Programme descriptions
Annex to the Education and Examination Regulations 2017-2018 of the Graduate School of Natural Sciences
Version 21 July 2017
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Artificial Intelligence

Admission to the degree 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, including set theory, probability theory and statistics (probabilistic models, machine learning), analysis (convergence) and linear algebra (robotics);
- 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

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 Artificial Intelligence programme is allowed.

Learning outcomes

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

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 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 of 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). Has mastery of the necessary logical, computational and experimental tools;</td>
</tr>
<tr>
<td>b) Has thorough experience with research in (pure or applied) artificial intelligence and awareness of the applicability of research in technological developments and organizational contexts;</td>
</tr>
<tr>
<td>c) Is able to read research articles in artificial intelligence.</td>
</tr>
</tbody>
</table>
Applying knowledge and understanding

a) Is capable of understanding a wide variety of different research problems in artificial intelligence and is able to formulate these at an abstract level. Is able to see, from the abstract level, the relation between diverse problems and to contribute creatively to their solution in the context of practical applications;
b) Is able to point at solutions for identified problems using the most advanced techniques from artificial intelligence;
c) Is capable of creating innovative software and information system designs, taking feasibility issues into account;
d) Has mastery of the necessary skills in theoretical analysis, modeling and experimentation.
e) Understands the potential dilemmas related to scientific integrity in his/her research field.

Making judgements

a) Is capable of assessing and discussing research results and of taking part in discussions within the research group;
b) 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;
c) Is capable of reflecting on his/her own activities as a researcher and is aware of social and ethical responsibilities concerning application of research.

Communication

a) 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;
b) Is capable of working in a (possibly interdisciplinary) team of experts performing the aforementioned activities and communicating easily in both written and spoken English.

Learning skills

a) Is capable of working independently and of taking initiatives where necessary; is capable of identifying areas where expertise is lacking and remediying the situation;
b) Is capable of writing a research proposal and independently carrying out research in an area of artificial intelligence;
c) Has the qualification to obtain a PhD position in the area of specialization or a key position in the software industry, in IT consultancy or at IT departments of organizations.
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: 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

<table>
<thead>
<tr>
<th>Course Type</th>
<th>Credits (EC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory courses</td>
<td>22.5</td>
</tr>
<tr>
<td>Primary electives</td>
<td>22.5</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>30</td>
</tr>
<tr>
<td>Research part</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong> EC</td>
</tr>
</tbody>
</table>

Students can select one of three currently approved study paths:
- Agents
Programme descriptions

- Cognitive Processing
- Reasoning

**Mandatory courses**

- Methods in AI Research (INFOMMAIR) (15 EC)
- Philosophy of AI (WBMV05003) (7.5 EC)

**Primary electives – mandatory per study path**

Three courses per study path, each 7.5 EC:

- Agents:
  - Intelligent Agents (INFOIAG)
  - Multi-Agent Systems (INFOMAS)
  - Multi-agent Learning (INFOMAL)
- Cognitive Processing:
  - Cognitive Modeling (INFOMCM)
  - Experimentation in Psychology and Linguistics (INFOMEPL)
  - Advanced Topics in Cognitive Science (INFOMATCS)
- Reasoning:
  - 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)
- 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 (INFOME), Enterprise Architecture (INFOEAR), Seminar Software ecosystems (INFOMSSE), Business Intelligence (INFOMBIN)
- Choice of other master courses within or outside the UU (subject to approval; courses from other universities in the Netherlands or other countries must also be approved by the Board of Examiners.)
- Courses to restore deficiencies, see below:

Logica voor Informatica (INFOB1LI)
Logica voor AI (INFOLAI)
Intelligente Systemen (INFOB3IS)
Computationele Intelligentie (INFOB3CI)
Modelleren en programmeren voor KI (K1V13009)
Databases (INFODB)
Datastructuren (INFODS)
Inleiding Cognitiewetenschap (K1V13002)
Experimentele methoden en statistiek (K1V13002)
inleiding taalkunde (K1V13004)
computationele linguïstiek (K2V13007)
Logische Complexiteit (K3V12013)
Research part

In the research part the student carries out a research project under the supervision of one of the staff members of the research groups offering the programme. Part of the research part is a master introduction programme and a discussion of scientific integrity. The research project is split into two parts of, respectively, 14 and 30 ec. The research project should be done on a topic related to core courses.

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 AI programme leader.

The research part is split into the following courses:
- Introducing Natural Sciences (INTRO-GSNS; 0,5 EC)
- Dilemmas for the scientist (FI-MHPSDIL; 0,5 EC)
- Artificial intelligence MSc thesis Part I (INFOMAI1; 14 EC)
- Artificial intelligence MSc thesis Part II (INFOMAI2; 30 EC)

Part I of the Thesis project can without specific approval of the AI programme leader only be started when both of the following conditions are met:
- the student has passed all mandatory courses and primary electives
- the student has obtained at least 60 ec.

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

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)

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with an educational or ‘applied data science’ 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.

<table>
<thead>
<tr>
<th>Course Type</th>
<th>EC</th>
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</thead>
<tbody>
<tr>
<td>Mandatory courses</td>
<td>22.5</td>
</tr>
<tr>
<td>Primary electives</td>
<td>22.5</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>0</td>
</tr>
<tr>
<td>Research part</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90</strong></td>
</tr>
</tbody>
</table>

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

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 enrolled into this programme prior to 1 September 2016. Instead, the course Msc Project Artificial Intelligence (INFOMAI2) will be 45 credits. This provision ends 31 August, 2018.
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)
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;
• 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.

