

# Programme descriptions

Annex to the Education and Examination Regulations 2018-2019  
Graduate School of Natural Sciences

Version 1.0, 12 July 2018

## Contents

Artificial Intelligence .....	3
Chemical Sciences .....	8
Nanomaterials Science .....	8
Debye Honours programme in Nanomaterials Science .....	13
Computer Science .....	16
Computing Science .....	16
Game and Media Technology .....	21
History and Philosophy of Science .....	25
Information Science .....	30
Business Informatics .....	30
Mathematical Sciences .....	36
Honours programme Utrecht Geometry Centre .....	42
Physics .....	44
Climate Physics .....	44
Experimental Physics .....	49
Theoretical Physics .....	54
Honours programme Q-Biology .....	58
Applied Data Science Profile .....	60
Complex Systems Profile .....	63
Educational Profile .....	66

## Artificial Intelligence

### Admission to the degree in Artificial Intelligence

Applicants should possess solid basic knowledge of at least the following two topics:

- logic as used in artificial intelligence, in particular propositional and predicate logic;
- programming languages as used in AI, in particular logic, imperative and/or object-oriented languages, and skills to develop and analyze programmes in these languages.

In addition, applicants should possess solid basic knowledge of at least one of the following four topics

- mathematics as used in artificial intelligence;
- cognitive psychology;
- formal linguistics and natural language processing;
- philosophy of cognitive science.

Finally, applicants should have the ability to communicate facts and findings verbally and in writing, also using information and communication technology and audio-visual means.

Applicants holding one of the following bachelor degrees are assumed to satisfy these requirements:

- A BSc in Artificial Intelligence from a Dutch University which is organized in KION (Kunstmatige Intelligentie Opleidingen Nederland)
- A BSc in Artificial Intelligence or Computer Science from Utrecht University

Degrees in all probability meeting the above requirements are:

- A BSc with a major in Artificial Intelligence
- A BSc with a major in Computer Science
- A BSc with a major in one of the following subjects, with some Computer-Science or AI-related courses:
  - Cognitive Science
  - Linguistics
  - Philosophy
  - Psychology
- A Dutch HBO diploma in Computer Science with a suitable programme

In case the student has not taken one of the above mentioned subjects, it can be taken as part of the MSc programme to remedy this deficiency (at most 7.5 EC, which counts as a secondary elective). The programme coordinator will decide which topics need to be followed. One course of the following Bachelor-level courses can be taken as deficiency course which is specifically mentioned in the student's Admission conditions. Each of the courses below is 7.5 EC, and note that they may be given in the Dutch language:

- Logica voor Informatica (INFOB1LI)
- Wiskunde voor KI (KIV13005)
- Inleiding Logica (KIV13001)
- Logica voor AI (INFOLAI)
- Intelligente Systemen (INFOB3IS)
- Computationale Intelligentie (INFOB3CI)
- Modelleren en programmeren voor KI (KI1V13009)
- Databases (INFODB)

- Datastructuren (INFODS)
- Inleiding Cognitiewetenschap (KI1V13002)
- Experimentele methoden en statistiek (KI3V14002)
- Inleiding Taalkunde (KI1V13004)
- Computatieve Linguïstiek (KI2V13007)
- Logische Complexiteit (KI3V12013)

## Premasters programme

A premaster of at most 30 EC is possible (for Dutch speaking students) and will be tailored by the board of admissions depending on the student's prior knowledge. The premasters programme should be finished (i.e. all courses passed) before entry into the Artificial Intelligence programme is allowed.

## Learning outcomes

The graduate of the master's programme in artificial intelligence:

<b>Knowledge and understanding</b>
<ol style="list-style-type: none"> <li>1) Has mastery of artificial intelligence at an advanced academic level. This means mastery of a number of advanced general subjects in the areas of agents, cognitive processing and reasoning, and in depth-knowledge and ability in at least one advanced subject (such as agent design, multi-agent communication, multi-agent learning, cognition and language, psychology of perception, conceptual semantics, logic and computation, logic and language, or argumentation). Mastery of the necessary logical, computational and experimental tools;</li> <li>2) Has thorough experience with research in (pure or applied) artificial intelligence and complete awareness of the applicability of research in technological developments and organizational contexts;</li> <li>3) Is able to read research articles in artificial intelligence.</li> </ol>
<b>Applying knowledge and understanding</b>
<ol style="list-style-type: none"> <li>4) Is capable of understanding a wide variety of different research problems in artificial intelligence 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;</li> <li>5) Is able to point at solutions for identified problems using the most advanced techniques from artificial intelligence;</li> <li>6) Is capable of creating innovative software and information system designs, taking account of feasibility issues;</li> <li>7) Has mastery of the necessary skills in theoretical analysis, modeling and experimentation.</li> <li>8) Understands the potential dilemmas related to scientific integrity in his/her research field.</li> </ol>
<b>Making judgements</b>
<ol style="list-style-type: none"> <li>9) Is capable of assessing and discussing research results and of taking part in discussions within the research group;</li> <li>10) Is able to evaluate research results in the context of similar research on artificial intelligence. Is capable of assessing the practical feasibility and usefulness of artificially intelligent designs;</li> <li>11) Is capable of reflecting on his/her own activities as a researcher and being aware of social and ethical responsibilities concerning application of research</li> </ol>
<b>Communication</b>
<ol style="list-style-type: none"> <li>12) Is capable of presenting one's own research in both written and spoken English to diverse audiences. Is able to adapt to the background and interest of the audience;</li> <li>13) Is capable of working in a (possibly interdisciplinary) team of experts performing the aforementioned activities and communicating easily in both written and oral English.</li> </ol>
<b>Learning skills</b>
<ol style="list-style-type: none"> <li>14) Is capable of working independently and of taking initiatives where necessary; is capable of identifying areas where expertise is lacking and remedying the situation;</li> </ol>

- 15) Is capable of writing a research proposal and independently carrying out research in an area of technical artificial intelligence;
- 16) Has the qualification to obtain a PhD position in the area of specialization or a key position outside of academia in the area of specialization. This includes but is not limited to working at R&D departments, working in (software) industry, consultancy, and government institutions.
- 17) Has a realistic idea of the career opportunities after graduating, and of the skills that he/she needs to successfully start a career.

## Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: **540** hours for the whole programme excluding the research part, which is **12** hours per week. The number of contact hours for a student in the research part of the programme is specified in individual application forms.

## Contents

Mandatory courses	16	EC
Primary electives	30	EC
Secondary electives	30	EC
Research part	44	EC
<b>Total</b>	<b>120</b>	<b>EC</b>

## Mandatory courses

- Methods in AI Research (INFOMMAIR) (7.5 EC)
- Philosophy of AI (WBMV05003) (7.5 EC)
- Introducing Natural Sciences (INTRO-GSNS) (0.5 EC)
- Dilemmas of the scientist (FI-MHPSDIL) (0.5 EC)

## Primary electives

Four courses from the following nine courses have to be chosen, each 7.5 EC:

- Intelligent Agents (INFOIAG)
- Multi-Agent Systems (INFOMAS)
- Multi-agent Learning (INFOMAL)
- Cognitive Modeling (INFOMCM)
- Experimentation in Psychology and Linguistics (INFOMEPL)
- Advanced Topics in Cognitive Science (INFOMATCS)
- Logic and Language (TLMV13020)
- Common-sense Reasoning and Argumentation (INFOCR)
- Logic and Computation (WBMV13005)

## Secondary electives

- Choice of all primary electives
- Research internship 7.5 EC (INFOMRIAI) or 15 EC (INFOMRIAI1)
- Seminar Social Simulation (INFOMSOCs)
- Free choice of courses from the UU master's programmes Neuroscience and Cognition, Computing Science, Game and Media Technology (as far as their courses are open for students of other master programmes).

- Free choice of courses from the UU master's programme Philosophy indicated in the Philosophy programme as "Programme electives".
- Free choice of courses from the UU master's programme Linguistics indicated in the Linguistics programme as "Compulsory" or "Electives", except "Individual Assignment", "Special Topic" and "Research School Linguistics".
- The following seven courses from the UU master's programme Business Informatics: ICT Advisory (INFOMICTA), Software Product Management (INFOMSPM), Software Architecture (INFOMSWA), Method Engineering (INFOEME), Enterprise Architecture (INFOEAR), Seminar Software ecosystems (INFOMSSE), Business Intelligence (INFOMBIN)
- Choice of other master courses within or outside the UU (subject to approval by the coordinator; see also art. 3.7, lid 2)

## Research part

In the research part the student carries out a research project under the responsibility of a scientific staff member of Utrecht University. Both the research project and the supervisor should be approved by the programme coordinator. The research part is split into the following courses:

- Artificial intelligence MSc thesis Part I (INFOMAI1; 14 EC)
- Artificial intelligence MSc thesis Part II (INFOMAI2; 30 EC)

The research project should be done on a topic related to primary electives. The project is normally performed within the research group of the supervising staff member but can also be done in a research-and-development department of a company or institution. Students who have not yet passed all primary electives or who have more than 15 EC still open can only start with the research part after approval by the programme coordinator.

Part II of the Thesis project can only be started when Part I results in an approval to continue with Part II.

The minimum grade for the course INFOMAI2 a student needs to obtain a *cum laude* degree qualification is 8.5. Please note that additional requirements need to be met to obtain this qualification.

## Labour market perspectives and scientific integrity

Scientific integrity is addressed in the research part.

The student can become familiar with labour market perspectives through a research internship (7.5 or 15 EC), and through the final thesis project when done externally.

## Profiles (Educational/Applied Data Science/Complex Systems)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with an *educational*, *'applied data science'*, or *'complex systems' profile*. The contents and further description of these profiles, including entry requirements to specific courses, are described in a separate appendix. In order to still meet the learning outcomes of the master's programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Mandatory courses	16	EC
Primary electives	30	EC
Secondary electives	0	EC

Research part	44	EC
<b>Total</b>	<b>90</b>	<b>EC</b>

### **Special provisions for students who enrolled in the programme Artificial Intelligence in the year 2015-2016 and earlier**

- 1- The courses „*Introducing Natural Sciences*„ (GSNS-intro), *Dilemmas of the scientist* (FI-MHPSDIL; 0,5 EC) and the thesis split components INFOMAI1 and INFOMAI2 are not mandatory for students that have started their Research part prior to 1 September 2018 and were already exempted from the split.
- 2- The following substitute courses may be used:
  - Cognitive Modeling (INFOMCM) may be replaced by Cognitive Systems (201300049)
  - Experimentation in Psychology and Linguistics (INFOMEPL) may be replaced by Linguistics Modeling and Experimental Research (TLMV13021)
  - Advanced Topics in Cognitive Science (INFOMATCS) may be replaced by Advanced Topics in Cognitive Science (201300050)

### **Special provision for students who enrolled before September 2018 and have already passed Methods in Artificial Intelligence Research (INFOMMAIR) for 15 EC**

These students can count INFOMMAIR as the mandatory INFOMMAIR course of 7.5 EC plus a primary elective of 7.5 EC.

## Chemical Sciences

### Nanomaterials Science

#### Admission to the degree in Chemical Sciences

Applicants should possess

- a sound basic knowledge and practical skills in physical, inorganic and/or organic chemistry; in particular skills and knowledge of at least three out of the following subjects is needed: Physical Chemistry (classical and statistical thermodynamics), Inorganic and Solid State Chemistry, Spectroscopy and structural analysis, Advanced organic chemistry combined with practical skills and Quantum Chemistry or Applied Density Functional Theory.
- the ability to work independently as well as in groups on solving chemical problems, present the results of solving problems and to read (English) chemistry literature at the level of graduate textbooks;
- the ability of writing a research report in English, such as a bachelor thesis, is a prerequisite. The report and the work must be assessed with good grades. In case of doubt a personal interview may be part of the admission procedure.

Degrees in all probability meeting these requirements are:

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

Students that do not fully comply to the above enumerated skills and with a deficiency not exceeding more than 15 EC can be conditionally admitted by taking one or two courses out of the following list as secondary elective during the course of their study:

Fysische chemie 2 (7.5 EC; SK-BFYCH)

Anorganische en Vaste Stof Chemie (Inorganic Chemistry and Solid State Chemistry) (7.5 EC; SK-BANVA13)

Advanced Organic Chemistry (7.5 EC, SK-BORC3)

Toegepaste Density Functional Theory (Applied Density Functional Theory) (7.5 EC; SK-BTDFT)

Advanced Super Structures Scattering and Microscopy (7.5 EC; SK-BASSM)

#### Premaster's programme

A premaster of at most 30 EC is possible and will be tailored by the board of admissions depending on the student's prior knowledge. The premasters programme should be finished (i.e. all courses passed) before entry into the nanomaterials science programme is allowed. Typically, students from a dutch applied science university (so called HBO institutions) follow this programme. Theoretical skills that will be trained in this programme are mathematics, physical and inorganic chemistry, quantum chemistry and spectroscopic analysis techniques. It is strongly advised to follow this programme as a minor within the third or fourth year of the HBO-degree programme. These courses could be combined i.e. with the HBO "afstudeerstage" in one of the Debye research groups.

The premaster's student will follow courses together with bachelor students of the chemistry programme. Bachelor courses at the level of a first and second year bachelor's programme are taught in Dutch at Utrecht. Students could also opt to remedy their deficiencies at another university of which the content and level of the courses will be examined by the board of examiners of the Graduate School of Natural Sciences. A premasters programme can also be followed by students with an academic background with deficiencies of more than 15 EC. A specific programme will be tailored to their needs.

#### Learning outcomes



## The graduate of the master's programme

<b>Knowledge and understanding</b>
<ol style="list-style-type: none"> <li>1. Has knowledge of and insight into nanomaterials with an emphasis on colloids, catalysts, and condensed matter;</li> <li>2. Is able with this knowledge to contribute to scientific research in these areas using appropriate methods and instrumentation;</li> <li>3. Is aware of recent developments in the research of colloids, catalysis and/or condensed matter and understands the relevance of these developments for the chosen field of specialisation and society.</li> <li>4. Has the skills to understand the professional literature in the area of colloids, catalysis, and condensed matter and to relate this to his/her own research.</li> <li>5. Has insight in the potential dilemmas related to scientific integrity in his/her research field</li> </ol>
<b>Applying knowledge and understanding</b>
<ol style="list-style-type: none"> <li>1. Is able to formulate an original research question for the synthesis of nanomaterials, or for obtaining new knowledge of the chemical or physical properties of such materials;</li> <li>2. Is able to design a research plan that addresses this research question and that conforms to the methodological and scientific standards of the discipline;</li> <li>3. Is able to carry out this research plan according to the rules of good experimental practice and ethics.</li> <li>4. Is able to analyze and interpret the acquired materials and/or data according to scientific standards.</li> </ol>
<b>Making judgments</b>
<ol style="list-style-type: none"> <li>1. Is able to discuss and relate the obtained results with the actual state of the chosen research specialisation and literature;</li> <li>2. Is able to reflect critically upon his/her own contribution to nanomaterials research, and that of others;</li> </ol>
<b>Communication</b>
<ol style="list-style-type: none"> <li>1. Has the skills to discuss, both in spoken and written English, the obtained results of own research, including the underlying knowledge and background for a group of specialists and non-specialists in an international context;</li> <li>2. Is able to function effectively in a possibly multidisciplinary team of experts working in the area of chemistry and/or physics of nanomaterials.</li> <li>3. Is able to participate critically and constructively in the scientific debate in the research group;</li> </ol>
<b>Learning skills</b>
<ol style="list-style-type: none"> <li>1. Has the skills to evaluate his/her own learning and development process and to adjust this process if necessary;</li> <li>2. Displays a professional and academic work attitude that enables him/her to work independently in a highly competitive labour market;</li> <li>3. Has a realistic idea of the career opportunities after graduating, and of the skills that he/she needs to successfully start a career</li> <li>4. Has the qualifications to enroll in a PhD programme or to acquire a (research) position in a (semi) public or commercial organization.</li> </ol>

**Contact hours**

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is **320** hours, or **16** hours per week, for the whole programme excluding the research part (52.5 EC) and the internship (30 EC). In the case that a student opts for 60 EC course work, the scheduled hours amount to **640** hours or 16h/w (excluding the research project of 52.5 EC).

