Solids & Surfaces (SK-MSOLS)	Soft Condensed Matter (NS-CP429M) (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-CP434M)(P)
Adsorption, Kinetics and Catalysis (SK-MAKC)	Soft Condensed Matter Theory (NS-TP453M)(P)
Advanced Quantum Chemistry (SK-MQUA) (C/P)	
Organometallic Chemistry and homogeneous Catalysis (SK-MOCHC)(C)	

Optional Courses

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 others with permission from the programme directors and a 15 to 30 ECTS internship outside Utrecht University. Internships can only start as soon as the mandatory course of the above mentioned table and the research project of 60 ECTS have been finished.

Optional courses can also be those required to fulfill the admission requirements in the case of deficiencies. The programme director decides which courses need to be followed.

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.

Research Part:	60 ECTS
Research project and thesis	60 ECTS

Students do their thesis research in one of the research groups of the Debye Institute of Nanomaterials Sciences or in other institutes associated with this programme.

Particle Physics

Admission's Criteria

Admission to the degree Physics and Climate Science

[See 2.1.a]

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

[See 2.1.b]

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

[see 2.3]

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 two* of the following courses must have been completed

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

[see 3.6.1 & 4.2]

Mandatory courses	18 ECTS
Optional courses	37-47 ECTS
Research part	65-55 ECTS
	120 ECTS

Mandatory courses

1. NS-PP 401M Particle Physics
2. NS-PP 402M Strong Interactions

Optional courses

A choice of ≥ 24 ECTS from:

- courses from the NIKHEF Particle & Astroparticle Physics programme e.g.
 - Astroparticle Physics
 - Particle Detection
 - NIKHEF project
 - caput lectures in Particle Physics
- CERN Summer Student programme
- NS-TP401M Quantum Field Theory
- C++ course
- NS-EP438M Modeling & Simulation

For the remaining ects:

-Any MSc course offered by the Graduate School of Natural Sciences

Courses to compensate deficiencies:

- NS-356B Quantum mechanics 2,
- NS-355B Thermal physics 2
- Classical Field theory

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. Contact person is Prof.dr Thomas Peitzmann.

External or incidental Courses

[see 4.1]

The courses from the NIKHEF Particle & Astroparticle Physics programme (see optional courses above).

Science and Business Management

Admission's Criteria

Admission to the degree in Science and Business

[See 2.1.a]

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

[see 2.3]

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

[see 3.6.1 & 4.2]

Mandatory courses	39 ects
Optional courses	18 ects
Research/internship	63 ects
	120 ects

Mandatory courses

Courses

	ECTS
• Introduction, return meetings and essay	4
• Course Fundamentals of Business and Economics	15
• Finance and management accounting	7.5
• Idea and start	7.5
• Theoretical science course(s)*	5

**This course may be chosen from the Utrecht university Master's degree science programmes*

Optional courses

- 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 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
- Internship 30 ects

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

Science Communication (Wetenschapscommunicatie)

Admission's Criteria

Admission to this programme is no longer possible from September 2009 onwards.

From September the 1st 2010, residing students will automatically be registered under the Master's degree programme Science Education Communication (SEC). Actual "Wetenschapscommunicatie" students are entitled to follow the course and programme descriptions as described in the OER Annex 2009-2010 which is copy-past below and differs from the SEC programme.

Contents

[see 3.6.1 & 4.2]

Mandatory courses	45 ects
Optional courses	15 ects
Research/internship	60 ects
	120 ects

Mandatory courses

Courses	ECTS
• Learning, communicating and research	15
• Domain specific education and communication	7.5
• Product development	7.5
• Theoretical courses at Master or 3 rd year Bachelor level	15

**These courses may be chosen from the Utrecht University Bachelor's or Master's degree science programmes*

Optional courses

- Students should select *science* courses for a total of at least 15 credits. The level of the elective components must be at least 3rd year Bachelor and they can be chosen from university Bachelor's or Master's degree science programmes;
or
- up to 15 ECTS can be used to extend the science research project.

Research/internship

- Science research project 30* ects
- Communication project/internship 30 ects

** (Part of the) optional courses may be used to extend the science research project to a maximum of 45 ects.*

Scientific Computing

Admission's Criteria

Admission to the degree Mathematical Sciences

At the start of the masters studies the student should possess solid knowledge in mathematics or sound basic knowledge in physics.