Admission to the programme

Students qualify for admission to this programme if they possess in particular skills and knowledge of at least three out of the following subjects: 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.

Premasters programme

Students with a Dutch "HBO"-degree are only eligible for admission when they have passed successfully a tailor-made premasters programme of a maximum of 30 EC. 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. 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 in Nanomaterials Science:

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
<th>Applying knowledge and understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Has knowledge of and insight into nanomaterials with an emphasis on colloids, catalysts, and condensed matter;</td>
<td>a) Is able to formulate an original research question for the synthesis of nanomaterials, or for obtaining new knowledge of the chemical or physical</td>
</tr>
<tr>
<td>b) Is able with this knowledge to contribute to scientific research in these areas using appropriate methods and instrumentation;</td>
<td>b)</td>
</tr>
<tr>
<td>c) Is aware of recent developments in the research of colloids, catalysis and condensed matter.</td>
<td>c)</td>
</tr>
<tr>
<td>d) Understands the relevance of these developments for his/her scientific discipline.</td>
<td>d)</td>
</tr>
<tr>
<td>e) 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.</td>
<td>e)</td>
</tr>
</tbody>
</table>
properties of such materials;

b) Is able to design 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 according to the rules of good experimental practice and ethics.
d) Is able to analyze and interpret the acquired materials and/or data according to scientific standards.

**Making judgments**

a) Is able to participate critically and constructively in the scientific debate in the research group;
b) Understands the potential dilemmas related to scientific integrity in his/her research field;
c) Is able to indicate the relevance of his/her research for the advancement of the chemistry and physics of nanomaterials;
d) Is able to reflect critically upon his/her own contribution to nanomaterials research, and that of others.

**Communication**

a) Has the skills to discuss, both in spoken and written English, the results of research, including the underlying knowledge and background;
b) Is able to function effectively in a possibly multidisciplinary team of experts working in the area of chemistry and physics of nanomaterials.

**Learning skills**

a) Has the skills to evaluate his/her own learning and development process and to adjust this process if necessary;
b) Displays a professional and academic work attitude that enables him/her to work in an area related to the research on nanomaterials;
c) Has a realistic idea of the career opportunities after graduating, and of the skills that he/she needs to successfully start a career;
d) Is qualified to acquire a research position in a (semi) public or commercial organization;
e) Has the qualifications to enroll in a PhD programme in one of the research groups of the Debye Institute or of related institutes working in the area of colloids, catalysis, or condensed matter;

**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 h/w** for the whole programme excluding the research part of 52,5 EC and the internship of 30 EC. The number of contact hours for a student in the research part as well as the internship of the programme is specified in individual application forms. 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).

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<tbody>
<tr>
<td>Mandatory courses</td>
<td>15 EC</td>
</tr>
<tr>
<td>Primary electives</td>
<td>22,5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>30 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>52,5 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120 EC</strong></td>
</tr>
</tbody>
</table>
Mandatory course

Academic Context Course (SK-MACCO): 6.5 EC
Introducing natural sciences (GSNS-INTRO): 0.5 EC
Scientific Integrity (Dilemmas of the scientist; FI-MHPSDIL): 0.5 EC
Adsorption, Kinetics and Catalysis (SK-MAKC): 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. The basic course for the Inorganic Chemistry and Catalysis group is mandatory for all students.

<table>
<thead>
<tr>
<th>Research group</th>
<th>Course (7.5 EC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensed Matter and Interfaces</td>
<td>Advanced Spectroscopy of Nanomaterials (SK-MASPN)</td>
</tr>
<tr>
<td>Inorganic Chemistry and Catalysis</td>
<td>Adsorption, Kinetics and Catalysis (SK-MAKC)</td>
</tr>
<tr>
<td>Organic Chemistry and Catalysis</td>
<td>Organometallic Chemistry and Homogeneous Catalysis (SK-MOCHC)</td>
</tr>
<tr>
<td>Physical and Colloid Chemistry</td>
<td>Colloid Science (SK-MCS)</td>
</tr>
</tbody>
</table>

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. Courses labeled with a P are provided by the Department of Physics and Astronomy. One course is offered by the Faculty of Geosciences, abbreviated with the label GEO.

Advanced Physical Chemistry (SK-MPC3)
Advanced Spectroscopy of Nanomaterials (SK-MASPN)
Colloid Science (SK-MCS)
Computational Quantum Mechanics (NS-NM431M) (P)
Experimental Quantum Physics (NS-EX401M) (P)
Organometallic Chemistry and Homogeneous Catalysis (SK-MOCHC)
Organic Synthesis Strategies (SK-MOSS)
Photon Physics (NS-EX418M) (P)
Modelling and Simulation (NS-TP432M) (P)
Soft Condensed Matter Theory (NS-TP453M) (P)
Photovoltaic Solar Energy Physics (GEO4-2513) (GEO)
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)(P)
Application of Light (and Electron microscopy) (3 EC, NS-EX419M)(P)1

1 This course is offered every two year and will not be scheduled in 17-18.

Secondary electives

For the remaining 30 EC, several options are possible such as any MSc course offered by the Graduate Schools of Natural Sciences including the remaining primary elective courses, courses offered by the Graduate School of Life Sciences or other courses with permission from the programme director, or a 15 to 30 EC internship outside Utrecht University.