**Contents**

Mandatory courses	15	EC
Primary electives	22.5	EC
Secondary electives	30	EC
Research part	52.5	EC
<b>Total</b>	<b>120</b>	<b>EC</b>

### Mandatory courses

Academic Context Course (SK-MACCO): 6.5 EC  
 Introducing natural sciences (GSNS-INTRO): 0.5 EC  
 Dilemmas of the scientist (FI-MHPSDIL): 0.5 EC  
 Advanced Spectroscopy (SK-MXXX): 7.5 EC

### Primary electives

There are four chemistry research groups participating in the Debye Institute for Nanomaterials Science. Each group requires one basic course to be taken by their students.

Research group	Course (7.5 EC)
Condensed Matter and Interfaces	-
Inorganic Chemistry and Catalysis	Adsorption, Kinetics and Catalysis (SK-MAKC)
Organic Chemistry and Catalysis	Organometallic Chemistry and Homogeneous Catalysis (SK-MOCHC)
Physical and Colloid Chemistry	Colloid Science (SK-MCS)

Before choosing the remaining courses, students should first check the course requirements of the research groups which are stated in the course guide of this programme.

Advanced Microscopy of Nanomaterials (SK-MAMN)<sup>1</sup>  
 Colloid Science (SK-MCS)  
 Computational Quantum Mechanics (NS-NM431M)<sup>2</sup>  
 Experimental Quantum Physics (NS-EX401M)  
 Organometallic Chemistry and Homogeneous Catalysis (SK-MOCHC)  
 Organic Synthesis Strategies (SK-MOSS)  
 Photon Physics (NS-EX418M)  
 Modelling and Simulation (NS-TP432M)  
 Soft Condensed Matter Theory (NS-TP453M)  
 Photovoltaic Solar Energy Physics (GEO4-2513)  
 Solids & Surfaces (SK-MSOLS)  
 Synthesis of Catalytic Nanomaterials (SK-MSYNA)  
 Toy Models (SK-MTOYM)  
 Physics of light (and Electron microscopy) (4,5 EC, NS-EX417M)  
 Application of Light (and Electron microscopy) (3 EC, NS-EX419M)

### Secondary electives

For the remaining 30 EC, several options are possible.  
 Option one: any MSc course offered by the Graduate School of Natural Sciences including the remaining primary elective courses, or courses offered by the Graduate School of Life

<sup>1</sup> Tentatively scheduled, could become part of the mandatory course Advanced Spectroscopy

<sup>2</sup> This course is offered every two years and will not be scheduled in 18-19.

Sciences. Other courses can be taken with permission from the Board of Examiners who will take a decision based on the programme directors's advise.

Note that predescribed deficiency courses (at most 15 EC) are deducted from the total credits of the secondary elective credits. When two deficiency courses are predescribed, option three is no longer valid.

The second option is to take a 15 up to 30 EC internship outside Utrecht University. Internships can only start as soon as the mandatory, primary elective courses and the research project of 52.5 EC have been finished.

The third option provided is to follow **one** of the following 3<sup>rd</sup> year bachelor's courses:

- *Advanced Physical Chemistry* (SK-BFYC3) or
- *The Origin of the Natural Sciences* BETA-B2NW.

## Research part

The research part is split into the following courses:

Part 1, *Introduction to the research project* (15 EC, SK-MRES1): Introduction to research and initiating the research project

Part 2, *Research and thesis project* (37.5 EC, SK-MRES2): Finalizing the Research project and writing a thesis on the research topic

Successfully completing Part 1 *Introduction to the research project* is a mandatory prerequisite to continue with Part 2. Both parts are supervised by the same staff members.

The entire research project of 52.5 EC will be performed at one of the research groups of the Debye Institute including those belonging to the physics department (i.e. Soft Condensed Matter and Biophysics group) or, with the permission of the programme director, in a closely related research lab, provided that a staff member of the Debye Institute is willing to act as the primary responsible supervisor and first examiner. The student may start with his/her research project before the completion of the mandatory courses and the primary elective courses with the permission of the programme director. Research group specific requirements including the choice of certain primary elective courses, or other activities, are noted on the Research Project Application Form before the start of the project.

The minimum grade for the course Sk-MRES2 a student needs to obtain a *cum laude* degree qualification is 8.5. Please note that additional requirements need to be met to obtain this qualification.

## Labour market perspectives and scientific integrity

The **Introducing Natural Science** course initiates master's students in both topics. The master's programme elaborates further on these subjects in:

1. The mandatory **Academic Context Course**;
2. The **Internship** of 30 EC;
3. The course **Teaching in the Academia** of 1 EC (on top of the regular 120 EC programme);

Scientific Integrity will be tested in two courses: in the **Dilemmas of the scientist** (FI-MHPSDIL; 0.5 EC) and in a specific module (1.5 EC) as part of the **Academic Context Course**. Scientific Integrity will further be practiced during the research project.

### Profile (Educational/Complex Systems/Applied Data Science)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with a **educational**, **complex systems**, or **applied data science** profile. The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix. In order to still meet the learning outcomes of the master's programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Mandatory courses	15 EC
Primary electives	22.5 EC
Secondary electives	0 EC
Research part	52.5 EC
<b>Total</b>	<b>90 EC</b>

Courses that are taken in the complex systems profile and who also appear in the list of the primary elective courses within this programme, can only be taken as either a primary elective course or either a complex systems profile course.

### Special provisions for students who entered the programme Nanomaterials Science before September 2018

The mandatory course for the cohorts enrolled 2016 into this programme as of September 2016 and before September 2018 remains the *Adsorption Kinetics and Catalysis* course (SK-MAKC). This provision ends on August 31, 2020.

The courses *Introducing Natural Sciences* (GSNS-INTRO, 0.5 EC), *Dilemmas of the scientist* (FI-MHPSDIL, 0.5 EC), *Academic Context* (SK-MACCO, 6.5 EC) are not mandatory for students enrolled into this programme prior to 1 September 2016 when they have successfully passed the course *Nanomaterials: Catalysis, Colloids, Nanophotonics*. For these students, the research project contains 60 EC in stead of 52.5 EC.

## Debye Honours programme in Nanomaterials Science

### Description

The **DEBYE HONOURS PROGRAMME** is open to students who start the MSc programme in Nanomaterials Science with an excellent track record and who are interested in research at the forefront of nanoscience. The student can bring in his/her own ideas before the research project starts. Extra supervision will be provided to enable the honours student to write a PhD research plan, or to write a research paper based on the MSc research project.

### Admission to the honours programme

The applicant should satisfy the admission criteria for the master's programme Nanomaterials Science. Moreover, the application will be reviewed by a selection-committee, consisting of representatives of the Debye Institute of Nanomaterials Science. The selection committee will base its final decision on previous study results (top 10-20% of the BSc population), master results (grade average of the obtained results is minimally 8) of the first term, motivation and the CV of the applicant. In the case the student meets all these mentioned selection criteria, the conditional admission to this programme will lead to a definite admission at the latest in February following the September start and July for students entering the programme in February.

### Learning outcomes

In addition to the learning outcomes of the Nanomaterials Science the graduate of this honours programme:

- a) Has knowledge in at least two specialisations from the Debye Institute in the field of chemistry and physics
- b) Has learned to write a paper of his/her own results or has learned to write a PhD proposal
- c) Has obtained intercultural skills by perform researching in an outstanding international laboratory abroad.

### Contents

Mandatory courses	15 EC
Primary electives	22.5 EC
Secondary electives	37.5 EC
Research part	60 EC
<b>Total</b>	<b>135 EC</b>

### Mandatory courses

Academic Context Course (SK-MACCO): 6.5 EC

Introducing natural sciences (GSNS-INTRO): 0.5 EC

Dilemmas of the scientist (FI-MHPSDIL): 0.5 EC

Advanced Spectroscopy (SK-MSPEC): 7.5 EC

### Primary electives

Honours students take three courses (each 7.5 credits) from the Debye list of courses which is given in the programme description of the Nanomaterials Science programme. The marks for these courses should reflect that the honours students indeed belong to the top 10-20% of their year. Furthermore, for honours students at least two courses with the label C/P or P are needed. These label prerequisites can also be obtained by choosing secondary courses.

### Secondary electives

Honours students are expected to take another course of 7.5 EC in addition to the primary courses. This course is meant to fulfill the label requirements or can be chosen from other master's programmes from Utrecht University or another university following the same criteria mentioned as for the internship. Permission could be granted to the honours student when particular courses are needed that are not provided by the predefined course list. The programme director will evaluate the student's written motivation.

Honours students are also expected to perform an internship of 30 EC in highly ranked research groups abroad within a company or research institute/university. Examples are ETH/Zürich, Oxford, Cambridge, Lund, Stanford, Berkeley, Johnson UK, etc.

The internship can only be started after the course work and the research project of 52.5 EC have been finished. The internship can also be used with the intention to start a PhD project in the Netherlands or abroad. The internship topic cannot coincide with the research project.

### Research part

The research part of 60 EC is split into the following courses:

Part 1:	15 EC; SK-MRES1	Introduction to research and initiating the research project
Part 2:	45 EC; SK-MHRES2	Research project and thesis including the research paper or PhD proposal

Successfully completing Part 1 (SK-MRES1) is a mandatory prerequisite to continue with Part 2 (SK-MHRES2). Both parts are content wise dealing with the same subject, and supervised by the same persons.

The research is done at one of the research groups of the Debye Institute including those belonging to the physics department (i.e. Soft Condensed Matter and Biophysics group) or, with the permission of the programme director, in a closely related research lab, provided that a staff member of the Debye Institute is willing to act as the primary

responsible supervisor and as first examiner. The student may start with his/her research project before the completion of the mandatory course and the primary elective courses with the permission of the programme director. Research group specific requirements including the choice of primary elective courses, or other activities, are noted on the Research Project Application Form before the start of the project.

52.5 EC of the research will be devoted to a research project including the master's thesis, as in the regular programme. However to obtain the honours degree the student will additionally be involved in one of the two following options:

- 7.5 EC will be spent on writing a PhD proposal of a topic to be freely chosen by the honours student. Supervision and coaching will be provided by two senior staff members who should be from different groups. Interdisciplinarity can also be established in a joint proposal with a supervisor from another Dutch university or research group, however the main supervisor should be located at Utrecht University. This proposal is eligible to compete in the Debye Graduate Program.
- Alternatively 7.5 EC can be spent on writing a research paper as a first author for an international peer-reviewed journal using the results of the master research project or the internship project that should be ready up to the level of submission. Supervision and coaching will be provided to guide the student through this process.

Active participation in a conference/symposium will be encouraged if conference dates correspond to the period in which the research project is performed and the results are ready to be presented.

### **Profile**

Within this honours programme there is no room for a profile.

### **Special provisions for students entering the programme before September 2018**

The course Adsorption Kinetics and Catalysis remains mandatory. This provision will end by August 2020.

## Computer Science

### Computing Science

#### Admission to the degree in Computer Science

Applicants should possess

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

Degrees in all probability meeting these requirements are:

- a BSc in Computer Science or Artificial Intelligence,
- 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.

#### 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;
- be able to communicate facts and findings verbally and in writing, including using information and communication technology and audio-visual means.

BSc degrees in Informatics (Computer Science) at many regular universities in the Netherlands and abroad are nowadays equivalent to the extent that is needed for entry in this 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 (data structures, 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 BSc degree in Computer Science
- a HBO-bachelor in the 'HBO-opleiding Informatica',
- a HBO-bachelor in Informatics/Information Technology other than the 'HBO-opleiding Informatica',

in all cases depending on the particular programme followed.



## Premasters programme

A premaster of at most 30 EC is possible and will be tailored by the board of admissions depending on the student's prior knowledge. The premasters programme should be finished (i.e. all courses passed) before entry into this Computing Science programme is allowed.

With HBO's whose bachelor programme(s) in informatics do not meet the entrance requirements fully as a rule, a premaster's package can be agreed, which students can embed in their individual HBO study programme if they wish to qualify for entrance beforehand.

## Learning outcomes

The graduate of the master's programme in Computing Science:

<b>Knowledge and understanding</b>
a) Can use his or her knowledge of computer science to make a substantial contribution to the development and/or application of scientific concepts and methods, often in a research context.
b) Is capable of understanding important recent developments in computer science, and of indicating their implications for society and the research field.
c) Is capable of interpreting and using specialized literature in the field of computing science.
d) Has insight into integrity related issues in computer science.
<b>Applying knowledge and understanding</b>
a) Is capable of translating a problem from the area of computer science or an application into a research question that is relevant to and suited for scientific development, product development or education.
b) Is capable of translating this research question into an appropriate research plan in accordance with the required scientific and methodological standards.
c) Is capable of independently performing this research with the required care and ethical responsibility and to process, interpret and evaluate the empirical data and other outcomes thus obtained in the appropriate manner.
<b>Making judgments</b>
a) Is capable of discussing the outcomes of empirical and theoretical research and to relate them to the current scientific state-of-the-art and literature.
b) Is capable of indicating the relevance of this research to the solution of problems in the area of computer science, also from the viewpoint of society wherever possible.
c) Has the capability to reflect critically on his or her own efforts as a researcher in the area of computer science from the viewpoint of society.
<b>Communication skills</b>
a) Is capable of clearly communicating the results of research, in writing as well as orally, to an audience of specialists and laymen, in an international context.
b) Is capable of functioning effectively in a research team of possibly multi-disciplinary composition.
<b>Learning skills</b>
a) Has the capability to evaluate his or her own learning- and development process during the study, and if necessary to motivate and adjust his- or herself.
b) Has acquired an effective and result driven way of working that allows him or her to function independently in a competitive labor market.
c) Has the qualification to obtain a PhD position as well as a job in business and industry.

- d) Has insight into employment opportunities and on the skills needed to make a successful start in the job market.

## Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is **400** hours, or **8** hours per week, for the whole programme excluding the research part.

## Contents

Mandatory courses	23.5	EC
Primary electives	22.5	EC
Secondary electives	30	EC
Research part	44	EC
<b>Total</b>	<b>120</b>	<b>EC</b>

## Study paths

Students follow "study paths". A study path is a coherent set of courses tailored towards a general topic within the master's programme. The following study paths (listed below) are pre-defined and set the standard for the programme. Alternatively, an individual study path can be composed, under approval of the programme director.

- **Programming technology**
- **Algorithm design and analysis**
- **Advanced planning and decision making**
- **Algorithmic data analysis**

The courses that belong to each of the above study paths are listed in the "Primary electives" section below.

## Mandatory courses

*Algorithms for decision support* (INFOMADS) (7.5 EC)

*Concepts of program design* (INFOMCPD) (7.5 EC)

*Big data* (INFOMBD) (7.5 EC)

*Introducing Natural Sciences* (GSNS-intro) (0.5 EC)

*Dilemmas of the scientist* (FI-MHPSDIL) (0.5 EC).

## Primary electives

The primary electives consist of at least three courses from the choice of four core courses defined by the study path chosen by the student. For each of these study paths, their corresponding courses (all are 7.5 EC) are listed below.