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

- A BSc with a major in Physics
- A BSc with a major 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

NB 2.1.b

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

Admission to the programme

Students admitted to the mathematical sciences degree qualify for admission to this programme if they possess the following skills and knowledge:
sufficient background in analysis, algebra, numerical methods, programming (in one or more of the following languages: C, C++, Java, Matlab, Fortran) and have experience with the application of mathematical techniques in one or more areas such as: physics, chemistry, economy, earth sciences.

Learning outcomes

The successful candidate will satisfy the following learning outcomes:

Graduates have profound knowledge of and insight into:

- the numerical solution of large-scale problems from scientific computing such as sparse and dense linear systems, eigensystems, and systems of partial differential equations;
- at least one area in the field of scientific computing such that the international research literature can be understood;
- an overview of the application of scientific computing methods in fields such as computational physics or biology.

Graduates have the skills to:

- identify, formulate, analyse and suggest possible solutions to problems independently in the field of scientific computing;
- model mathematically a situation from the real world and to transfer mathematical expertise to non-mathematical contexts
- conduct research in the field of scientific computing and report on it in a manner that meets the customary standards of the discipline under supervision of a scientific staff member;
- communicate conclusions in English both written and orally, as well as the underlying knowledge, grounds and considerations, to an audience composed of specialists or non-specialists;
- work with large-scale computing techniques to model complex problems and solve them numerically, and to write computer programs that are suitable for modern hardware architectures such as parallel computers
- work together in a (possibly interdisciplinary) team of experts with different backgrounds;
- work in the interdisciplinary field of mathematics, physics and its application areas;

- enrol in a PhD programme of scientific computing related topics.

Contents

[see 3.6.1 & 4.2]

Mandatory courses	45 ects
Optional courses	30 ects
Research part	<u>45 ects</u>
	120 ects

Mandatory courses

- Scientific Computing Laboratory WISM 454
- Parallel Algorithms WISM 459
- Numerical Linear Algebra WISM 458
- Numerical Partial Differential Equations WISM 457
- Modelling and Simulation NS-EP438M
- Application course: either Simulation of Ocean, Atmosphere, and Climate (NS-MO501M) or Computational Biology (B-MBIFPR07)

If any of these courses have already been completed as part of a Bachelor's degree, then the programme director will assign a suitable alternative course of equal number of credits and at the same level.

Optional courses

15 ECTS of courses out of the list:

- Computational materials science NS-CP432M
- Geometric Algebras with Applications NS-EP439M
- Topics in Climate Science NS-MO440M
- Wavelets and Fourier transforms WISM 453
- High-Performance computing WISM 455
- Geometric algorithms INFOGA
- Evolutionary algorithms INFOEA
- Algorithms and networks INGOAN
- Software Engineering INFOSWE

15 ECTS:

2 graduate courses in the discipline of the thesis work, i.e. in mathematics, physics, chemistry, economy, earth sciences or any MSc-course of the graduate school of natural sciences, or courses that are part of the national Mastermath programme.

Research part

Research Part:	45 ECTS
Thesis and Seminar	45 ECTS

Research can be done in the following directions:

Internship carrying out a research project in industry or at a research institute in the area of scientific computing, numerical analysis, or computational science.

Carrying out a research project at a university in the area of scientific computing, numerical analysis, or computational science;

The research part includes active participation during one year in the Scientific Computing Research Seminar.

During the work on the Master Thesis the student is supervised by at least one staff member of the Mathematical Institute. This main supervisor invites a second reader of the thesis. Before a final

grade can be given, the student must publicly defend his or her thesis in a 45 minute presentation. The main supervisor gives a final grade for the Master thesis, after consulting with the second reader.

After completion, the student should send a .pdf file and a hardcopy of the thesis to the library.

Science Education and Communication*

Degree Science Communication and Education

And

Degree Teacher Education - Computer Science

*The formerly programmes Science Teacher Education, Science teacher education-informatics and Research and Development in Science Education are replaced by one programme, namely Science Education and Communication. Students in one of these two programmes, will graduate as Science Education and Communication master students. There are no changes into their respective chosen study programme.

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 Communication and Education 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.

Learning outcomes

All graduates of this programme have acquired knowledge, skills and attitudes with regard to a (range of) science subject(s), science education and communication practice, and science education and communication research. In order to qualify for a teacher degree within this programme, students will need 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.universitairelerarenopleiding.nl).