There is no permission to follow bachelor courses unless it is stated as a deficiency in the Letter of Admission.

Internships can only start as soon as the mandatory, primary elective courses and the research project of 52.5 EC have been finished.

Secondary electives can also be those courses required to fulfill the admission requirements in the case of deficiencies (not more than a maximum of 15 EC). The programme director decides which of the courses aiming to catch-up skills and/or knowledge need to be followed during the master’s programme. Deficiencies will be stated in the Letter of Admission.
Programme descriptions

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 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. 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.

Labour market perspectives and scientific integrity

Both topics already start at the Graduate School’s Introduction days.

Labour market perspectives are part of:
- the mandatory Academic Context Course. It comprises: participating to the annual career event/week with labour market representatives and alumni, participating at workshops during the Graduate Schools’ Introduction, following Debye lunches and lectures;
- the internship for 30 EC in a company;
- courses taught by a lecturer with a combined appointment at the Academia and Industry;
- the course *Teaching in the Academia* of 1 EC (on top of the regular 120 EC programme) to receive a professional training in teaching and assessing bachelor’s students. This training is taken prior to the appointment of a student assistantship supporting bachelor student’s laboratory sessions and/or seminars.

Scientific Integrity will be assessed 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 an *educational, a 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.

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>15 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>0 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>52.5 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90 EC</strong></td>
</tr>
</tbody>
</table>
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.
Chemical Sciences

Nanomaterials: Chemistry & Physics
This programme can be completed within the framework of two degrees:

1) Chemical Sciences
2) Physics & Climate Science

This programme will end on August 31, 2018. Students who do not graduate before this date, must comply to the Nanomaterials Science programme before graduation.

Admission to the programme
There is no admission anymore

Learning outcomes

The graduate of the master’s programme in Nanomaterials: Chemistry & Physics:

Knowledge and understanding

d) Has knowledge of and insight into nanomaterials with an emphasis on colloids, catalysts, and condensed matter;
e) Is able with this knowledge to contribute to scientific research in these areas using appropriate methods and instrumentation;
f) Is aware of recent developments in the research of colloids, catalysis and condensed matter.
d) Understands the relevance of these developments for his/her scientific discipline.
e) 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.

Applying knowledge and understanding

e) Is able to formulate together with the supervisor an original research question for the synthesis of nanomaterials, or for obtaining new knowledge of the chemical or physical properties of such materials;
f) 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;
g) 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.
h) Is able to analyze and interpret the acquired materials and/or data according to scientific standards.

Making judgments

e) Is able to participate critically and constructively in the scientific debate in the research group;
f) Is able to indicate the relevance of his/her research for the advancement of the chemistry and physics of nanomaterials;
g) Is able to reflect critically upon his/her own contribution to nanomaterials research, and that of others.

Communication

c) Has the skills to discuss, both in spoken and written English, the results of research, including the underlying knowledge and background;
d) Is able to function effectively in a possibly multidisciplinary team of experts working in the area of chemistry and physics of nanomaterials.

Learning skills

f) Has the skills to evaluate his/her own learning and development process and to adjust this process if necessary;
g) Displays a professional and academic work attitude that enables him/her to work in an area related to the research on nanomaterials;  
h) Is qualified to acquire a research position in a (semi) public or commercial organization;  
i) Has the qualifications to enroll in a PhD programme in one of the research groups of the Debye Institute or of related institutes working in the area of colloids, catalysis, or condensed matter;

**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 h/w** for the whole programme excluding the research part and the internship of 30 EC. The number of contact hours for a student in the research part as well as the internship of the programme is specified in individual application forms. In the case that a student opts for 60 EC course work, the scheduled hours amount to **640 hours or 16h/w**.

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<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>7.5 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>30 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120 EC</strong></td>
</tr>
</tbody>
</table>

**Mandatory course**

Nanomaterials: Catalysis, Colloids and Nanophotonics (SK-MNCCN).  
This course has been taught for the last time in September 2016.

**Primary electives**

**Chemical Sciences** students must take 3 courses irrespective of their signature, while **Physics and Climate Science students** must take 3 courses with a Physical Sciences (P) or a combined C/P signature. All courses have a study load of 7.5 EC. Before choosing these courses, students should first check the course requirements of each research group.

<table>
<thead>
<tr>
<th>Chemistry courses (C)</th>
<th>Physics courses (P)</th>
<th>Interdisciplinary courses (C/P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Synthesis Strategies (SK-MOSS)</td>
<td>Soft Condensed Matter Theory (NS-TP453M)</td>
<td>Computational Quantum Mechanics (NS-NM431M) (P)</td>
</tr>
<tr>
<td>Advanced Spectroscopy of Nanomaterials (SK-MASPN)</td>
<td>Photon Physics (NS-EX418M)</td>
<td>Colloid Science (SK-MCS)</td>
</tr>
<tr>
<td>Solids &amp; Surfaces (SK-MSOLS)</td>
<td>Modelling and Simulation (NS-TP432M) (P)</td>
<td>Advanced Physical Chemistry (SK-MPC3)</td>
</tr>
<tr>
<td>Adsorption, Kinetics and Catalysis (SK-MAKC)</td>
<td>Experimental Quantum Physics (NS-EX401M)</td>
<td>Application of Light (and Electronmicroscopy) (3 EC, NS-EX419M)(P)¹</td>
</tr>
<tr>
<td>Organometallic Chemistry and Homogeneous Catalysis (SK-MOCHC)</td>
<td></td>
<td>Toy Models (SK-MTOYM)</td>
</tr>
</tbody>
</table>