- **Programming technology**, courses:
  - Advanced functional programming* (INFOAFP)
  - Compiler construction* (INFOMCCO)
  - Program semantics and verification* (INFOMPSM)
  - Technologies for learning.* (INFOMTFL)
- **Algorithm design and analysis**, courses:
  - Geometric algorithms* (INFOGA)
  - Algorithms and networks* (INFOAN)

*Scheduling and time-tabling* (INFOSTT)  
*Crowd Simulation* (INFOMCRWS)  
*Network science* (INFOMNWSC)

- **Advanced planning and decision making**, courses:  
*Probabilistic reasoning* (INFOPROB)  
*Algorithms and networks* (INFOAN)  
*Evolutionary computing* (INFOEA)  
*Scheduling and time-tabling* (INFOSTT)
- **Algorithmic data analysis**, courses:  
*Data mining* (INFOMDM)  
*Multimedia retrieval* (INFOMR)  
*Pattern recognition* (INFOMPR)  
*Pattern set mining* (INFOMPSM)

## Secondary electives

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

- Any course from the above "Primary Electives" list.
- An experimentation project of either 7.5 or 15 EC.
- A literature study under supervision of a CS staff member (*capita selecta*) of 7.5 EC.
- Any MSc course from the Computer Science curriculum
- Any MSc course offered by Universiteit Utrecht: a student may take up to 15 EC worth of **relevant** courses outside of the regular Computer Science curriculum upon approval in advance of the programme director. Of these, 7.5 EC worth of course can be chosen outside the Faculty of Science.
- Up to two courses (15 EC) of the following Bachelor-level courses can be taken as deficiency courses which are specifically mentioned in the student Admission's conditions. Each of the courses below is 7.5 EC, and note that they are only given in the Dutch language:

<i>Logica voor informatica</i>	(INFOB1LI)
<i>Databases</i>	(INFODB)
<i>Datastructuren</i>	(INFODS)
<i>Functioneel programmeren</i>	(INFOFP)
<i>Modelleren en systeemontwikkeling</i>	(INFOMSO)
<i>Onderzoeksmethoden voor informatica</i>	(INFOB3OMI)
<i>Onderzoeksmethoden voor gametech</i>	(INFOB3OMG)
<i>Optimalisering en complexiteit</i>	(INFOOPT)
<i>Talen en compilers</i>	(INFOB3TC)
<i>Algoritmie</i>	(INFOAL)
<i>Software testing en verificatie</i>	(INFOB3STV)
<i>Data-analyse en retrieval</i>	(INFOB3DAR)

## Research part

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 Primary Elective courses.

The overall research part is split into the following parts:

- Thesis project Part I (15 EC)
- Thesis project Part II (25 EC)
- The Computing Science colloquium (4 EC)

Part I of a thesis project can only be started when the student has completed the mandatory, primary and secondary electives with a total of at least 67.5 EC. Part II of the thesis project can only be started when Part I results in an approval to continue with Part II.

To obtain a *cum laude* degree qualification, the minimum grade for the Part II of a thesis project is 8.5. Please note that additional requirements need to be met to obtain this qualification.

### Labour market perspectives and scientific integrity

Scientific integrity is a part of the Computing Science colloquium and consists of two sessions: one at the start of the programme and one during the programme. A wide variety of activities related to labour market perspectives are offered by Career Services to the Computing Science students.

### Profile (Complex Systems/Education/Applied Data Science)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme's Secondary Elective space with a Complex Systems, Education, or Applied Data Science "**profile**". The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix. In order to still meet the learning outcomes of the master's programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Mandatory courses	23.5 EC
Primary electives	22.5 EC
Secondary electives	0 EC
Research part	44 EC
<b>Total</b>	<b>90 EC</b>

### Special provisions for students 2015-2016 and earlier

The courses Introducing Natural Sciences (GSNS-INTRO, 0,5 EC) and Dilemmas of the scientist (FI-MHPSDIL, 0,5 EC) are not mandatory for students enrolled into this programme prior to 1 September 2016. Instead, the colloquium will be 5 EC (INFOMCCS).

## Game and Media Technology

### Admission to the degree in computer science

Applicants should possess

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

Degrees in all probability meeting these requirements are:

- A BSc in Computer Science or Artificial Intelligence
- 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;

### Admission to the programme

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

- the ability to make a computer programme of reasonable complexity and size, in an object-oriented programming language such as Java, C++ 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 mathematics, notably calculus, logic, linear algebra, probability and statistics
- 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. In this case, an average grade of at least 7/10 for the core courses is required next to the already mentioned skills and knowledge.

### Premasters programme

A premaster of at most 30 EC is possible and will be tailored by the board of admissions depending on the student's prior knowledge. The premasters programme should be finished (i.e. all courses passed) before entry into the **Game and Media Technology** programme is allowed.

### Learning outcomes

The graduate of the master's programme in Game and Media Technology:

<b>Knowledge and understanding</b>	
a)	Can use his or her knowledge of computer science and its applications in the field of game and media technology to make a substantial contribution to the development and/or application of scientific concepts and methods, often in a research context.
b)	Is capable of understanding important recent developments in computer science and its applications in the field of game and media technology, and of indicating their implications for society and the research field.
c)	Is capable of interpreting and using specialized literature in the field of game and media technology.
d)	Has insight in the integrity dilemmas that play a role in the field of game and media technology.
<b>Applying knowledge and understanding</b>	
a)	Is capable of translating a problem from the area of computer science and its applications in the field of game and media technology or an application into a research question that is relevant to and suited for scientific development, product development or education.
b)	Is capable of translating this research question into an appropriate research plan in accordance with the required scientific and methodological standards.
c)	Is capable of independently performing this research with the required care and ethical responsibility and to process, interpret and evaluate the empirical data and other outcomes thus obtained in the appropriate manner.
<b>Making judgments</b>	
a)	Is capable of discussing the outcomes of empirical and theoretical research and to relate them to the current scientific state-of-the-art and literature.
b)	Is capable of indicating the relevance of this research to the solution of problems in the area of computer science and its applications in the field of game and media technology, also from the viewpoint of society wherever possible.
c)	Has the capability to reflect critically on his or her own efforts as a researcher in the area of computer science, and its applications in the field of game and media technology from the viewpoint of society.
<b>Communication skills</b>	
a)	Is capable of clearly communicating the results of research, in writing as well as orally, to an audience of specialists and laymen, in an international context.
b)	Is capable of functioning effectively in a research team of possibly multi-disciplinary composition.
<b>Learning skills</b>	
a)	Has the capability to evaluate his or her own learning- and development process during the study, and if necessary to motivate and adjust him- or herself.
b)	Has acquired an effective and result driven way of working that allows him or her to function independently in a competitive labor market.
c)	Has the qualification to obtain a PhD position as well as a job in business and industry.
d)	Has a good overview of the opportunities and necessary skills to make a successful transition to the labour market.

## Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: **400** hours for the whole programme excluding the research part. The number of contact hours for a student in the research part of the programme is specified in individual application forms.

## Contents

Mandatory courses	16	EC
Primary electives	45	EC

Secondary electives	15 EC
Research part	44 EC
<b>Total</b>	<b>120 EC</b>

## Mandatory courses

INFOMCV	Computer vision (7.5 EC),
INFOMCIP	Scientific Perspectives (7.5 EC),
GSNS-intro	Introducing Natural Sciences (0.5 EC),
FI-MHPSDIL	Dilemmas of the scientist (0.5 EC)

## Primary electives

Select out of the following list of courses, amounting to a total of 45 EC:

INFOGA	geometric algorithms (7.5 EC),
INFOMADVG	advanced graphics (7.5 EC),
INFOMCANIM	computer animation (7.5 EC),
INFOMGMAG	games and agents (7.5 EC),
INFOMGP	game physics (7.5 EC),
INFOMMMI	multimodal interaction (7.5 EC),
INFOMMOB	mobile interaction (7.5 EC),
INFOMOMA	motion and manipulation (7.5 EC),
INFOMOV	optimization and vectorization (7.5 EC),
INFOMCRWS	crowd simulation (7.5 EC),
INFOMR	multimedia retrieval (7.5 EC),
INFOMSMT	sound and music technology (7.5 EC),
INFOMPR	pattern recognition (7.5 EC),
INFOMSPGMT	small project GMT (15 EC)

## Secondary electives

- Any master's course offered by the UU (including the not chosen primary electives), or master's courses from another university in or outside the Netherlands, subject to approval by the programme coordinator.
- At most one capita selecta (INFOCSM, 7.5 EC) on an approved subject.
- Courses that remove deficiencies, as recommended by the programme coordinator.

Examples of common deficiency courses include:

INFOIBV	beeldverwerking (image processing) (7.5 EC),
INFOB3APGA	applied games (7.5 EC),
INFOB3OMG	onderzoeksmethoden voor gametech (research methods for game tech) (7.5 EC),
INFOAL	algoritmiëk (algorithms) (7.5 EC),
INFOB3IT	interactietechnologie (interaction technology) (7.5 EC),
INFODDM	driedimensionaal modelleren (geometric modelling) (7.5 EC)

## Research part

The research part is split into the following courses:

INFOMGMT1	thesis project part 1 (15 EC)
INFOMGMT2	thesis project part 2 (25 EC)
INFOMCGM4	colloquium (4 EC)



The thesis project part 1 can only be started if the student has finished the mandatory courses and has obtained at least 45 EC in total of the electives listed in her/his study plan.

Successfully completing the course INFOMGMT1 is a mandatory prerequisite to continue with the course INFOMGMT2.

The minimum grade for the course INFOMGMT2 a student needs to obtain a *cum laude* degree qualification is 8.5. Please note that additional requirements need to be met to obtain this qualification.

### Labour market perspectives and scientific integrity

Scientific integrity is a part of the colloquium (INFOMCQGM4) and consists of two sessions: one at the start of the programme and one during the programme. A wide variety of activities related to labour market perspectives are offered by Career Services to the GMT students.

### Profiles (Educational, Complex Systems, Applied Data Science)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with a *profile* such as the educational profile, the complex systems profile, or the applied data science profile. The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix. In order to meet the learning outcomes of the master's programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Four courses (7.5 EC each) should be selected out of the primary electives. The small project cannot be selected. The mandatory courses (16 EC) and the research part (44 EC) do not change.

Mandatory courses	16 EC
Primary electives	30 EC
Secondary electives	0 EC
Research part	44 EC
<b>Total</b>	<b>90 EC</b>

### Special provisions for students who enrolled in the programme Game and Media Technology in the year 2015-2016 and earlier

For these students, there are no mandatory courses in the GMT programme. Hence, the courses *Introducing Natural Sciences* (GSNS-intro) and *Dilemmas of the scientist* (FI-MHPSDIL; 0,5 EC) are not mandatory for students enrolled into this programme prior to 1 September 2016. Instead, the colloquium will be 5 credits (INFOMCGMT). The contents of a study programme may partly consist of courses enumerated in previous versions of the programme specific part of the OER, pending approval by the programme coordinator. This provision ends 31 August, 2019.

### Special provisions for students who enrolled in the programme Game and Media Technology in the year 2017-2018 and earlier

For these students, the course *Scientific Perspectives* is not mandatory. However, the course Motion and Manipulation is mandatory.



## History and Philosophy of Science

### Admission to the degree in History and Philosophy of Science

Applicants should possess

- A university Bachelor's degree;
- solid basic knowledge in one academic discipline with demonstrable interest in history and/or philosophy of the sciences and/or the humanities, for instance demonstrated by successfully completed courses in HPS of 10-15 EC and a motivation letter;
- the ability to work independently in writing a thesis as well as in groups during the courses;
- the skills to write essays and a thesis in English on an academic level (as demonstrated by a writing sample).

### Premasters programme

A premaster of at most 30 EC is possible and will be tailored by the board of admissions depending on the student's prior knowledge. The premasters programme should be finished (i.e. all courses passed) before entry into the History and Philosophy of Science programme is allowed.

### Learning outcomes

The graduate of the master's programme in History and Philosophy of Sciences:

<b>Knowledge and understanding</b>	
a)	Has a basic knowledge and understanding of the main issues in history and philosophy of the sciences and the humanities.
b)	Has detailed knowledge of one of the areas of history and/or philosophy of the sciences and the humanities.
c)	Is able to contribute to scientific research in one of these areas using an appropriate methodology.
d)	Is aware of important recent developments in one of these areas and understands the relevance of these developments for his/her scientific discipline. Understands the possible social relevance of these developments.
e)	Has the skills to understand the specialized literature on at least one of these areas and has the skills to use and interpret this literature adequately.
f)	Understands the potential dilemmas related to scientific integrity in his/her research field.
<b>Applying knowledge and understanding</b>	
a)	Is able to formulate an original research question in one of these areas relevant for scientific development, education, or public understanding.
b)	Is able to formulate a fitting research plan in accordance with scientific and methodological standards.
c)	Is able to apply his/her understanding to current issues in science and academia, and to relate this to social, cultural and political developments.
d)	Is aware of the possibilities and pitfalls in applying his/her knowledge to social questions, and can relate this to his/her own work.
e)	Is able to carry out a research plan according to the rules of good practice and ethics.
<b>Making judgements</b>	
a)	Is able to participate critically and constructively in scientific debates.

b)	Is able to assess the scientific and possible social relevance of his/her research.
c)	Is able to reflect critically upon his/her own historiographical or philosophical position within the chosen area, also from a social and cultural perspective.
<b>Communication</b>	
a)	Has the skills to conceive papers for international peer-reviewed journals. Is able to present his/her work orally on an academic level.
b)	Is able to cooperate effectively with fellow researchers.
c)	Is able to present complex issues in a clear way, both written and orally.
<b>Learning skills</b>	
a)	Has the skills to work self-reliantly, to evaluate his/her own learning and development process and to adjust this process if necessary.
b)	Is able to write, with the help of a senior researcher, a grant proposal.
c)	Is qualified to compete for a position for which an academic training in one of the areas is required or useful.
d)	Has the qualifications to enroll in a PhD programme in the field of history and philosophy of science and is qualified to acquire a position as a professional in the field of history and philosophy of science, or e.g. science publishing, science communication, public policy, science management, or science museums.
e)	Has a realistic idea of the career opportunities after graduating, and of the skills that he/she needs to successfully start a career.

## Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: 412 hours, or approximately 9 hours per week, for the whole programme excluding the research part. The number of contact hours for a student in the research part of the programme is specified in individual application forms.

## Contents

Mandatory courses	30	EC
Primary electives	30	EC
Secondary electives	7.5	EC
Research part	52.5	EC
<b>Total</b>	<b>120</b>	<b>EC</b>

Mandatory courses and primary electives reflect the body of knowledge in which a student must be sufficiently prepared to successfully engage in research. A secondary elective can be used for further specialization.

## Mandatory courses

- FI-MHPSHNS History of the Natural Sciences (7.5 EC)
- FI-MHPSPS Philosophy of Science (7.5 EC)
- OGMV05006 History of the Humanities (7.5 EC)
- FI-MHPSSR Research Seminar (6.5 EC), consisting of:
  - reading group (history, philosophy or philosophy of physics)
  - colloquium attendance (a minimum of 20)
- GSNS-intro Introducing Natural Sciences (0.5 EC)
- FI-MHPSDIL Dilemmas of the scientist (0.5 EC)

## Primary electives

At least 30 EC, to be chosen out of the following list:

code	title	EC
FI-MHPSDM	Science and the Dilemmas of Modernity	7,5
FI-MHPSFQM	The Quantum World	7,5
FI-MHPSFST	Philosophy of Space and Time	7,5
FI-MHPSHLS	History of the Modern Life Sciences	7,5
FI-MHPSIJ	Investigative Journalism	7,5
FI-MHPSPSI	Professional Skills and Identity	3,75
FI-MHPSSP	Science and the Public	7,5
FI-MHPSTOP	Special Topic	2,5
FI-MHPSTUT/FI-MHPSTU2	Tutorial HPS	7,5
FI-MSECSIS	Science in Society	5
FRRMV16014	History and Philosophy of Objectivity	5
FRRMV16015	20th century German Philosophy	5
FRRMV16020	Current Issues in Analytic Philosophy	5
FRRMV17009/FRRMV17010	Tutorial Philosophy	5
FFRMV16008	Topics in Metaphysics	5
FFRMV16010	Topics in Early Modern Philosophy	5
FFRMV16011	Topics in Epistemology and Philosophy of Science	5
FFRMV16013	Topics in Moral Psychology	5
GKRMV16051	Art & Science seminar	5 or 10
B-B3GESB05	Geschiedenis en Filosofie van de Biologie	7,5
RGMURWOM08	Law as an academic discipline	7,5
201600160	Philosophy of the Social Sciences	7,5
BMB507812	History of Medicine	7,5
FA-MA214	Pharmaceutical Humanities	7,5
WBMV05003	Philosophy of Artificial Intelligence	5
WBMV13005	Logic of Computation	7,5
WISM481	Research Seminar History of Mathematics	7,5

The curriculum can contain no more than 15 EC of tutorials (FI-MHPSTUT, FI-MHPSTU2, OFRM16006, OFRM16007), and no more than 15 EC of Bachelor-level courses.