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 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

Contents

Curriculum requirements vary dependent on the following two choices:

- Whether the student takes the full teacher education component, so as to obtain a teacher certificate in one of the school subjects
- Whether the student's research project is in science or in science education

The following table presents the curriculum requirements framed on these two choices:

	ECTS	Research project in Science	Research project in Science Education and Communication	
		Teacher degree		No teacher degree
Courses				
Introduction to science education and communication theories	3.75	M	M	M
Designing science education and communication	3.75	M	M	M
Innovation and dissemination: strategies for change in science education and communication	3.75	E	M	M
Research methods	3.75	E	M	M
Public Science writing with multimedia	3.75	E	E	M
Seminar: Advanced topics in science education and communication	3.75	E	E	M
Elective science courses		22.5	22.5	30
Professional practice component				
Teacher education		52.5	52.5	
Educational/communicative internship				22.5
Research component				
Science research project		30		
Science education & communication research project			30	45
Science education & communication action research (PGO)		7.5		

M: Mandatory; E: Elective

Explanation

Elective science courses

- Science courses at Master or 3rd year Bachelor level from Utrecht University Bachelor's or Master's degree science programmes;
- up to 15 ECTS can be used to extend the research project to a maximum size of 45 ECTS.
- Up to 15 ECTS can be used to take prescribed courses to compensate deficiencies in the student's prior education. The general requirements on course levels do not apply for such prescribed courses.

Teacher education

In order to qualify for a teacher degree a student will take 52.5 ECTS of teacher education. The teacher education component can be in Dutch (regular variant) or, if the student gets admitted, in English (U-Teach). Course components are slightly different for both variants:

Teacher education regular variant		Teacher education U-Teach variant	
Component	ECTS	Component	ECTS
Introduction	3	Initial portfolio	5
Initial portfolio	4	Final portfolio	5
Final portfolio	7	School practice 1	12,5
School practice 1	13	School practice 2	12,5
School practice 2	13	Teaching methodology 1	4
Teaching methodology 1	4	Teaching methodology 2	4,5
Teaching methodology 2	4,5	VIL	1
VIL	1	Literature conference	3
Literature conference	3	Teaching in English	2,5
		Intercultural cross-cultural ed.	2,5

Software Technology

Admissions Criteria

Admission to this programme is no longer possible from September 2010 onwards. Students who enrolled before this date, will obtain a degree in Computer Science under the programme name Computing Science. This programme fully covers the Software Technology curriculum. The underlying learning outcomes and courses of the Software Technology programme will appear on the graduate's Diplome Supplement.

Learning outcomes

The successful candidate will satisfy the following learning outcomes:

Graduates have theoretical and practical knowledge:

- in subjects as:
programming language concepts, design and implementation
programming language concepts, design and implementation
program generation, program analysis and program transformation
large scale software architectures
- which enables them to follow the international research literature in one of the aforementioned areas;

Graduates have the skills to:

- identify, formulate, analyse and suggest possible solutions to problems associated with the aforementioned areas;
- conduct research in one of the mentioned areas 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 in written and oral form, as well as the underlying knowledge, grounds and considerations, to an audience composed of specialists or non-specialists in English;
- recognise and assess new developments in the aforementioned areas;
- implement technical designs in the aforementioned areas in the form of a computer program;
- know how and when to apply acquired knowledge in the construction of software systems.

Graduates display attitudes that enable them to:

- have a 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 the development of software in the broadest sense.

Stochastics & Financial Mathematics

Admission's Criteria

Admission to the degree mathematical sciences

[See 2.1.a]

At the start of their masters' studies, the student should possess solid knowledge in mathematics or sound basic knowledge in physics.

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

NB 2.1.b

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.