¹ This course is offered every two year and will not be scheduled in 17-18.
Secondary electives

For the remaining 30 EC, several options are possible such as any MSc course offered by the Graduate Schools of Natural and Life Sciences or other courses with permission from the programme directors, or a 15 to 30 EC internship outside Utrecht University. Internships can only start as soon as the mandatory and primary elective courses and the research project of 60 EC have been finished. Secondary electives can also be those courses required to fulfill the admission requirements in the case of deficiencies (not more than a maximum of 15 EC). The programme director decides which of the courses aiming to catch-up skills and/or knowledge need to be followed during the master’s programme. Deficiencies will be stated in the Letter of Admission.

Research part

The research is done in one of the research groups of the Debye Institute 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. The student may start with his/her research project before the completion of the mandatory course with the permission of his/her supervisor. Research group specific requirements, such as a literature thesis, primary elective courses, or other activities, are noted on the research project application form before the start of the project.

Educational/Complex Systems and Applied Data Science Profiles

Instead of the regular programme described above, the student may elect to replace 30 EC of the regular programme with a profile. The contents and further description of the profiles, including entry requirements to specific courses, is described at the end of this 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 a profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

<p>| | |</p>
<table>
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<tr>
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<tbody>
<tr>
<td>Mandatory courses</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>0 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90 EC</strong></td>
</tr>
</tbody>
</table>
Debye Honours programme in Nanomaterials Science

Admission Criteria and Selection Committee

The applicant should satisfy the admission criteria for the master’s programme Nanomaterials Science.

Selection

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.

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: 450 hours or 12 h/w for the whole programme excluding the research part and the internship of 30 EC. The number of contact hours for a student in the research part as well as the internship of the programme is specified in individual application forms.

Contents

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>15 EC</th>
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</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>37.5 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>135 EC</strong></td>
</tr>
</tbody>
</table>

Mandatory course

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): 0.5 EC
Adsorption, Kinetics and Catalysis (SK-MAKC): 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 (outside Utrecht University). Going abroad is highly stimulated. Alternatively the internship might be performed at an outstanding research laboratory of a multinational such as Philips, Shell, DSM and BASF.

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:

<table>
<thead>
<tr>
<th>Part 1:</th>
<th>15 EC; SK-MRES1</th>
<th>Introduction to research and initiating the research project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 2:</td>
<td>45 EC; SK-MRES2</td>
<td>Research project and thesis including the research paper or PhD proposal</td>
</tr>
</tbody>
</table>

Successfully completing Part 1 (SK-MRES1) is a mandatory prerequisite to continue with Part 2 (SK-MRES2). 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. 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.
Debye Honours programme in Nanomaterials: Chemistry and Physics

Admission Criteria and Selection Committee

Admission possible to this honours programme is closed. The honours programme will end on August 31, 2018. There is no re-enrolment to the Debye honours programme in Nanomaterials Science after the ending of this programme.

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: 450 hours or 12 h/w for the whole programme excluding the research part and the internship of 30 EC. The number of contact hours for a student in the research part as well as the internship of the programme is specified in individual application forms.

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<tr>
<td>Secondary electives</td>
<td>45 EC</td>
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<tr>
<td>Research part</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>135 EC</strong></td>
</tr>
</tbody>
</table>

Mandatory and primary electives

Honours students follow the mandatory course Nanomaterials: Catalysis, Colloids and Nanophotonics (SK-MNCCN) and take three courses (each 7.5 credits) from the Debye list of courses which is given in the programme description of the Nanomaterials: Chemistry & Physics 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 who will graduate in Chemical Sciences, at least two courses with the label C/P or P are needed, while for honours students who will graduate in Physics and Climate Science at least two courses with the label C/P or C must be taken. These label prerequisites can also be obtained by choosing secondary courses.

Secondary electives

Honours students are expected to take courses of 15 EC in addition to the primary courses. These courses are meant to fulfill the label requirements or can be chosen from another master’s programme 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 (outside Utrecht University). Going abroad is highly stimulated. Alternatively the internship might be performed at an outstanding research laboratory of a multinational such as Philips, Shell, DSM, BASF.

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
52.5 EC of the research will be spent 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.

Profiles

Within this honours programma there is no room for taking a profile.

The programme description of this honours programme leading to two degrees in Chemical Sciences and in Physics and Climate Science is given in the physics section.
Computer Science

Computing Science

Admission to the degree Computer Science

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

Degrees in all probability meeting these requirements are:
- A BSc 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 (‘profileringsruimte’) 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, and
- 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 the master’s programme ‘ Computing Science’. Suitable standards must be achieved in basic backgrounds, as in the UU major, in the domains of programming (Java, C#, Haskell, software engineering) and algorithmic and formal methods (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 the 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 standard 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:

**Knowledge and understanding**

- 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.

**Applying knowledge and understanding**

- 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.

**Making judgments**

- 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.

**Communication skills**

- 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.