## Secondary electives

Any master level course offered by Utrecht University, up to 7.5 EC.

## Research part

The research part consists of:

- FI-MHPSRPP Research Project: proposal (15 EC)

And:

- FI-MHPSRP Research Project: thesis (22.5 or 37.5 EC, or 45 in case of a TWIN programme)

And, in case of a 22.5 EC thesis:

- FI-MHPSINT Internship (15 ects)
- or:
- extra courses (15 EC), preferably abroad, subject to approval of the Board of Examiners.

Successfully completing FI-MHPSRPP is a mandatory prerequisite to continue with FI-MHPSRP.

The subjects of the thesis and the internship have to be approved by the programme director. One of the supervisors of the thesis has to be a member of the Descartes Centre for the History and Philosophy of the Sciences and Humanities. Students can only start with the research project after finishing the mandatory courses, with the exception of the research seminar FI-MHPSSR.

The minimum grade for the thesis (FI-MHPSRP) a student needs to obtain a *cum laude* degree qualification is 8.5. Please note that additional requirements need to be met to obtain this qualification (specified in the OER).

### Labour market perspectives and scientific integrity

**Scientific integrity:** reflection on the values of science, both in theory and in practice, is a key part of this programme. Students are encouraged to discuss values and practices in historical and philosophical contexts, and to relate this to their own research. These issues are included in the assessment criteria for the research project. They are also addressed in the required course FI-MHPSDIL Dilemmas of the scientist.

**Labour market perspectives** are discussed in various settings:

- The research project and the research seminar are part of the preparation for an academic research career.
- Students are encouraged to do an internship outside academia.
- Students are offered courses (for example FI-MHPSPSI) and workshops on career perspectives
- Personal counseling by the tutor.
- UU Career Services.

### Profiles

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with an **educational profile**, aimed at obtaining a teacher degree (subject to teaching degree requirements). The profiles **Complex Systems** and **Applied Data Science** can also be followed as part of the HPS programme, but this requires permission of the Board of Examiners.

The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix.

In order to still meet the learning outcomes of the master's programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Mandatory courses	30 EC
Primary electives	22.5 EC
Secondary electives	0 EC

Research part: thesis proposal and small thesis	37.5 EC
<b>Total</b>	<b>90 EC</b>

## Information Science

### Business Informatics

#### Admission to the degree Information Science and to the programme Business Informatics

Applicants should possess at least five of the following:

- solid basic knowledge in the field of information and computing sciences (including data and process models, object-oriented modeling, and programming languages);
- solid basic knowledge of research methods;
- solid basic knowledge of cognitive and communication science;
- solid basic knowledge of organization science (including organizational structure, strategy, and culture);
- basic knowledge of product software development, delivery, implementation and use;
- basic knowledge of information systems design methods and modeling;
- the ability to communicate facts and findings verbally and in writing, also using information and communication technology and audio-visual means.

Degrees meeting these requirements are (see remarks on HBO below):

- a BSc in Information Science
- a BSc in Computer Science

Applicants holding one of the following bachelor degrees are likely to satisfy these requirements but probably require a deficiency course(s) or a premaster's programme:

- Innovation Management, Liberal Arts and Science, Management Science, or Artificial Intelligence, with a minor in Information Science;
- a BSc (other than the ones mentioned above) with a major in Information Science;
- a BSc in Computer Science (or another information technology bachelor, e.g. Information Engineering);

Students with a HBO-background need an average score of at least 7.5 for their professional bachelor programme and a score of at least 7.5 for their thesis project. The bachelor course on Scientific Research Methods is a standard deficiency course for HBO students which is taught in the master's programme. For WO students *it is recommended* to have 7 or higher as well and to have finished their bachelor program within a maximum of  $n + 1$  years, where  $n$  is the number of years their bachelor program is supposed to take.

Please note that candidates may be rejected based on low grades and long study paths, independent of their previous experience.

#### Premaster programme

A premaster of at most 30 EC is possible and will be tailored by the board of admissions depending on the student's prior knowledge. The premaster programme consists of courses from the bachelor in Information Science. The premaster programme should be finished (i.e. all courses passed) before entry into the Business Informatics programme is allowed. Please note that many of these courses are not offered in English.

The possible pre-master courses and possible deficiency courses are: Mobiel Programmeren (INFOB1MOP), Datamodelleren (INFOB1DM), Imperatief Programmeren (INFOIMP), "Mens, Maarschappij, en ICT" (INFOB1IMM), Modelleren en

Systeemontwikkeling (INFOMSO), Wetenschappelijke Onderzoeksmethoden (INFOWO), Data Analytics (INFOB3DA), Informatieuitwisseling (INFOB1IUW), Product Software (INFOB3PS), Databases (INFODB), Interactietechnologie (INFOB3IT), Ontwerpen van Interactieve Systemen (INFOB1OIS), Organisaties en ICT (INFOB1OICT), Persuasive Technologies (INFOB3PET), Strategisch Management van Organisaties en ICT (INFOB3SMI), Webtechnologie (INFOB2WT), E-Business (INFOEBU), Informatiesystemen (INFOB1ISY), Kennisystemen (INFOB3KSY), Usability Engineering en User Experience (INFOUE).

## Learning outcomes

The graduate of the master's programme in Business Informatics:

<b>Knowledge and understanding</b>	
a)	Has theoretical and practical knowledge of advanced general subject such as methodology of development, implementation and adoption of software products, and ICT entrepreneurship.
b)	Is able with this knowledge to contribute to scientific research in these areas using an appropriate methodology.
c)	Is aware of important recent developments on subject such as methodology of development, implementation and adoption of software products, and ICT entrepreneurship.
d)	Understands the relevance of these developments for his/her scientific discipline.
e)	Has the skills to understand the specialized literature on at least one area in the field of: software product development methodology; implementation and adoption of systems; ICT entrepreneurship.
f)	Has the skills to relate this literature to his/her own research.
g)	Has insight into the integrity dilemmas that occur in the domain.
<b>Applying knowledge and understanding</b>	
a)	Is able to formulate together with the supervisor an original research question in the field of Business Informatics.
b)	Is able to design, under supervision of a member of the scientific staff, a research plan that addresses a research question and that conforms to the methodological and scientific standards of the discipline.
c)	Is able to carry out this research plan under the supervision of a member of the scientific staff according to the rules of good experimental practice and ethics and is able to analyze and interpret the acquired materials and/or data according to scientific standards.
d)	Is able to create a plan for the implementation of an academic artifact in society and valorize the artifact.
<b>Making judgements</b>	
a)	Is able to participate critically and constructively in the scientific debate.
b)	Is able to indicate the relevance of his/her research to solve problems and issues in the field of Business Informatics, both from a scientific and a societal point of view.
c)	Is able to reflect critically upon his/her own research contribution and that of the student's peers from a societal point of view, including ethical perspectives such as privacy, scientific integrity, and information security.
<b>Communication</b>	
a)	Has the skills to communicate research results, both in written and spoken English, to an audience of specialists or non-specialists.
b)	Is able to function effectively in a possibly multidisciplinary team of experts working in the field of Business Informatics.
<b>Learning skills</b>	
a)	Has the skills to evaluate his/her own learning and development process and to adjust this process if necessary.

- |    |   |
|----|---|
| b) | Has a result oriented working attitude that enables him/her to work as a professional in the field of information technology. |
| c) | Has the qualifications to enroll in a PhD programme in the field of Information Science.                                      |
| d) | Is qualified to acquire a position as a professional in the field of information technology.                                  |

## Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: 400 hours for the whole programme excluding the research part. This number is based on an average of 8 contact hours per week during normal education periods, times 50 weeks, as students follow 5 periods of 10 weeks. The number will be higher for students who follow more than the required number of courses.

The number of contact hours for a student in the research part of the programme is specified in individual application forms.

## Contents

Mandatory courses	24.5 EC
Primary electives	30-52.5 EC
Deficiency course*	0-7.5 EC
Secondary electives	0-22.5 EC
Research	43 EC
<b>Total**</b>	<b>120 EC</b>

\* Deficiency courses are courses that fill in gaps in the knowledge of students, typically from the information science bachelor program.

\*\* The total always has to add up to at least 120EC.

## Mandatory courses

- Advanced Research Methods (INFOARM)
- Method Engineering (INFOME)
- Data Science and Society (INFOMDSS)
- Introduction to MBI (INFOSPMBI): 1 EC
- Introducing Natural Sciences (GSNS-intro, 0.5 EC)
- Dilemmas of the scientist (FI-MHPSDIL; 0.5 EC)

## Primary electives

- Knowledge Management (INFOKMT)
- Technologies for Learning (INFOMTFL)
- Data Mining (INFOMDM)
- Big Data (INFOMBD)
- ICT Advisory (INFOMICTA)
- Software Architecture (INFOMSWA)
- Software Ecosystems (INFOMSSE)
- Enterprise Architecture (INFOEAR)
- Mobile Interaction (INFOMMOB)
- Business Intelligence (INFOMBIN)
- ICT Entrepreneurship (INFOIE)
- Requirements Engineering (INFOMRE)
- Natural Language Generation (INFOMNLG)
- Adaptive Interactive Systems (INFOMAIS)



- Pattern Recognition (INFOMPR)

### Primary electives (Seminars, max 2 per program)

- Seminar Multimedia Discourse Interaction (INFOMMDI)
- Seminar Medical Informatics (INFOMSMI)
- Seminar Software Production (INFOMSPR)

### Secondary electives

- Possible deficiencies (at most 7.5 EC): deficiency courses are defined by the programme coordinator.
- Any MSc course from the Computer Science curriculum.
- Any related MSc course offered by Utrecht University when approved in advance by the programme coordinator.
- Capita Selecta (INFOCSM): at most 7,5 EC, but fewer are possible to fill a gap (individual course on a topic of preference). Capita Selecta are not a standard course option and need to be agreed to by a supervisor before admission to the course.

### Limitations

- Only two seminars can be followed in one MBI program.
- Bachelor courses are not allowed in the master program, unless they are deficiency courses, prescribed during the admission process.

### Research part

The research part consists of the following:

- Thesis Project Part 1: 14EC
- Thesis Project Part 2: 25EC
- MBI Colloquium (INFOCQMBI4): 4EC

The thesis project can be started when all primary electives, secondary electives, and deficiency courses have been completed. Exceptions need to be approved by the program coordinator.

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

Research can be done on all subjects related to the list of courses or related to the interests of the staff of the department staff, with a focus on information science, after agreement with a supervisor within the department.

### Cum Laude

The minimum grade for the course **"Thesis Project Part 2"** a student needs to obtain a cum laude degree qualification is 8.5. Please note that additional requirements need to be met to obtain this qualification, as per stated in the main OER document.

### Course Organization, Content, and Assessment

The MBI program employs different methods for assessment, such as group work, projects, presentations and pitches, exams, essays, etc. For each course, at least 20% needs to be assessed on individual basis. Furthermore, for each course at most 15% for

each assessment part of a course can be judged based on language, layout, and document quality. The other rubrics should consider content, understandability, etc.

All primary elective courses with more than 50 students in the previous year are taught by at least two lecturers, unless the lecturer volunteers to teach the course alone. At least one of the lecturers must be in possession of the basic teaching qualification.

### **Labor Market Perspectives**

To support students in entering the labor market effectively, the following tools are used:

- Empirical data gathered during company visits in courses such as Enterprise Architecture and Method Engineering
- Guest lectures in many of the courses
- The research of the research group and its master students requires empirical data, which is typically gathered by collaborating with large organizations, such as technology companies and consultancy firms (“Society is our Lab”)
- The courses of ICT-Advisory and ICT-Entrepreneurship also train students in professional activities and prepare them for running their own business
- Students are stimulated to use Career Services made available by the university

Students are actively discouraged from working while following the MBI program as it is a fulltime program.

### **Scientific Integrity**

Scientific integrity is supported and ensured by using the following instruments:

- In the introduction to Business Informatics course the topic of scientific integrity is discussed
- Students have to hand in project work with a cover page stating that this is their original work
- Students collaborate with senior staff on research projects
- The course of Advanced Research Methods spends two lectures on research integrity and ethics in research
- Students follow the course Scientific Integrity (0.5EC)

### **Profiles (Educational/Complex Systems/Applied Data Sciences)**

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with one *profile*. The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix. In order to still meet the learning outcomes of the master’s programme, the remaining 90EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120EC) programme structure.

Students must request participation in a profile from the programme coordinator.

Mandatory courses	24.5 EC
Primary electives	15-30 EC
Deficiency course*	0-7.5 EC
Profile courses and projects	30 EC
Research	43 EC
<b>Total**</b>	<b>120 EC</b>

\* Deficiency courses are courses that fill in gaps in the knowledge of students, typically from the information science bachelor program.

\*\* The total always has to add up to at least 120EC.

### Special provisions

for students that started in 2017-2018 and before Knowledge Management (INFOKMT) is obligatory. Students starting in 2018-2019 can choose Knowledge Management (INFOKMT), Data Science and Society (INFOMDSS), or both. For students starting in 2019-2020 Data Science and Society (INFOMDSS) is obligatory.

## Mathematical Sciences

### Admission to the degree in Mathematical Sciences

Applicants should possess:

- A solid basic knowledge of mathematics at the bachelor level, including single-variable and multi-variable real analysis, linear algebra (theory and applications), basic knowledge of probability and statistics and advanced knowledge of at least four of the following eight subjects: differential equations, complex analysis, probability theory and statistics, numerical mathematics, geometry and topology, algebra and number theory, discrete mathematics, optimization and decision theory;
- The ability to analyze mathematical problems;
- The ability to communicate findings verbally and in writing, in an appropriate mathematical manner.

In principle, the bachelor qualifications that meet these criteria are:

- A BSc with a major in Mathematics
- A BSc with a major in Physics, Computer Science or in Science with a strong component in Mathematics, which is comparable with the major part of the Utrecht University Bachelor in mathematics.

### Premasters programme

A premaster of at most 30 EC is possible and will be tailored by the board of admissions depending on the student's prior knowledge. The premasters programme should be finished (i.e. all courses passed) before entry into the Mathematical Sciences programme is allowed.