Admission to the programme

[see 2.3]

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

- Solid basic knowledge in probability theory and statistics.
- The ability to work with scientific literature.
- The ability to think analytically

Applicants are therefore expected to hold one of the following degrees

- A BSc in Science with a major in mathematics
- A BS in science (physics, econometrics, computer science) with a strong mathematical component

Learning outcomes

The successful candidate will satisfy the following learning outcomes:

Graduates:

- have theoretical and practical knowledge of advanced general subjects such as Probability Theory, Mathematical Statistics, Stochastic Processes, Industrial Statistics, Mathematical Statistical Mechanics, Stochastic Operational Research, Ergodic Theory, Forensic Statistics and Financial Mathematics.
- have in-depth knowledge of at least one area in the field of stochastics 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 Probability, Statistics and Financial Mathematics
- conduct research in the field of stochastics and report on it in a manner that meets the customary standards of the discipline
- model complex processes in natural sciences, engineering and economics
- comprehensive analysis of random phenomena
- 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

- apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession
- have an 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 taking initiatives where necessary;
- enrol in a PhD programme in the field of stochastics and its applications to other fields
- continue in organisations or companies such as Banks, option Companies, Insurance Agencies, Research Laboratories.

Contents

[see 3.6.1 & 4.2]

Mandatory courses	8 ects
Optional courses	76 ects
Research part	<u>36 ects</u>
	120 ects

Mandatory courses

- Measure theoretic probability

Optional courses

38 ECTS of the following list	38 ECTS of the following list
-stochastic processes -stochastic integration -stochastic optimization -asymptotic statistics -stochastic processes for finance -simulation methods in statistics -semiparametric statistics -Bayesian statistics -financial stochastics -control of stochastic systems in continuous time -forensic statistics and graphical models -modern applied statistics with R -information theoretic learning -intermediate financial mathematics	-industrial statistics -time series -stochastic models for telecommunication systems -percolation -combinatorial stochastic processes -ergodic theory -Introduction to spacial probability models -portfolio theory -mathematical statistical mechanics -Any MSc course offered by the Graduate School of Natural Sciences

Research part

Research Part:	36 ECTS
Thesis/internship	36 ECTS

The thesis can be performed in various directions in the fields of probability, statistics, financial mathematics, statistical genetics. The thesis can be based on theoretical research or research performed in the form of an internship in a research institute/laboratories or financial institutions/banks or insurance companies.

Technical Artificial Intelligence

Admission's Criteria

Admission to the degree Computer Science

[See 2.1.a]

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;

[See 2.1.b]

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

[see 2.3]

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).

There is room (15 ects) in the master programme to remedy possible deficiencies in the student's knowledge of logic or Artificial Intelligence.

Learning Outcomes

The Master's programme in Technical Agent Technology has the following exit qualifications:

1. Mastery of agent technology at an advanced academic level. This means mastery of a number of advanced general subjects in the areas of intelligent agents and multi-agent systems, 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 agent technology, such that the international research literature can be understood.
3. Thorough experience with research in (pure or applied) agent technology 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

[see 3.6.1 & 4.2]

Mandatory courses	15 ects
Optional courses	60 ects
Research part	<u>45 ects</u>
	120 ects

Mandatory courses

Intelligent Agents
Multi-Agent Systems

Optional courses

A choice of four courses (in total 30 ECTS) from:

- Games and Agents
- Commonsense Reasoning
- Evolutionary Computing
- Experimentation project TAT
- Multi-Agent Programming
- Philosophy of AI
- Adaptive Agents
- Development of Knowledge Systems

For the remaining 30 ECTS:

- Semantic Web
- Any other course of the list above not yet taken.
- Any MSc course from the Computer Science curriculum designated at <http://www.cs.uu.nl/education/> under AT as "te kiezen in vrije ruimte"

Research part

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

Theoretical Physics

Starting Moments

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

Admission's 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 B.Sc. program, these courses are:

- o Quantum mechanics 2 (NS-356B)
- o Thermal physics 2 (NS-355B)
- o 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 program.

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

[see 3.6.1 & 4.2]

Mandatory courses	30 ects
A Master level course in Mathematics *	7.5 ects
optional courses	37.5 ects
Research part	45 ects
	120 ects

*Some mathematics courses offered in the third year of the bachelor program 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.

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.

Optional courses

22,5 ECTS to choose out of the following list	15 ECTS to choose out of the following list
<ul style="list-style-type: none"> -General Relativity -Cosmology -String Theory -Modelling and Simulation -Field Theory in Condensed Matter -Field theory in Particle Physics -Soft Condensed Matter theory 	<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.

-Field Theory in Particle Physics	
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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.

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 [13 for mathematical sciences] credits of the thesis project exceeding the research part of the programme may be counted towards "the optional courses" 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 masterprogrammes