**Learning skills**

- 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 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.
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<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>30     EC</td>
</tr>
<tr>
<td>Research part</td>
<td>45     EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong> EC</td>
</tr>
</tbody>
</table>

Format

Study paths
Students follow individual study paths, under approval of the programme director. The student can follow an individual study path, to be approved by the programme director, or follow one of the following study paths that are pre-defined and set the standard for the programme, with options depending on the specific research orientation of the student:

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

Mandatory courses

Algorithms for decision support (INFOMADS) (7.5 EC)
Concepts of program design (INFOMCPD) (7.5 EC)
Big data (INFOMBD) (7.5 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 the pre-defined study paths, these courses are:

- Programming technology:
  Advanced functional programming, compiler construction, program semantics and verification, technologies for learning.
- Algorithm design and analysis:
  Geometric algorithms, algorithms and networks, scheduling and time-tabling, path planning.
- Advanced planning and decision making:
  Probabilistic reasoning, algorithms and networks, evolutionary computing, scheduling and time-tabling.
- Algorithmic data analysis:
  Data mining, multimedia retrieval, pattern recognition, pattern set mining.

Secondary Electives

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

- Courses listed under core courses that are not part of the primary elective courses in the chosen study path (so, these can be courses from other Computing Science’s study paths).
- 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.
Programme descriptions

Each of the courses below is 7.5 EC, and note that they are only given in the Dutch language.

- Logica voor informatica (INFOB1LI)
- Databases (INFODB)
- Datastructuren (INFODS)
- Functioneel programmeren (INFOFP)
- Modelleren en systeemontwikkeling (INFOMSO)
- Onderzoeksmethoden voor informatica (INFOB3OMI)
- Onderzoeksmethoden voor gametech (INFOB3OMG)
- Optimalisering en complexiteit (INFOOPT)
- Talen en compilers (INFOB3TC)
- Algoritmiek (INFOAL)
- Software testing en verificatie (INFOB3STV)
- Data-analyse en retrieval (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 core courses.

The research part is split into the following courses:

- Thesis project Part I (15 EC)
- Thesis project Part II (25 EC)
- The Computing Science colloquium (4 EC)
- Introducing Natural Sciences (GSNS-INTRO, 0.5 EC)
- Dilemmas of the Scientist (FI-MHPSDIL, 0.5 EC)

Part I of the 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.

Core courses in the Computing Science programme

All courses are 7.5 EC

- Advanced functional programming (INFOAFP)
- Algorithms and networks (INFOAN)
- Algorithms for decision support (INFOMADS)
- Big data (INFOMBD)
- Compiler construction (INFOMCCO)
- Data mining (INFOMDM)
- Evolutionary computing (INFOEA)
- Geometric Algorithms (INFOGA)
- Multimedia retrieval (INFOMR)
- Pattern recognition (INFOMPR)
- Pattern set mining (INFOMPSM)
- Probabilistic reasoning (INFOPROB)
- Program semantics and verification (INFOMPSV)
- Scheduling and time tabling (INFOSTT)
- Technologies for learning (INFOMTFL)
- Network Science (volgt nog)

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.
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.

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>22.5 EC</th>
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<tbody>
<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
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<tr>
<td>Secondary electives</td>
<td>0 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>45 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90 EC</strong></td>
</tr>
</tbody>
</table>

Special provisions for students who enrolled in the programme Computing Science in the year 2015-2016 and earlier

The courses *Introducing Natural Sciences* (GSNS-intro), *Dilemmas of the scientist* (FI-MHPSDL; 0,5 EC) are not mandatory for students enrolled into this programme prior to 1 September 2016. Instead, the colloquium will be 5 credits (INFOMCCS). This provision ends 31 August, 2018
Computer Science

Game and Media Technology

Admission to the degree computer science

Applicants should possess:

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

Degrees in all probability meeting these requirements are:

- A BSc 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 or C++;
- knowledge of data structures, algorithms and related concepts of reasonable complexity, such as sorting algorithms, O(..)-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:

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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</td>
</tr>
</tbody>
</table>
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.

**Applying knowledge and understanding**

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.

**Making judgments**

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 whereever 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.

**Communication skills**

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.

**Learning skills**

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.

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<td>Primary electives</td>
<td>45</td>
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<tr>
<td>Secondary electives</td>
<td>15</td>
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<tr>
<td>Research part</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>

**Mandatory courses**
Programme descriptions

INFOMCV  computer vision,
INFOMOMA  motion and manipulation

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),
INFOMOV  optimization and vectorization (7.5 EC),
INFOMPAPL  crowd simulation (7.5 EC),
INFOMR  multimedia retrieval (7.5 EC),
INFOMSMT  sound and music technology (7.5 EC),
INFOMPAPL  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 (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.

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  algoritmiek (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)
GSNS-INTRO  introducing natural sciences (0.5EC)
FI-MHPSDL  dilemmas of the scientist (0.5EC)

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.

Labour market perspectives and scientific integrity

Scientific integrity is a part of the colloquium (INFOMCGM4) 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 (15 EC) and the research part (45 EC) do not change.

<table>
<thead>
<tr>
<th>Course Type</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory courses</td>
<td>15</td>
</tr>
<tr>
<td>Primary electives</td>
<td>30</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>0</td>
</tr>
<tr>
<td>Research part</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90</strong></td>
</tr>
</tbody>
</table>

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

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, 2018.
History and Philosophy of Science

Admission to the degree in History and Philosophy of Science

At the start of their master studies, students 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.

In the case of BSc degree graduates, students with a minor in History and/or Philosophy are especially encouraged to enroll.