### Learning outcomes

The graduate of the master's programme in Mathematical Sciences has:

<b>Knowledge and understanding</b>
<ul style="list-style-type: none"> <li>a) a theoretical and practical understanding of advanced general concepts, principles and techniques of fundamental and/or applied mathematics;</li> <li>b) an overview of the area of scientific research and development in question;</li> <li>c) in-depth knowledge of at least one area in the field of fundamental or applied mathematics at a sufficient level that international research literature can be understood;</li> <li>d) an overview of the role of dilemmas of integrity in scientific research.</li> </ul>
<b>Applying knowledge and understanding</b>
<ul style="list-style-type: none"> <li>a) the ability to independently identify, formulate, analyse and suggest possible solutions to problems in the field of mathematical sciences;</li> <li>b) the ability to assimilate complex mathematical ideas and arguments;</li> <li>c) the ability to conduct research in the field of mathematical sciences and report on it in a manner that meets the standards of the discipline (including correct referencing, appropriate layout and style)</li> </ul>
<b>Making judgements</b>
<ul style="list-style-type: none"> <li>a) a theoretical and practical knowledge of advanced general concepts, principles and techniques of fundamental and applied mathematics, sufficient to evaluate one's own research and the research of others in a broad perspective.</li> </ul>
<b>Communication skills</b>
<ul style="list-style-type: none"> <li>a) the ability to cooperate in a, possibly interdisciplinary, team of experts;</li> <li>b) the ability to communicate results in English, both orally and in writing, including the underlying ideas, grounds and considerations, to an audience composed of specialists or non-specialists.</li> </ul>
<b>Learning skills</b>

- a) the ability to reflect on one's own research and on research of others;
- b) the ability to enroll in a PhD programme in mathematics, or to embark on a professional career as a mathematician, including having an overview of his/her career options;
- c) has a realistic idea of the career opportunities as a mathematician after graduating, and of the skills that he/she needs to successfully start a career.

## Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is 480 hours for the whole programme excluding the research part. The number of contact hours for a student in the research part of the programme is specified in individual application forms.

## Contents

Mandatory courses	15 EC
Primary electives	45 EC
Secondary electives	15 EC
Research part	45 EC
<b>Total</b>	<b>120 EC</b>

## Mandatory courses

- Orientation on Mathematical Research (WISM102, 7.5 EC)
- Mathematical Colloquium (WISM103, 2.5 EC)
- Mathematics for Industry (WISM104, 4 EC)
- Master introduction (INTRO-GSNS, 0.5 EC)
- Dilemmas of the scientist (FI-MHPSDIL, 0.5 EC)

## Primary Electives

Students make a tailor made course plan in consultation with their tutor so as to create a coherent course load in one of the eight specializations. The programme director has to give approval to the selected courses. The eight specializations are:

In Fundamental Mathematics:

- Algebraic Geometry and Number Theory (AGNT)
- Differential Geometry and Topology (DGT)
- Logic (L)
- Pure Analysis (PA)

In Mathematical Modelling:

- Applied Analysis (AA)
- Complex Systems (CS)
- Probability, Statistics, and Mathematical modelling (PS)
- Scientific Computing (SC)

Students must follow an advanced seminar in Mathematics (of at least 7.5 EC) in which they themselves have to give oral presentations. If approved by the programme director,

the student can follow a seminar in Theoretical Physics. This seminar can also be followed while the student is working on the research project.

All other primary elective courses are chosen from the course list given below or, if approved by the executive panel of Mathematical Sciences of the board of examiners from other mathematics courses given at a university in the Netherlands.

## Secondary Electives

The secondary elective courses can be any course from the course list below or other courses on the master level or an internship of 15 EC, if approved by the programme director. Courses to remedy deficiencies (i.e., level three bachelor courses from the major in Mathematics of Utrecht University) are also counted in this category.

## Research part

The research part is split into the following parts:

- Research project: Proposal (15 EC, WISM105)
- Research project: Thesis (30 EC, WISM106)

For students that started the master before September 2016 the research part is split into Research project: proposal (15 EC, WISM105) and Research project: Thesis (32 EC, WISM106).

Successfully completing the part Research project: Proposal is a mandatory prerequisite to continue with the Research project: Thesis.

The research part is under the main guidance of a researcher of the Mathematical Institute. This work can also be done as an internship. The student can start with the research project when 45 EC of the mandatory courses or primary electives is completed, or if approved by the programme director.

Students can participate in the PhD Research training (WISM111, 7.5 EC). The credit points do not contribute to the 120 EC of the masters programme.

The minimum grade for the *Research project: Thesis* a student needs to obtain a *cum laude* degree qualification is 8.5. Please note that additional requirements need to be met to obtain this qualification.

## Course list

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

Between brackets you find cluster that organises the course and the specialisations the course typically belongs to. Note however, that the course is open for all Mathematical Sciences students that fulfill the prerequisites of the course.

## Mastermath courses 2018-2019

### Fall 2018

Continuous Optimization (WISL103; 6 EC; LNMB/4TU; SC, AA)  
 Discrete Optimization (WISL101; 6 EC; LNMB/4TU; SC)  
 Heuristic Methods in Operations Research (WISL110; 6 EC; LNMB/4TU; PS)  
 Systems and Control (WISL201; 6 EC; DISC/4TU; SC)  
 Functional Analysis (WISL401; 8 EC; NDNS+; PA, PS)  
 Dynamical Systems (WISL404; 8 EC; NDNS+; AA)  
 Partial Differential Equations (WISL402; 8 EC; NDNS+; AA)  
 Commutative Algebra (WISL526; 8 EC; Diamant; AGNT)  
 Algebraic Geometry 1 (WISL509; 8 EC; Diamant; AGNT)  
 Differential Geometry (WISL503; 8 EC; GQT; AGNT, DGT)  
 Algebraic Topology 1 (WISL508; 8 EC; GQT; AGNT, DGT)  
 Symmetries and Conservation Laws of Nonlinear PDE (WISL432; 8 EC; GQT; DGT)  
 Asymptotic Statistics (WISL702; 8 EC; STAR; PS)  
 Measure-theoretical Probability (WISL701; 8 EC; STAR; PS)  
 Machine Learning Theory (WISL712; 8 EC; STAR; PS)  
 Interacting Particle Systems: Theory and Applications (WISL431; 8 EC; STAR; PS, SC, AA, CS)  
 Parallel Algorithms (WISL603; 8 EC; Num.Wisk.; SC)  
 Numerical Linear Algebra (WISL601; 8 EC; Num.Wisk.; SC)  
 Advanced Algebraic Geometry: Abelian Varieties (WISL525; 8 EC; Wonder/GQT; AGNT, DGT)  
 Algebraic Number Theory (WISL305; 8 EC; Diamant; AGNT)  
 Ergodic Theory (WISL708; 8 EC; Diamant/STAR; PS, AGNT)  
 Cryptology (WISL304; 5 EC; Diamant; AGNT)  
 Analytic Number Theory (WISL329; 8 EC; Diamant; AGNT)  
 p-Adic Numbers (WISL533; 8 EC; Diamant; AGNT)  
 Set Theory (WISL316; 8 EC; Logica; L)  
 Topos Theory (WISL328; 8 EC; Logica; L)  
 Probabilistic and Extremal Combinatorics (WISL561; 8 EC; Diamant; AGNT, SC)  
 Forensic probability and Statistics (WISL716; 8 EC; Multi; PS)

### Spring 2019

Stochastic Differential Equations (WISL108; 6 EC; 4TU; PS)  
 Applied Statistics (WISL106; 6 EC; 4TU; PS)  
 Applied Finite Elements (WISL204; 6 EC; 4TU; SC)  
 Scheduling (WISL107; 6 EC; LNMB/4TU; PS)  
 Advanced Linear Programming (WISL105; 6 EC; LNMB; SC)  
 Queueing Theory (WISL109; 6 EC; LNMB/4TU; PS)  
 Quantum Computing (WISL117; 8 EC; Multi; SC)  
 Quantum Information Theory (WISL119; 8 EC; Multi; SC)  
 Topology in Physics (WISL118; 8 EC; Multi, DGT)  
 History and Philosophy of Mathematics (WISL810; 6 EC; Multi)  
 Nonlinear Waves (WISL409; 8 EC; NDNS+; SC, AA)  
 Inverse Problems in Imaging (WISL430; 8 EC; NDNS+; SC, AA)  
 Advanced Complex Analysis (WISL433; 8 EC; NDNS+; AA)  
 Algebraic Topology in Dynamical Systems (WISL434; 8 EC; NDNS+; AA, DGT)  
 Selected Areas in Cryptology (WISL534; 8 EC; Diamant AGNT)  
 Riemann Surfaces (WISL514; 8 EC; GQT; AGNT, DGT)  
 Lie Groups and Lie Algebras (WISL535; 8 EC; GQT; DGT, PA)  
 Operator Algebras (WISL517; 8 EC; GQT; DGT, L)  
 Stochastic Processes (WISL703; 8 EC; STAR; PS)  
 Statistical Theory for High- and Infinite Dimensional Models (WISL713; 8 EC; STAR; PS)  
 Percolation: from Introduction to Frontiers of Current Research (WISL715; 8 EC; STAR; PS)  
 Bayesian Statistics (WISL538; 8 EC; STAR; PS)  
 Introduction to Numerical Bifurcation Analysis of ODE's and Maps (WISL606; 8 EC; Num.Wisk.; AA, SC)  
 Numerical Methods for Time-dependent PDE (WISL602; 8 EC; Num.Wisk.; CS, SC)  
 Numerical Bifurcation Analysis of Large-Scale Systems (WISL425; 8 EC; Num.Wisk.; CS, SC, AA)  
 Coding Theory (WISL306; 8 EC; Diamant; AGNT)  
 Additive Combinatorics (WISL330; 8 EC; Diamant; AGNT)  
 Geometric Functional Analysis and Its Applications (WISL331; 8 EC; Diamant; AGNT; PA; AA)  
 Elliptic Curves (WISL303; 8 EC; Diamant; AGNT)

Multiple Zeta Functions (WISL332; 8 EC; Diamant; AGNT)  
 Algebraic Methods in Combinatorics (WISL540; 8 EC; Diamant; AGNT, PS)  
 Algebraic Geometry 2 (WISL539; 8 EC; GQT; AGNT, DGT)  
 Algebraic Topology 2 (WISL541; 8 EC; GQT; AGNT, DGT)  
 Symplectic Geometry (WISL516; 8 EC; GQT; DGT)  
 Geometric PDE (WISL566; 8 EC; GQT/NDNS+; DGT, AA)  
 Model Theory (WISL323; 8 EC; Logica; L)  
 Geschiedenis (WISLEER903, 6 EC) (The course 'Geschiedenis' is in Dutch and organised by mastermath for teachers, Mathematical Sciences students can follow the course with an extra assignment, all specialisations)

### Local courses 2018-2019

#### Fall 2018:

Introduction to Complex Systems (WISM484; 7.5 EC; CS)  
 Seminar Bifurcations in Dynamical Systems (WISM415; 7.5 EC; AA)  
 Crash Course Deep Learning with Applications in Biology (WISM480; 3 EC; CS, SC)  
 Orientation on Mathematical Research (WISM102; 7.5 all specialisations, not open for students that have followed WISM556 in 2015-2016)

#### Spring 2018:

Seminar on Number Theory (WISM559; 7.5 EC; AGNT)  
 Seminar on Algebraic Topology (WISM567; 7.5 EC; PA, DGT, L)  
 Seminar on Logic (WISM551; 7.5 EC; L)  
 Seminar Numerical Linear Algebra (WISM471; 7.5 EC; SC, CS)  
 Seminar History of Mathematics (WISM481; 7.5 EC)  
 Seminar Modelling Health Effect of Ionizing Radiation (WISM409; 7.5 EC; CS, PS)  
 Laboratory Class Scientific Computing (WISM454; 7.5 EC; SC)  
 Reading Course Differential Delay Equations (WISM537; 7.5 EC; AA)  
 Mathematical Colloquium (WISM103; 2.5 EC; all specialisations)  
 Mathematics for Industry (WISM104; 4 EC; all specialisations)

### Stochastics and Financial Mathematics (SFM) courses 2018-2019

Will be published on the student website.

### Industrial and Applied Mathematics (IAM) courses 2018-2019

#### Q1 :

Cryptology (5 EC, 2MMC10)

#### Q2 :

Applied Cryptography (5 EC, 2DMI10)  
 Multilinear Algebra and Applications (5 EC, 2MMD20)  
 Introduction to Molecular Modeling and Simulations (5 EC, 2MMN40)

#### Q3 :

Stochastic Networks (5 EC, 2MMS40 )  
 Cryptographic Protocols (5 EC, 2DMI00)  
 Graphs and Algorithms (5 EC, 2MMD30)

#### Q4 :

Algebraic Combinatorics (5 EC, 2MMD50)  
 Random Graphs (5 EC, 2MMS60)

### Labour market perspectives and Scientific Integrity

- Scientific Integrity is included in Research project, the Introduction programme of the Graduate School of Natural Sciences and in Dilemmas of the scientist.
- Labour market perspectives is the focus of Mathematics for Industry (WISM104) and of the Career Orientation event of Mathematical Sciences.



## Profiles (Educational/Complex Systems/Applied Data Science)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with a Complex Systems, Educational or Applied Data Science *profile*. The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix. In order to still meet the learning outcomes of the master's programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Mandatory courses	15 EC
Primary electives	45 EC
Secondary electives	0 EC
Research part	30 EC
<b>Total</b>	<b>90 EC</b>

For students that have started before September 2016

Mandatory courses	0 EC
Primary electives	52.5 EC
Secondary electives	7.5 EC
Research part	30 EC
<b>Total</b>	<b>90 EC</b>

The research part is split into the following parts:

- Research project: Proposal (10 EC, WISM105)
- Research project: Thesis (20 EC, WISM106)

Successfully completing the course Research project: Proposal is a mandatory prerequisite to continue with the Research project: Thesis.

### Special provisions for students who enrolled in the programme Mathematical Sciences in the year 2016-2017 and earlier

For students who enrolled into the programme prior to 1 September 2016 the courses 1T *Introducing Natural Sciences* (INTRO-GSNS) 1T, *Dilemmas of the scientist* (FI-MHPSDIL), *Orientation on Mathematical Research* (WISM102), *Mathematical Colloquium* (WISM103) and *Mathematics for Industry* (WISM104) are not mandatory. The research project for this group of students is 47 EC in total (15 EC proposal, 32 EC thesis).

For students who enrolled in the academic year 2016-2017 in the programme the courses *Orientation on Mathematical Research* (WISM102), *Mathematical Colloquium* (WISM100) and *Mathematics for Industry* (WISM101) are mandatory. For this group of students the courses *Introducing Natural Sciences* (INTRO-GSNS), *Dilemmas of the scientist* (FI-MHPSDIL) are part of the research part and the Research part: Proposal is 14 EC, or combined with a profile, the proposal is 9 EC.

## Honours programme Utrecht Geometry Centre

### Description

This programme, which is an extension of the master's programme Mathematical Sciences, prepares students for a PhD-position in Geometry and related fields.

### Admission to the honours programme

The applicant should satisfy the admission criteria for the master's programme Mathematical Sciences. Additionally to this, the applicant will be reviewed by the selection committee of the Utrecht Geometry Centre. The selection committee will base its decision on previous study results, motivation and the CV of the applicant.

### Learning outcomes

In addition to the learning outcomes of the masters programme Mathematical Sciences the student is able to write a research proposal for a PhD-position in geometry and related fields.

### Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: 530 hours for the whole programme excluding the research part. The number of contact hours for a student in the research part of the programme is specified in individual application forms.

### Contents

Mandatory courses	15 EC
Primary electives	45 EC
Secondary electives	15 EC
PhD Research training	7.5 EC
Research part	45 EC
<b>Total EC</b>	<b>127.5 EC</b>

For students that have started before September 2016

Mandatory courses	7.5 EC
Primary electives	50.5 EC
Secondary electives	15 EC
PhD Research training	7.5 EC
Research part	47 EC
<b>Total EC</b>	<b>127.5 EC</b>

### Mandatory Courses

See the appendix of Mathematical Sciences.

### **Primary Electives**

Students must follow two advanced seminars in Mathematics in which they themselves have to give oral presentations. All other primary elective courses are chosen from the course list given in the appendix of Mathematical Sciences.

### **Secondary Electives**

See the appendix of Mathematical Sciences.

### **Research part**

See the appendix of Mathematical Sciences. In addition to the research part of the masters programme Mathematical Sciences the participants of the Honours programme UGC will follow a training in writing a graduate research proposal and write a full PhD proposal under the supervision of a staff member of the Mathematical Institute (PhD Research Training, WISM111, 7.5 EC). The PhD Research Training will be graded on a pass/fail basis. The student participates for at least a semester in the weekly research seminar of the UGC.

### **Mid-term reviews of honours students**

The progress of honours students will be reviewed by the selection committee after 1 year of study. Honours students should have obtained a minimum of 45 EC after 1. Students who do not meet this criteria may be denied from the honours programme by the selection committee.

## Physics

### Climate Physics

#### Admission to the degree Physics

Applicants should possess:

- Solid knowledge of basic physics and mathematics at undergraduate level that is necessary to complete the degree programme (for details see admission criteria of the master's programmes);
- The ability to work independently as well as in groups on solving physical problems and presenting the results and to read (English) physics literature at the level of graduate textbooks;
- The ability to write a research report in English, such as a bachelor thesis.

Degrees that most probably meet these requirements are

- A BSc degree in Physics,
- A BSc degree in Physics and Astronomy,
- A BSc degree with a major in Physics,
- A major in Science with a strong component in physics.

#### Admission to the programme

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

1. Solid basic knowledge in classical physics, especially fluid dynamics, 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 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 is sufficient.

In case the student has not taken one of the above mentioned subjects, it can be taken as part of the MSc programme to remedy this deficiency (at most 15 EC). The programme director will decide which topics need to be followed.

#### Premasters programme

A premaster of at most 30 EC is possible and will be tailored by the board of admissions depending on the student's prior knowledge. The premasters programme must be completed (i.e. all courses passed) before entry into the Climate Physics programme is allowed.

#### Learning outcomes

The graduate of the master's programme in Climate Physics:

<b>Knowledge and understanding</b>
<ul style="list-style-type: none"> <li>a) has in-depth knowledge of and insight into the physics of the climate system, i.e. the dynamics of atmosphere, ocean and climate;</li> <li>b) is aware of recent developments in the field of global climate models and of process-oriented models, and is able to state the relevance of these developments for the research field and society;</li> <li>c) can read and understand the professional literature in the field of at least one of the five research themes of the programme, and is able to relate this to his/her own research.</li> <li>d) understands the potential dilemmas related to scientific integrity in his/her research field.</li> </ul>
<b>Applying knowledge and understanding</b>
<ul style="list-style-type: none"> <li>a) is able to define, under the supervision of a staff member, a scientific problem in Climate Physics; to formulate a research question, and to design a basic strategy to solve this problem;</li> <li>b) is able to carry out this research plan under supervision of a scientific staff member according to the rules of good experimental practice and ethics, and report on it in a manner that meets the customary standards of the discipline;</li> <li>c) is able to analyse and interpret, under the supervision of a staff member, the acquired results, materials and/or data according to scientific standards.</li> </ul>
<b>Making Judgements</b>
<ul style="list-style-type: none"> <li>a) is able to participate critically and constructively in the scientific debate in the research group;</li> <li>b) is able to indicate the relevance of his/her research for the advancement of physics;</li> <li>c) is able to critically reflect on his/her own results, as well as on published scientific literature in the field of climate dynamics.</li> </ul>
<b>Communication</b>
<ul style="list-style-type: none"> <li>a) is able to transfer knowledge and results of scientific research in the field of climate physics to both a specialised and a more broadly interested audience, both in oral and written form;</li> <li>b) is able to professionally act in a (possibly multi-disciplinary and international) research team.</li> </ul>
<b>Learning skills</b>
<ul style="list-style-type: none"> <li>a) has the skills to reflect upon his/her learning process and, if necessary, adjust this process; has acquired sufficient scientific knowledge and skills to conduct independent scientific research, or to conduct other discipline-related work;</li> <li>b) is able to apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;</li> <li>c) has the qualifications to enroll in a PhD programme in Climate Physics; is qualified to acquire a position as a professional in a (semi) public or commercial organisation.</li> <li>d) Has a realistic idea of the career opportunities after graduating, and of the skills that he/she needs to successfully start a career.</li> </ul>

## Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: **900** hours for the whole programme excluding the research part. The number of contact hours for a student in the research part of the programme is specified in individual application forms.

## Contents

Mandatory courses	38.5 EC
Primary Electives	22.5-37.5 EC
Secondary Electives	0-15 EC
Research part	44 EC
<b>Total</b>	<b>120 EC</b>

### Mandatory courses

- Dynamical Oceanography (NS-MO401M, 7.5 EC)
- Dynamical Meteorology (NS-MO402M, 7.5 EC)
- Atmospheric Composition and Chemical Processes (NS-MO405M, 7.5 EC)
- Simulation of Ocean, Atmosphere and Climate<sup>a</sup> (NS-MO501M, 7.5 EC)
- Making, Analysing and Interpreting Observations<sup>a</sup> (NS-MO502M, 7.5 EC)
- Introducing Natural Sciences (GSNS-INTRO, 0.5 EC)
- Dilemmas of the scientist (FI-MHPSDIL, 0.5 EC)

The course NS-MO502M (Making, Analysing and Interpreting Observations) is labelled as Data Science course.

### Primary Electives

At least 22,5 EC has to be chosen from the following list of courses

- Ocean Waves (NS-MO428M, 7.5 EC)
- Ice and Climate (NS-MO427M, 7.5 EC)
- Current Themes in Climate Change (NS-MO434M, 7.5 EC)
- Boundary layers, Transport and Mixing (NS-MO408M, 7.5 EC)
- Marine Masters Summer Course (NS-MO446M, 3.75 EC)
- Turbulence in Fluids<sup>b</sup> (NS-376B, 7.5 EC)
- Wave Attractors (NS-MO477M, 7.5 EC)
- One of the following courses:
  - Morphodynamics of Tidal Systems (GEO4-4435, 7.5 EC)
  - Morphodynamics of Wave-Dominated Coasts (GEO4-4434, 7.5 EC)

<sup>a</sup> Students participating in the (coordinated) exchange with the master programmes “Integrated Climate System Studies” (ICSS), “Ocean and Climate Physics” (OCP) or “Meteorologie” at the Universität Hamburg are allowed to replace, after approval of the programme director or programme coordinator, either NS-MO501M or NS-MO502M by a course, followed during this exchange within the programmes listed above, that includes a clear numerical (NS-MO501M) or observational (NS-MO502M) component.

<sup>b</sup> Selection of this course requires permission of the programme director and of the programme coordinator.

The course NS-MO477M (Wave Attractors) is labelled as Complex Systems course. Students enrolled in the year 2016-2017 and earlier may use NS-MO428M as Complex Systems course, but only if NS-MO428M was completed in the year 2016-2017 or earlier.

### Secondary electives

1. At most 15 EC may be chosen from all MSc courses offered by the Graduate School of Natural Sciences.

2. For other courses, e.g. the BSc course Geophysical Fluid Dynamic (NS-353B), approval by the programme director is required.
3. Secondary electives may be used for courses required to fulfill the admission requirements in the case of deficiencies.

## Research part

Students who have more than 15 EC still open can only start with the research part after approval by the programme director or the programme coordinator.

Before starting the research project a meeting with the programme coordinator is mandatory to check the (planned) study program.

The research part is split as follows:

Thesis project part 1 (NS-MO551M): 14 EC,

Thesis project part 2 (NS-MO552M): 30 EC.

Research is done under the supervision of a staff member of the Institute for Marine and Atmospheric Research. This research is concluded with a written master's thesis.

Research can be done in the following directions:

1. Ice and Climate;
2. Ocean Circulation and Climate;
3. Atmospheric Physics and Chemistry;
4. Atmospheric Dynamics and the Hydrological Cycle;
5. Coastal and Shelf Sea Dynamics.

Only for students that have enrolled on or after 1 September 2018: The minimum grade for the course Thesis project part 2 a student needs to obtain a cum laude degree qualification is 9. Please note that additional requirements need to be met to obtain this qualification.

## Labour market perspectives and scientific integrity

Both aspects are discussed during the master introduction days. Besides, students attend two additional mandatory sessions on scientific integrity in their first and second year. Information about labour market perspectives is also given in several courses, as well as during sessions between student and programme coordinator and during research projects and internships.

## Profiles (Educational/Complex Systems/Applied Data Science)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with a *profile*. The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix. In order to still meet the learning outcomes of the master's programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Mandatory courses	38.5 EC
Primary electives	22.5 EC
Secondary electives	0 EC
Research part	29 EC
<b>Total</b>	<b>90 EC</b>

The research part is split into thesis part 1 (NS-MO551M, 14 EC) and thesis part 2 (NS-MO552M, 15 EC).

Remark: in this programme it is permitted to combine the research part of the profile Complex Systems (15 EC) with the research part (29 EC) in the table above, but the two research parts will be separately assessed.

**Special provisions for students who enrolled in the programme Meteorology, Physical Oceanography & Climate in the year 2015-2016 and earlier**

The courses *Introducing Natural Sciences* (GSNS-intro, 0.5 EC), *Dilemmas of the scientist* (FI-MHPSDIL; 0.5 EC) and the thesis split components part 1 and part 2 are not mandatory for students enrolled into this programme prior to 1 September 2016.

This provision ends 31 August, 2019.



## Experimental Physics

### Admission to the degree Physics

Applicants should possess:

- Solid knowledge of basic physics and mathematics at undergraduate level that is necessary to complete the degree programme (for details see admission criteria of the master's programmes);
- The ability to work independently as well as in groups on solving physical problems and presenting the results and to read (English) physics literature at the level of graduate textbooks;
- The ability to write a research report in English, such as a bachelor thesis.

Degrees that most probably meet these requirements are

- A BSc degree in Physics,
- A BSc degree in Physics and Astronomy,
- A BSc degree with a major in Physics,
- A major in Science with a strong component in physics.

### Admission to the programme

Students qualify for admission to this programme, if they possess skills and knowledge in Quantum Mechanics, Statistical Physics at an advanced bachelor level and have general knowledge on the subject of Subatomic Physics, Solid State Physics/Condensed Matter Physics, and in Soft Condensed Matter Physics.

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

In case the student has not taken one of the above mentioned subjects, it can be taken as part of the MSc programme to remedy this deficiency (at most 15 EC). The programme director will decide which topic need to be followed.

### Premasters programme

A premaster of at most 30 EC is possible and will be tailored by the board of admissions depending on the student's prior knowledge. The premasters programme must be completed (i.e. all courses passed) before entry into the Experimental Physics programme is allowed.

### Learning outcomes

The graduate of the master's programme in Experimental Physics:

#### Knowledge and understanding

- a) has in-depth knowledge of and insight into modern experimental physics with an emphasis on at least two of the following topics: Particle Physics (PP), Atomic, Molecular and Optical (AMO) physics, Soft Condensed Matter & Biophysics (SCMB); is aware of recent developments in experimental and data analysis techniques in at least one of the following fields: Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter & Biophysics, and is able to state the relevance of these developments for the research field and society;
- b) is aware of recent developments in experimental physics, and is able to state the relevance of these developments for the research field and society;

- c) can read and understand the professional literature in the field of at least one of the following topics: Particle Physics, Atomic, Molecular and Optical Physics, Soft Condensed Matter & Biophysics; and to relate this to his/her own research;
- d) understands the potential dilemmas related to scientific integrity in his/her research field.

#### Applying knowledge and understanding

- a) is able to define, under the supervision of a staff member, a scientific problem in Particle Physics, Atomic, Molecular and Optical physics or Soft Condensed Matter & Biophysics, formulate a research question, and design a basic strategy to solve this problem;
- b) is able to carry out this research plan under supervision of a scientific staff member according to the rules of good experimental practice and ethics, and report on it in a manner that meets the customary standards of the discipline;
- c) is able to analyse and interpret, under the supervision of a staff member, the acquired results, materials and/or data according to scientific standards;

#### Making judgements

- a) is able to participate critically and constructively in the scientific debate in the research group;
- b) is able to indicate the relevance of his/her research for the advancement of physics;
- c) is able to reflect critically upon his/her own contribution to the research in the selected field (Particle Physics, Atomic, Molecular and Optical physics, or Soft Condensed Matter Physics & Biophysics), and that of others.

#### Communication

- a) has the skills to present and discuss, in spoken and written English, the results of research, including the underlying knowledge and background, to a target group composed of specialists or non-specialists.
- b) is able to work together in a constructive critical way in an international (possibly interdisciplinary) team of experts and use modern means of scientific communication.

#### Learning skills

- a) has the skills to evaluate his/her own learning and development process and to adjust this process if necessary; has the skills to work independently and take initiatives where necessary;
- b) is able to apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
- c) has the qualifications to enrol in a PhD programme in at least one of the following fields: Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter & Biophysics; is qualified to acquire a position as a professional in a (semi) public or commercial organisation.
- d) Has a realistic idea of the career opportunities after graduating, and of the skills that he/she needs to successfully start a career.

## Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: **750** hours for the whole programme excluding the research part. The number of contact hours for a student in the research part of the programme is specified in individual application forms.

## Contents

Mandatory courses	22-23.5 EC
Primary electives	21.5-23 EC*
Secondary electives	15 EC*
Research part	60 EC

<b>Total</b>	<b>120 EC</b>
--------------	---------------

\* Alternatively, it is possible to combine 15 EC of primary electives and 15 EC of secondary electives to carry out a 30 EC internship. For this, permission of the programme director and the Board of Examiners is required before the start of the internship. Internships can only start after the mandatory courses, primary elective courses, and the research project have been finished, unless explicit permission is given by the programme director.

## Mandatory courses

There are five mandatory courses in total, two of which are the same for all students:

GSNS-INTRO	Graduate school's master introduction	0.5 EC
FI-MHPSDIL	Dilemmas of the scientist	0.5 EC

and a choice of three which may be chosen out of the following list of four:

NS-EX403M	Particle Physics 1	6 EC
NS-EX418M	Photon Physics	7.5 EC
NS-EX401M	Experimental Quantum Physics	7.5 EC
NS-TP453M	Soft Condensed Matter Theory	7.5 EC

If a student follows all four courses from the above list, one will be counted as a primary elective.

## Primary electives

A choice from the following list of courses:

For research in either of the three specialisations (PP: Particle Physics, AMO: Atomic and Molecular Physics, SCMB: Soft Condensed Matter & Biophysics) it is strongly recommended to choose 22.5 EC from the corresponding column in the table below.

Advisory Path →			PP	AMO	SCMB
Course ↓					
Utrecht Courses:					
NS-EX404M	Particle Physics 2	7.5 EC	•		
NS-EX417M	Physics of Light & Electron Microscopy	4.5 EC	•	•	•
NS-EX419M	Application of Light & Electron Microscopy	3 EC	•	•	•
NS-TP432M	Modelling and Simulation	7.5 EC	•	•	•
NS-TP401M	Quantum Field Theory	10 EC	•	•	
NS-TP402M	Statistical Field Theory	10 EC	•	•	•
SK-MASPN	Adv. Spectroscopy of Nanomaterials	7.5 EC			•
SK-MCS	Colloid Science	7.5 EC			•
Shared NIKHEF Master Courses:					
NS-EX430M	Beyond the standard model	3 EC	•		
NS-EX415M	CP violation and Flavor Physics	3 EC	•		
NS-EX432M	Gravitational Waves	3 EC	•		
NS-EX422M	Particle Detection A	3 EC	•		
NS-EX423M	Particle Detection B	3 EC	•		
NS-EX433M	Programming C++	3 EC	•	•	•
NS-EX405M	Computational Methods	6 EC	•	•	•
NS-EX427M	Astroparticle Physics	6 EC	•		
NS-EX434M	Statistical Data Analysis	6 EC	•	•	•
NS-EX429M	Nikhef project	6 EC	•		
NS-EX406M	CERN Summer Student Programme	6 EC	•		

The course NS-TP432M (Modelling and Simulation) is labelled as Complex Systems course.