In the case of BA degree graduates, students with a major in History or Philosophy, and a minor in one of the sciences are especially encouraged to enroll.

In the other cases the candidate should be able to demonstrate an interest in history and/or philosophy of the sciences and/or of the humanities.

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 to the History and Philosophy of Science programme is allowed.

Learning outcomes

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

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Has a basic knowledge and understanding of the main issues in history and philosophy of the sciences and the humanities.</td>
</tr>
<tr>
<td>b) Has detailed knowledge of one of the areas of history and/or philosophy of the sciences and the humanities.</td>
</tr>
<tr>
<td>c) Is able to contribute to scientific research in one of these areas using an appropriate methodology.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>f) Understands the potential dilemmas related to scientific integrity in his/her research field.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Applying knowledge and understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Is able to formulate an original research question in one of these areas relevant for scientific development, education, or public understanding.</td>
</tr>
<tr>
<td>b) Is able to formulate a fitting research plan in accordance with scientific and methodological standards.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>e) Is able to carry out a research plan according to the rules of good practices and ethics.</td>
</tr>
</tbody>
</table>

Making judgements
Programme descriptions

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.

Communication

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.

Learning skills

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

<table>
<thead>
<tr>
<th>Course Type</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory courses</td>
<td>30</td>
</tr>
<tr>
<td>Primary electives</td>
<td>30</td>
</tr>
<tr>
<td>Secondary elective</td>
<td>7.5</td>
</tr>
<tr>
<td>Research part</td>
<td>52.5</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
</tr>
</tbody>
</table>

Mandatory courses and primary electives reflect the body of knowledge in which a student must be sufficiently prepared to successfully engage in research. At least 30 EC of primary electives need to be taken. A secondary elective can be used for further specialization.

Mandatory courses

- FI-MHPSSHNS  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)
• Introduction programme of the graduate school: introducing natural sciences (INTRO-GSNS: 0.5 EC) and scientific integrity Dilemmas of the Scientist (FI-MHPSDIL; 0.5 EC)

**Primary electives**

At least 30 EC, to be chosen out of the following list:
- FRRMV17003 Topics in Philosophy of Language and Logic
- 201500160 Philosophy of the Social Sciences
- B-B3GESB05 Geschiedenis en Filosofie van de Biologie
- BMB507812 History of the Medical Sciences
- FA-332 Verslaving en verslavingsmiddelen
- FI-MHPSDM Science and the Dilemmas of Modernity
- FI-MHPSFQM Foundations of Quantum Mechanics
- FI-MHPSFST Philosophy of Space and Time
- FI-MHPSPLS Philosophy of the Modern Life Sciences
- FI-MHPSPSI Professional Skills and Identity
- FI-MHPSSEM Research Seminar
- FI-MHPSSP Science and the Public
- FI-MHPSTOP Special Topic
- FI-MHPSTU2 Tutorial 2
- FI-MHPSTUT Tutorial HPS
- FI-MSECSS Science in Society
- FRRMB16014 History and Philosophy of Objectivity
- FRRMV16015 20th century German Philosophy (Habermas)
- FRRMV16020 Current Issues in Analytic Philosophy
- FFRMV17002 Topics in German Idealism
- FRRMV17007 Topics in Philosophy of Mind
- NS-361B Geschiedenis van de Moderne Natuurkunde
- OFRM16006 Tutorial Philosophy
- OFRM16007 Tutorial Philosophy 2
- RGMAWE100 Law as an academic discipline
- WBMV05003 Philosophy of Artificial Intelligence
- WBMV13005 Logic and Computation
- WISB382 Geschiedenis van de wiskunde
- WISM481 Research Seminar History of Mathematics

**Secondary electives**

• Any master course, 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-MHPSSEM.

Students who have not yet passed all required courses can only start the research part after the approval of the HPS programme director.

**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 stimulated 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 Masters introduction of the graduate school.

**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 and workshops on career perspectives
- Personal counseling by the tutor.
- UU Career Services.

**Educational Profile**

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 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.

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>30 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>0 EC</td>
</tr>
<tr>
<td>Research part: thesis proposal and small thesis</td>
<td>37.5 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90 EC</strong></td>
</tr>
</tbody>
</table>

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.

**Special provisions for students who enrolled in the programme History and Philosophy of Science in the year 2015-2016 and earlier**

The courses Introducing Natural Sciences (GSNS-intro), Dilemmas of the scientist (FI-MHPSDIL; 0.5 EC) and the thesis split components FI-MHPSRPP and FI-MHPSRP are not mandatory for students enrolled into this programme prior to 1 September 2016. Instead, one large research project (FI-MHPSRP, 52.5 credits) is required, and the course FI-MHPSSEM will be 7.5 credits. This provision ends 31 August, 2018.
Honours programme History and Philosophy of Sciences and Mathematical Sciences

Admission Criteria

The applicant should satisfy the admissions criteria for the master’s programmes Mathematical Sciences and History and Philosophy of Science (hereafter HPS), which are stated in the corresponding programme descriptions.