The course NS-EX434M (Statistical Data Analysis) is labelled as Data Science course.

The course NS-EX431M is held every other year, and not in the period 2018/2019.

### Secondary electives

For the remaining 15 EC, several options are possible: any remaining course from the list of primary electives, any other course offered by the Graduate Schools of Natural and Life Sciences; the course GEO4-2513 Solar Energy Physics; other courses with permission from Board of Examiners; or an internship of 15 EC outside Utrecht University (note also the possibility of a 30 EC internship, as described under 'Contents'). Selection of courses should be discussed with the programme director. Internships can start as soon as all mandatory courses and primary elective courses, as well as the research part have been finished, or sooner with permission of the programme director.

Secondary electives can also be those courses required to fulfil the admission requirements in the case of deficiencies.

### Research part

Before starting the research project, a meeting with the programme coordinator is mandatory to check the (planned) study program.

Students can only start with the research part after approval by the programme director or the programme coordinator.

The research part is split as follows:

Thesis project part 1 (NS-EX551M): 15 EC;

Thesis project part 2 (NS-EX552M): 45 EC.

Successfully completing part 1 of the Thesis project is a mandatory prerequisite to continue with part 2 of the Thesis project. Explicit permission is given to reuse data and written material graded in research part 1 for research part 2.

Research is done at either the Particle Physics section or at one of the research groups of the Debye Institute including those belonging to the chemistry department (Condensed Matter & Interfaces, Physical & Colloid Chemistry) or, with the permission of the programme director, in a closely related research lab, provided that a staff member of the department of physics is willing to act as the primary responsible supervisor and as a second examiner. The student may start with his/her research project before the completion of the mandatory course and the primary elective courses only with the permission of the programme director. Research group specific requirements, including the choice of certain primary elective courses or other activities, are noted on the Research Project Application Form before the start of the project.

Only for students that have enrolled on or after 1 September 2018: The minimum grade for the course Thesis project part 2 a student needs to obtain a cum laude degree qualification is 9. Please note that additional requirements need to be met to obtain this qualification.

### Labour market perspectives and scientific integrity

Both aspects are discussed during the master introduction days. Besides, students attend two additional mandatory sessions on scientific integrity in their first and second year. Labour market perspectives are also discussed during sessions between student and programme coordinator and during research projects and internships.

### Profiles (Educational/Complex Systems/Applied Data Science)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with a *profile*. The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix. In order to still meet the learning outcomes of the master's programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Mandatory courses	22-23.5 EC
Primary electives	21.5-23 EC
Secondary electives	0 EC
Research part	45 EC
<b>Total</b>	<b>90 EC</b>

The research is split into thesis part 1 (NS-EX551M, 15 EC) and thesis part 2 (NS-EX552M, 30 EC).

Remark: in this master's programme it is permitted to combine the research part of the profiles Complex Systems and Data Science (15 EC) with the research part (45 EC) in the table above, but the two research parts will be separately assessed.

## Theoretical Physics

### Admission to the degree Physics

Applicants should possess:

- Solid knowledge of basic physics and mathematics at undergraduate level that is necessary to complete the degree programme (for details see admission criteria of the master's programmes);
- The ability to work independently as well as in groups on solving physical problems and presenting the results and to read (English) physics literature at the level of graduate textbooks;
- The ability to write a research report in English, such as a bachelor thesis.

Degrees that most probably meet these requirements are

- A BSc degree in Physics,
- A BSc degree in Physics and Astronomy,
- A BSc degree with a major in Physics,
- A major in Science with a strong component in physics.

### Admission to the programme

Students admitted to the Physics degree qualify for admission to this master's programme if they have successfully completed advanced courses in quantum mechanics, statistical physics, and electrodynamics (typically the second courses on these topics in a physics curriculum), and preferably also a course on solid-state or condensed-matter physics. Students who did not pass these courses with high grades (above average) are advised not to choose this master's programme.

### Premasters programme

A premaster of at most 30 EC is possible and will be tailored by the board of admissions depending on the student's prior knowledge. The premasters programme must be completed (i.e. all courses passed) before entry into the Theoretical Physics programme is allowed.

### Learning outcomes

The graduate of the master's programme in Theoretical Physics:

#### Knowledge and understanding

- a) has in-depth knowledge of and insight into field-theoretic and mathematical methods in theoretical physics and its use in high-energy physics and/or condensed matter physics and/or statistical physics;
- b) is aware of recent developments in theoretical physics, and is able to state the relevance of these developments for the research field and society;
- c) can read and understand the professional literature in the field of at least one of the following topics: high energy physics, condensed matter physics, statistical physics, and to relate this to his/her own research;
- d) understands the potential dilemmas related to scientific integrity in his/her research field.

#### Applying knowledge and understanding

- a) is able to define, under the supervision of a staff member, a scientific problem in Modern theoretical physics, formulate a research question, and design a basic strategy to solve this problem;
- b) is able to carry out this research plan under supervision of a scientific staff member according to the rules of good experimental practice and ethics, and report on it in a manner that meets the customary standards of the discipline;
- c) is able to analyse and interpret, under the supervision of a staff member, the acquired results, materials and/or data according to scientific standards;

#### Making judgements

- a) is able to participate critically and constructively in the scientific debate in the research group;
- b) is able to indicate the relevance of his/her research for the advancement of physics;
- c) can critically reflect on this theoretical-physics research.

#### Communication

- a) can explain the results of this research to an audience of specialists as well as fellow students, both orally and in writing, in English;
- b) can conduct a theoretical-physics research project, supervised by a staff member, possibly as part of a (multidisciplinary) research team.

#### Learning skills

- a) has the skills to evaluate his/her own learning and development process and to adjust this process if necessary; has obtained the ability to study focused and independently;
- b) is able to apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
- c) is qualified to be admitted to a PhD research project in the field of theoretical physics, physics in general, and/or mathematics; is qualified to acquire a research position in a (semi) public or commercial organization.
- d) has a good idea of the employment possibilities and the skills needed to make a successful start in the labour market.

## Contact hours

The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: **972** hours for the whole programme excluding the research part. The number of contact hours for a student in the research part of the programme is specified in individual application forms.

## Contents

Mandatory courses	30 EC
Primary electives	30 EC
Secondary electives	15 EC
Research part	45 EC
<b>Total</b>	<b>120 EC</b>

## Mandatory courses (each 10 EC)

- Quantum Field Theory (NS-TP401M)
- Statistical Field Theory (NS-TP402M)
- Student seminar in Theoretical Physics (NS-TP503M)

The student seminar is split into the following parts:

Dilemmas of the scientist	(FI-MHPSDIL; 0.5 EC);
Graduate school's master introduction	(GSNS-INTRO; 0.5 EC);
Seminar	(NS-TP501M, 9 EC).

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

## Primary Electives

22.5 EC to choose out of the following list:

- Advanced Topics in Theoretical Physics I	(NS-TP433M)
- Advanced Topics in Theoretical Physics II	(NS-TP530M)
- Cosmology	(NS-TP430M)
- Field Theory in Condensed Matter	(NS-TP457M)
- Field Theory in Particle Physics	(NS-TP529M)
- General Relativity	(NS-TP428M)
- Modelling and Simulation	(NS-TP432M)
- Soft Condensed Matter Theory	(NS-TP453M)
- String Theory	(NS-TP526M)
- Theory for Technology	(NS-TP531M)*

In this master's programme the course Modeling and Simulation (NS-TP432M) is labeled as Complex Systems course.

\* In collaboration with the TU/Eindhoven

7.5 EC to choose from any Master level course in Mathematics or a third year course of the bachelor programme in mathematics from the following list:

- Differentieerbare variëteiten	WISB342
- Complexe functies	WISB311
- Topologie en Meetkunde	WISB341
- Maat en Integratie	WISB312
- Stochastische processen	WISB362
- Distributies	WISB314
- Functionaalanalyse.	WISB315
- Intl. Scientific Computing	WISB356
- Intl. niet-lineaire systemen	WISB333 or
- Hamiltoniaanse dyn. syst.	WISB331

Note that at most one of these bachelor courses can be selected as part of the master's programme, that the official language of education in these courses is possibly Dutch, that appearance in this list is not a guarantee that the course will actually be taught in a particular year, and that courses which are listed on the Bachelor's degree cannot be used for the Master's degree.

## Secondary Electives

15 EC to choose out of the following list:

- Any MSc course offered by the Graduate School of Natural Sciences (including the primary elective theoretical physics courses listed above).
- With the consent of the programme director and of the Board of Examiners also other master courses may be selected.



## Research part

Students who have not yet passed all primary electives or who have more than 15 EC still open can only start with the research part after approval by the programme director or the programme coordinator. Before starting the research project a meeting with the programme coordinator is mandatory to check the (planned) study program.

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 and course work has been finished.

The research part is split as follows:

Thesis project part 1 (NS-TP551M): 15 EC

Thesis project part 2 (NS-TP552M): 30 EC.

Successfully completing part 1 of the Thesis project is a mandatory prerequisite to continue with part 2 of the Thesis project.

Only for students that have enrolled on or after 1 September 2018: The minimum grade for the course Thesis project part 2 a student needs to obtain a cum laude degree qualification is 9. Please note that additional requirements need to be met to obtain this qualification.

## Labour market perspectives and scientific integrity

Both aspects are discussed during the master introduction days. Besides, students attend two additional mandatory sessions on scientific integrity in their first and second year. Information about labour market perspectives is also given in several courses, as well as during sessions between student and programme coordinator and during research projects and internships.

## Profiles (Educational/Complex Systems/Applied Data Science)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with a *profile*. The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix. In order to still meet the learning outcomes of the master's programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

Mandatory courses	30 EC
Primary electives	30 EC
Secondary electives	0 EC
Research part	30 EC
<b>Total</b>	<b>90 EC</b>

The research is split into thesis part 1 (NS-TP551M, 15 EC) and thesis part 2 (NS-TP552M, 15 EC).

Remark: in this master's programme it is permitted to combine the research part of the profile Complex Systems (15 EC) with the research part (30 EC) in the table above, but the two research parts will be separately assessed.

## Honours programme Q-Biology

### Description

This honoursprogramme is open to all natural and life science students. Extended information about admission, dead-lines, selection procedure, content of this programme can be found at: <http://theory.bio.uu.nl/qbio/honours.html> or in the Education and Examination regulations (OER in dutch) of the Graduate School of Life Sciences.

### Admission to the programme

The pre-selection will be done by the coordinators of the QBio program, and will be based on the following criteria:

1. a letter of motivation expressing interest in interdisciplinary Life Sciences research,
2. evaluation from supervisors of current disciplinary Master's programme,
3. grades and the particular selection of relevant courses in the Bachelor's programme, and
4. grades and track chosen during the high school education (e.g. choice of math courses).

Beginning of January every year the applicants will be notified whether or not they fulfill the pre-selection criteria and that they can take part in the first part of Qbio honors programme (max. 25 students).

The students that are pre-selected for Qbio programme will join the monthly journal club meetings from January to June. The aim of this journal club is to learn to read interdisciplinary papers and to develop current overview of Quantitative Biology. In June the students will take the Qbio course and **their performance in this course is the final selection criteria** for the Qbio honors programme. The students will present a paper and make a pitch on interdisciplinary projects they are involved in. To prepare them for these presentations, there will be regular meetings between January till June on obtaining interdisciplinary skills.

### Learning outcomes

Discoveries in the biological and biomedical sciences increasingly require combining sophisticated technologies, quantitative measurements, and theoretical approaches such as bioinformatics, mathematical modelling and computer simulations. Hence, modern Life Sciences research faces the challenge to integrate different scientific disciplines and foster collaborative projects between biologists, chemists, physicists, computer scientists and mathematicians to make biology a quantitative natural science.

Therefore, the most important learning outcomes of this honors program is:

1. Student is able to work in interdisciplinary teams.
2. Student gains the basic information on life sciences to be able to talk with life sciences researchers.
3. Student can communicate his/her disciplinary work to an interdisciplinary audience.
4. Student can critically read papers outside of his own discipline and can search for the possibilities of integrating his own discipline to resolve the biological research question.

## Contents

The programme has the following components:

- **Attending Monthly journal club** : The students that are pre-selected for Qbio programme will join the monthly journal club meetings from January to June. The aim of this journal club is to learn to read interdisciplinary papers and to develop current overview of Quantitative Biology.
- **Three week QBio course** (4.5 EC). This course is an extended version of the master course Systems Biology (May 28- June 15, 2018, program is in preparation) for honour students (max 25 participants). The aim of this course is to learn about interdisciplinary research in life sciences.
  - Perform at least **one interdisciplinary research project** within the institute of Bioinformatics and Biocomplexity (**IBB**) or any other groups associated with Qbio honours programme (see <http://tbb.bio.uu.nl/qbio/honours.html>) during their Master.
- In the second year of Qbio honours programme, the students will organize a **one day symposium** on Quantitative Biology and continue to attend monthly journal clubs.
- **Writing own PhD proposal** as final literature thesis. Students are free to choose their own research topic, and by which group they would prefer to be supervised (7.5 EC). The supervisor may decide to submit your PhD proposal to NWO.

## Applied Data Science Profile

### Description

Data are everywhere. From the sciences to industry, commerce, and government, large collections of diverse data are becoming increasingly more indispensable for decision making, planning, and knowledge discovery. But how can we sensibly take advantage of all the opportunities that these data potentially provide while avoiding the many pitfalls? The Master's profile Applied Data Science addresses this challenge.

Applied Data Science (ADS) is a multidisciplinary profile for students who are not only interested in broadening their knowledge and expertise within the field of Data Science, but are also eager to apply these capabilities in relevant projects within their research domain. The two mandatory courses provide a thorough introduction to data science, its basic methods, techniques, processes, and the application of data science within specific domains. The foundations of applied data science include relevant statistical methods, machine learning techniques and programming skills. Moreover, key aspects and implications of ethics, privacy and law are covered as well.

The multidisciplinary nature of the Applied Data Science profile is also embodied in the collaborative design of the mandatory courses and (optionally) the research project. This means that both the teaching staff and students will have different backgrounds as means to help broaden perspectives and stimulate creativity. We investigate data science methods and techniques through case studies and applications throughout the life sciences & health, social sciences, geosciences, and the humanities. Therefore, students applying for this master's profile should have an affinity for this multidisciplinary approach.

### Admission to the profile

It is assumed that you have already completed a bachelor level course in statistics and/or programming before starting the ADS profile. If not, you must have completed a certified introductory MOOC course on basic statistical methods and/or programming in Python or R beforehand instead.

To apply for the ADS profile, you should first contact the ADS profile coordinator to discuss your eligibility, and subsequently register through the online form accessible from the ADS education web pages at <https://students.uu.nl/en/science/applied-data-science>. The ADS profile coordinator will then assess your profile.

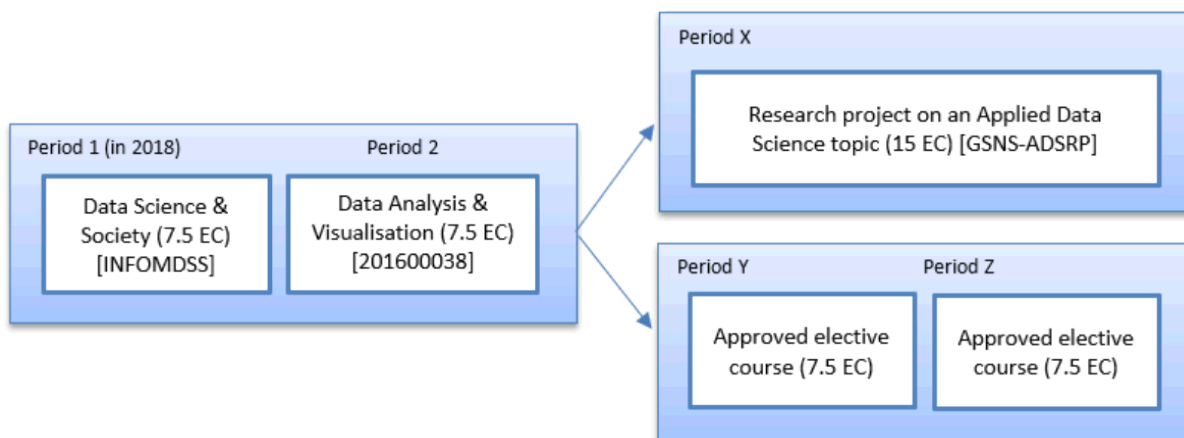
### Learning outcomes

Upon completion of the Master's profile Applied Data Science the student:

- Understands the basic methods and techniques in data science
- Is able to apply this knowledge and analyse large datasets in a specific domain
- Understands the potential and risks of applying data science for research and society

### Contents

The ADS profile comprises two mandatory multidisciplinary courses (15 EC), complemented with either a selection of two elective courses (15 EC) from the elective courses table listed below, OR a multidisciplinary research project (15 EC). The illustration below visualises the Master's profile Applied Data Science.



### Two mandatory courses [15 EC]

- *Data Science & Society* [INFOMDSS]  
(coord: dept. Computer science / GSNS; in 2018-19 in period 1)
- *Data Analysis & Visualisation* [201600038]  
(coord: dept. Methods & Statistics / GSSBS; in period 2)

### Complementary course(s) [15 EC]

- Research project on an Applied Data Science topic [INFOMADSRP] (15 EC)

Focus should be on interdisciplinary aspects and at least two supervisors from different departments/faculties should be involved.

The topic should not correspond to the topic of the master thesis, however if the master research project deals with an applied data science subject, it is for certain master's programmes permitted to combine the research project of the master's profile Applied Data Science (15 EC) with the master research thesis. Both parts must be separately assessed and a supervisor from a different department or faculty is involved in this part of the research project.

The topic should be approved by the profile coordinator, and by the programme director of the master programme for which the student is admitted. Upon approval the student and profile coordinator will together be responsible for finding a supervising staff member for the ADS aspects of the disciplinary project. This will be done on a case-by-case basis depending on the research topic, but commitment from an ADS staff member is required before the research project is allowed to commence.

- Two elective courses (15 EC)

Due to the complexity of the Research Project option above, an attractive alternative to the Research Project is to complete the ADS profile by complementing the mandatory courses with two additional courses from the elective courses list below. Please refer to the Applied Data Science profile web page for up to date information, and consult your own master programme coordinator for approval nevertheless.

Note that you can select courses from any of the participating master's programmes in the list below, as long as your own master's programme coordinator also agrees with the inclusion of the selected ADS profile courses as

eligible electives within your own master's curriculum (*i.e.* you need permission from both the ADS profile coordinator and your master's programme coordinator).

Master's programme	Elective course	Osiris code
<b>Artificial Intelligence</b>	Multi-agent learning	INFOMAA
	Cognitive Modeling	INFOMCM
	Experimentation in Psychology and Linguistics	INFOMEPL
	Logic and Language	TLMV13020
	Logic and Computation	WBMV13005
<b>Business Informatics</b>	Business Intelligence	INFOMBIN
<b>Climate Physics</b>	Measuring Analyzing and Interpreting Observations	NS-MO501M
<b>Computing Science</b>	Data mining	INFOMDM
	Pattern set mining	INFOMPSM
	Big data	INFOMBD
	Pattern recognition	INFOMPR
<b>Experimental Physics</b>	Statistical Data Analysis	NS-EX434M
<b>Game and Media Technology</b>	Multimedia Retrieval	INFOMR
	Pattern Recognition	INFOMPR
<b>Mathematical Sciences</b>	Seminar Scientific Computing	WISM470
	Parallel Algorithms	WISL603
	Network Dynamics	WISL116
	Complex Networks	WISL115
<b>Methodology and Statistics for the Behavioural, Biomedical and Social Sciences</b>	Computational inference with R	MSBBSS04

Please note that the total number of EC of each master's programme will NOT be increased by completing the master profile Applied Data Science.

Students receive a certificate by completing the Master's profile Applied Data Science.

## Complex Systems Profile

### Description and aims

The Master's profile Complex Systems is an interdisciplinary profile for students who are interested to broaden their knowledge and expertise within the field of Complex Systems. In this research field societal issues, such as a financial crisis, a sudden epidemic or climate change are studied from a quantitative modelling perspective. Students will get an understanding of the various models used in the complexity field and the behaviour (i.e. transitions, predictability) of these models.

The aim of the Complex Systems Profile is for students to develop or improve their

- affinity for quantitative approaches in order to address societal issues,
- ability to build models that are amenable to quantitative approaches,
- familiarity with standard (quantitative) methods in the toolbox for analysing complex systems, and
- ability to work in interdisciplinary teams.

### Learning outcomes

Upon completion of the Master's profile the student

- is able to recognise the complex systems aspects when confronted with a societal problem,
- is able to develop models of complex systems and/o has a good overview of model-building for complex systems,
- has a good overview of the methods in the complex systems toolbox, can apply them to models and extract quantitative results, and
- communicate/explain complex-systems models and methods to (interdisciplinary) teammates.

### Programme

The Master's profile comprises 30 EC and consists of the following parts:

- Two electives (7.5 EC each) from the following courses (one of these is mandatory):
  1. Introduction to Complex Systems (WISM484)
  2. Algorithms in finance (WISM410)
  3. Seminar Modelling Health Effects of Ionizing Radiation (WISM409)
  4. Understanding Complexity: Economy and the Planet (NS-MO450M)
  5. A course from a Master's programme, other than the programme for which the student is admitted, that is labelled as a Complex Systems course (see list below). **Note:** Some programmes may require one of their own primary elective courses, labelled as Complex Systems course to be taken. More information can be found in the specific programme description section of the Education and Examination Regulations.
- A research Project on a Complex Systems topic (15 EC), for which focus should be on interdisciplinary aspects and at least two supervisors from two different departments/faculties must be involved.

The topic should not correspond to the topic of the master thesis, however if the master research project deals with a complex system subject – currently available only for Theoretical Physics, Experimental Physics and Climate Physics Master

programmes at Utrecht University – it is permitted to combine the research project of the master’s profile Complex Systems (15 EC) with the master thesis project. In case the master research project deals with a complex system subject, the complex systems aspects must be separately assessed and a supervisor from a different department or faculty other than the department related to the student’s master programme needs to be involved in assessing the complex system aspects of the research project.

The topic must be approved by the coordinator of the profile as well as by the coordinator of the master programme to which the student is admitted.

The total number of EC of each master’s programme will NOT be increased by completing the master profile Complex Systems. Students receive a certificate by completing the Master’s profile Complex Systems.

### Entry requirements

- The student belongs to one of the participating master programmes
- Upon consultation with the coordinator for the profile, it is also possible for students from outside Utrecht University to participate in the profile, when their master programme has an affinity to complex systems

### Participating Master’s programmes

- Climate Physics
- Computing Science
- Energy Science
- Artificial Intelligence
- Experimental Physics
- Game and Media Technology
- Mathematical Sciences
- Nanomaterials Science
- Sociology and Social Research
- Sustainable Development
- Theoretical Physics
- Multidisciplinary Economics

### List of courses labelled as a complex systems course

Master’s programme	Course	Osiris code
<b>Climate Physics</b>	Wave attractors	NS-MO447M
<b>Computing Science</b>	Data mining Pattern recognition Evolutionary algorithms	INFOMDM INFOMPR INFOEA
<b>Energy Science</b>	Energy systems modelling	GEO4-2515
<b>Experimental Physics</b>	Modelling and simulation	NS-TP432M
<b>Game and Media Technology</b>	Pattern recognition Crowd simulation	INFOMPR INFOMCRWS
<b>Artificial Intelligence</b>	Seminar social simulation	INFOMSOCs
<b>Mathematical Sciences</b>	Laboratory class for scientific computing Inverse problems in imaging* Interacting particle systems: Theory and applications* Numerical bifurcation analysis of large-scale systems*	WISM454 WISL430 WISL431 WISL425
<b>Multidisciplinary Economics</b>	Advanced behavioural and experimental finance	ECRMABEF
<b>Nanomaterials Science</b>	Toy models Modelling and simulation	SK-MTOYM NS-TP432M
<b>Sustainable Development</b>	Sustainability modelling and indicators	GEO4-2331



**Theoretical Physics**

Modelling and simulation

NS-TP432M

\* Registration via [elo.mastermath.nl](http://elo.mastermath.nl)

## Educational Profile

### Description

A major feature of the profile is the emphasis on practitioner skills and school-based activities. Throughout the programme, learning theories and teaching methods will be taught closely linked to your day to day classroom. This programme is tailored to meet the professional development needs of teachers in the early stages of their careers.

The aim of the educational profile is to:

- convey specialised knowledge, skills and insight in the field of education for one of the school subjects information technology, physics, chemistry or mathematics, as well as more in-depth and comprehensive knowledge of the domain involved;
- prepare for professional practice as a teacher in one of the above-mentioned school subjects;
- prepare for professional practice in the field of information, education and communication about the discipline, about discipline-related academic topics and their societal context, in the wider educational field, such as in educational services and science centres, with publishers, in domain-specific educational research, information and journalism.

The programme, the level that is achieved and the qualification to be obtained depend on previous qualifications obtained by the student.

### Educational Profile after a previously obtained (limited) second degree teaching qualification

#### Admission

- The student holds a (limited) second degree teaching qualification for the particular school subject;
- The exam programme of the student's current programme covers the subject matter requirements for the school subject;
- The student has demonstrated domain knowledge, understanding and academic skill that is founded upon and extends and/or enhances the level that typically associated with Bachelor's level;
- The students has the learning skills, and the social and communicative skills that are needed to develop as a teacher in secondary education.

Matching will be part of the selection procedure. The decision about admitting a candidate is up to the admissions committee of the Graduate School of Teaching.

#### Learning outcomes

The following learning outcomes pertain to students who obtained a (limited) second degree teaching qualification (for example as the result of an educational minor). The graduate of the Master's programme the profile is part of:

- has demonstrated subject- and (subject-)didactical knowledge, insights and experiences in one of the above-mentioned school subjects that is founded upon and extends and/or enhances that typically associated with the Bachelor's level, makes critical use of these in educational practice, and does so – within or outside a research context – in an academic manner, so that he or she contributes to new knowledge about the development of school subjects and education;
- demonstrably possesses adequate theoretical knowledge in the field of communication, pedagogy and educational science to be able to contribute in a

- scientifically sound manner to defining, analysing and solving problems in secondary education;
- can apply knowledge, insights and problem-solving skills in new or unfamiliar situations and broader contexts, to integrate new knowledge and to handle complex materials and processes;
- has the ability to formulate judgements, also on the basis of incomplete or limited information; to act on the basis of these judgements, taking into account social, societal and ethical responsibilities that are part of subject and profession;
- is able to clearly and unambiguously pass on knowledge, motives, motivations and the conclusions based on them to various audiences (students, colleagues, parents or guardians, specialists and lay people, within or outside school);
- has the learning skills that will allow him or her to start a follow-up study with a largely self-managing or autonomous character.

## Contents

The programme consists of the following parts, starting September 2018:

- Teaching practice 2 (15 EC, GSTMS2)
- Teaching Methodology 2 (3.75 EC, GSTALGD2)
- Subject Teaching Methodology 2 – [subject] (3.75 EC, GSTVD2IN/GSTVD2NK/GSTVD2SK/GSTVD2WK)
- Introduction Educational Research (3.75 EC, GSTPGO1)
- Practice Based Research (3.75 EC, GSTPGO2)

The programme consists of the following parts, starting February 2019:

- Teaching practice 2 (10 EC, GSTPIP2)
- Teaching Methodology 2 (2.5 EC, GSTPED2)
- Subject Teaching Methodology 2 – [Subject] (7.5 EC, GSTVAKD2IN/GSTVAKD2NK/GSTVAKD2SK/GSTVAKD2WK)
- Mandatory elective (5 EC, choose from GSTPKC01 – GSTPKC07)
- Mandatory elective (5 EC, choose from GSTOKC01 – GSTOKC10, FI-MSECSIS)

With the learning outcomes, the profile in combination with the completed Master's programme, covers the competency requirements for a first degree teacher qualification as described in the Law on professions in education ("Wet op de beroepen in het onderwijs" – Wet BIO, 2006), and the competences derived from it as described in the nationally agreed upon competency profile for academic teacher education.

## Educational profile for students without a prior educational qualification

### Admission

- The exam programme of the student's current programme covers the subject matter requirements for the school subject involved.
- The student has demonstrated domain knowledge, understanding and academic skill that is founded upon the level that typically associated with Bachelor's level.
- The students has the learning skills, and the social and communicative skills that are needed to develop as a teacher in secondary education.

Matching will be part of the selection procedure. The decision about admitting a candidate is up to the admissions committee of the Graduate School of Teaching.

### Learning outcomes

The following learning outcomes pertain to students who have no prior professional qualification for secondary education. The graduate of the Master's programme the profile is part of is able to:

- achieve good cooperation with individual pupils;

- create a safe learning environment for groups and individual pupils;
- set up a strong learning environment for groups and individual pupils, supporting pupils to gain mastery of the subject;
- create a well-organised and orderly task-oriented learning and working environment in group work and in other contacts with pupils;
- exchange relevant information with pupils' caretakers outside school, and to take care of coordination;
- give empirically grounded clarification of, critically examine and further develop his or her own views on being a teacher and his or her own teaching abilities.

## Contents

The programme consists of the following parts:

- Teaching practice 1a (10 EC, GSTPIP1A)
- Teaching practice 1b (10 EC, GSTPIP1B)
- Teaching Methodology 1 (5 EC, GSTPED1)
- Subject teaching methodology 1 - [Subject] (5 EC, GSTVAKD1IN/GSTVAKD1NK/GSTVAKD1SK/GSTVAKD1WK)

In case the student's Bachelor's programme matches with the Bachelor's programmes registered in the "Verwantschapstabel" (<http://wetten.overheid.nl/BWBR0028148/2015-10-01>), with these learning outcomes, the profile covers the competency requirements for a (limited) second degree teacher qualification for lower secondary education (vmbo-t and the lower grades in havo and vwo) as described in the Law on professions in education ("Wet op de beroepen in het onderwijs" – Wet BIO, 2006), and the competences derived from it as described in the nationally agreed upon competency profile for academic teacher education.

In any case the students will receive exemptions of 30 EC for the Master's programme for a first degree qualification.

## Non-Dutch students

The educational profile is primarily targeted towards teaching in the Dutch school system and, by default, the courses and the internships are in Dutch. However, non-native candidates are welcome provided they have a basic proficiency in Dutch. There will be limited placement opportunities in bilingual or international schools. Admission is possible if the candidate masters the Dutch language for reading and listening at B2 level. Sufficient passive control of the Dutch language can be demonstrated during either 1) the selection interview or 2) by obtaining the Reading and Listening components of the State Examination NT2 before the start of the course (minimum score 500 points). If you would be interested, please send an email to inquire about your eligibility.