Selection

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

Contact hours

The average number of contact hours for a student of this programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is estimated at 10 hours per week on average 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

<table>
<thead>
<tr>
<th>Mandatory HPS courses</th>
<th>29 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory Mathematics courses</td>
<td>15 EC</td>
</tr>
<tr>
<td>Introduction programme of the graduate school: introducing natural sciences (INTRO-GSNS: 0,5 EC) and scientific integrity Dilemmas of the scientist (FI-MHPSDIL; 0,5 EC)</td>
<td>1 EC</td>
</tr>
<tr>
<td>Primary electives HPS</td>
<td>30 EC*</td>
</tr>
<tr>
<td>Primary electives Mathematics</td>
<td>45 EC*</td>
</tr>
<tr>
<td>Research Part</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>180 EC</strong></td>
</tr>
</tbody>
</table>

* Alternatively, students may take 22.5 EC of optional HPS courses and 37.5 EC of optional Mathematics courses, and conduct an additional 15 EC internship. The topic of this internship/research project should be different from that of the Research Part in the table above, and requires approval of both programme directors.

Mandatory HPS courses

<table>
<thead>
<tr>
<th>FI-MHPSHNS</th>
<th>History of the Natural Sciences</th>
<th>7.5 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI-MHPSPS</td>
<td>Philosophy of Science</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>OGMV05006</td>
<td>History of the Humanities</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>FI-MHPSSEM</td>
<td>Research Seminar (including scientific integrity and master’s introduction)</td>
<td>6.5 EC</td>
</tr>
</tbody>
</table>

Mandatory Mathematics courses

<table>
<thead>
<tr>
<th>WISM102</th>
<th>Orientation on Mathematical Research</th>
<th>7.5 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISM101</td>
<td>Mathematics for Industry</td>
<td>3.75 EC</td>
</tr>
</tbody>
</table>
Primary Electives HPS

The list of primary electives is specified in the HPS programme description.

Primary electives Mathematics

See the programme appendix of Mathematical Sciences. The optional courses should include a seminar.

Research part

Students who are registered (1) for both the master’s programme in HPS and the master’s programme in Mathematical Sciences, and (2) are registered for the honours programme in HPS and Mathematics and (3) fulfill all of the other requirements to successfully complete the honours programme, can do a thesis project of 60 EC, co-supervised by a staff member each of the Descartes Centre and the Mathematics Institute.

The research part is split as follows:

- Thesis project part 2 (FI-MHPSRP): 45 EC

The thesis has to meet the standard of both programmes.

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

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 60 EC after 1 year. Students who do not meet these criteria may be excluded from the honours programme by the selection committee.
Information Science

Business Informatics

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

Applicants should possess at least four 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 premasters 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.

Premaster programme

The premaster programme is tailored to the specific needs of the students and consists of courses from the bachelor in Information Science. Size of the premaster programme is minimum 15 EC and maximum 30 EC. The premaster programme should be finished (i.e. all courses passed) before entry into the Business Informatics programme is allowed. Half of all pre-master courses must be mandatory courses in the bachelor program of information science.

Learning outcomes

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

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Has theoretical and practical knowledge of advanced general subject such as methodology of development, implementation and adoption of software products, and ICT entrepreneurship.</td>
</tr>
<tr>
<td>b)</td>
<td>Is able with this knowledge to contribute to scientific research in these areas using an appropriate methodology.</td>
</tr>
<tr>
<td>c)</td>
<td>Is aware of important recent developments on subject such as methodology of development, implementation and adoption of software products, and ICT entrepreneurship.</td>
</tr>
<tr>
<td>d)</td>
<td>Understands the relevance of these developments for his/her scientific discipline.</td>
</tr>
<tr>
<td>e)</td>
<td>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.</td>
</tr>
<tr>
<td>f)</td>
<td>Has the skills to relate this literature to his/her own research.</td>
</tr>
</tbody>
</table>
g) Has insight into the integrity dilemmas that occur in the domain.

**Applying knowledge and understanding**

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.

**Making judgements**

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.

**Communication**

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.

**Learning skills**

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**

<table>
<thead>
<tr>
<th>Category</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory courses</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Primary electives</td>
<td>15-52.5 EC</td>
</tr>
<tr>
<td>Secondary electives and deficiency courses**</td>
<td>0-22.5 EC</td>
</tr>
<tr>
<td>Research</td>
<td>45 EC</td>
</tr>
<tr>
<td><strong>Total</strong>*</td>
<td><strong>120 EC</strong></td>
</tr>
</tbody>
</table>

* The total always has to add up to at least 120EC.
** Deficiency courses are courses that fill in gaps in the knowledge of students, typically from the information science bachelor program.
Programme descriptions

**Mandatory courses**
- Advanced Research Methods (INFOARM)
- Method Engineering (INFOME)
- Knowledge Management (INFOKMT)

**Primary electives**
- Business Intelligence (INFOMBIN)
- Enterprise Architecture (INFOEAR)
- Game Production (INFOMGPR)
- ICT Advisory (INFOMICTA)
- ICT Entrepreneurship (INFOIE)
- Software Architecture (INFOMSWA)
- Software Product Management (INFOMSPM)
- Mobile Interaction (INFOMOB)
- Data Mining (INFOMDM)
- Simulation (INFOSIM)
- Technologies for Learning (INFOMTFL)
- Software Ecosystems (INFOMSSE)
- Data Science and Society (INFOMDSS)

**Primary electives (Seminars, max 2 per program)**
- Seminar Multimedia Discourse Interaction
- Seminar Medical Informatics (INFOMSMI)
- Seminar Serious Gaming (INFOMSEGA)
- Seminar Text Mining

**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).
- A maximum of three secondary electives can be followed without deficiencies.

**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.

**Research part**
The research part consists of the following:
- Thesis Project Part 1: 14EC
- Thesis Project Part 2: 25EC
- MBI Colloquium (INFOCQMBI3): 4EC
- Introduction to MBI: 1EC
- GSNS Introduction Courses: 1EC

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.

**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 more than 50% 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
• 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 MBI 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

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 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 90EC must be filled in as described below. Note that if the student fails to succesfully 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.

<table>
<thead>
<tr>
<th>Category</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory courses</td>
<td>22.5</td>
</tr>
<tr>
<td>Primary electives</td>
<td>15-30</td>
</tr>
<tr>
<td>Deficiency courses**</td>
<td>0-7.5</td>
</tr>
<tr>
<td>Profile courses and projects</td>
<td>30</td>
</tr>
<tr>
<td>Research</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>

* The total always has to add up to at least 120EC.
** Deficiency courses are courses that fill in gaps in the knowledge of students, typically from the information science bachelor program.

Special provisions for students who enrolled in the programme Business Informatics in the year 2015-2016 and earlier

The courses Introducing Natural Sciences (GSNS-intro), Dilemmas of the scientist (FI-MHPSDIL; 0,5 EC) are not mandatory for students enrolled into this programme prior to 1 September 2016. Instead, this course is replaced in the research part by a 24EC graduation project.

Students who enrolled prior to the 1st of September 2015 also do not have to adopt the thesis split although they are advised to do so. For those that opt out, the courses INFOMMBI (40EC), INFOCQMBI4 (4EC), and INFOSPMBI (1EC) make up the research part.

These provisions end 31 August, 2018.
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.

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

- A BSc with a major in Mathematics
- A BSc with a major in Physics, 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:

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) a theoretical and practical understanding of advanced general concepts, principles and techniques of fundamental and/or applied mathematics;</td>
</tr>
<tr>
<td>b) an overview of the area of scientific research and development in question;</td>
</tr>
<tr>
<td>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;</td>
</tr>
<tr>
<td>d) an overview of the role of dilemmas of integrity in scientific research.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Applying knowledge and understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) the ability to independently identify, formulate, analyse and suggest possible solutions to problems in the field of mathematical sciences;</td>
</tr>
<tr>
<td>b) the ability to assimilate complex mathematical ideas and arguments;</td>
</tr>
<tr>
<td>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)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Making judgements</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Communication skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) the ability to cooperate in a, possibly interdisciplinary, team of experts;</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) the ability to reflect on one’s own research and on research of others;</td>
</tr>
</tbody>
</table>
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.

**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**

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>15 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>45 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>15 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>45 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong> EC</td>
</tr>
</tbody>
</table>

For students that started before September 2016:

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>0 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>58 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>15 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>47 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong> EC</td>
</tr>
</tbody>
</table>

**Mandatory courses**

- Orientation on Mathematical Research (WISM102, 7.5 EC)
- Mathematics for Industry (WISM101, 3.75 EC)
- Mathematical Colloquium (WISM100, 3.75 EC)

For students that started before September 2016 the above courses are not mandatory.

**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:

Algebraic Geometry and Number Theory (AGNT)

Applied Analysis (AA)

Complex Systems (CS)

Differential Geometry and Topology (DGT)

Logic (L)

Probability, Statistics, and Mathematical modelling (PS)

Pure Analysis (PA)

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. For the year 2017-2018 the student can choose from WISM409, WISM470, WISM540, WISM558, WISM551, WISM566, WISM565. 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.
Programme descriptions

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:

- Master introduction (0.5 EC, INTRO-GSNS)
- Dilemmas of the scientist (0.5 EC, FI-MHPSDIL)
- Research project: Proposal (14 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.

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 2017-2018

Fall 2017
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)
Intensive course Categories & Modules (WISL527; 0 EC; Diamant; AGNT, L)
Intensive reminder on manifolds (WISL563; 0 EC; GQT; AGNT, DGT)
Commutative Algebra (WISL526; 8 EC; Diamant; AGNT)
Algebraic Geometry 1 (WISL509; 8 EC; Diamant; AGNT)
Programme descriptions

Differential Geometry (WISL503; 8 EC; GQT; AGNT, DGT)
Algebraic Topology 1 (WISL508; 8 EC; GQT; AGNT, DGT)
Poisson Geometry (WISL564; 8 EC; GQT; AGNT, DGT)
Asymptotic Statistics (WISL702; 8 EC; STAR; PS)
Measure-theoretical Probability (WISL701; 8 EC; STAR; PS)
Machine Learning Theory (WISL712; 8 EC; STAR; PS)
Parallel Algorithms (WISL603; 8 EC; Num.Wisk.; SC)
Numerical Linear Algebra (WISL601; 8 EC; Num.Wisk.; SC)
Advanced Algebraic Geometry: Algebraic Surfaces (WISL565; 8 EC; Wonder/GQT; AGNT, DGT)
Advanced Combinatorics (WISL711; 8 EC; Wonder/Diamant; SC, AGNT)
Advanced Hamiltonian Dynamics (WISL412; 8 EC; Wonder/GQT/NDNS++; PA, AA)
Discrete Choice Analysis: Theory and Applications (WISL714; 8 EC; Wonder/STAR; PS)
Algebraic Number Theory (WISL305; 8 EC; Diamant; AGNT)
Cryptology (WISL304; 5 EC; Diamant; AGNT)
Set Theory (WISL316; 8 EC; Logica; L)
Probabilistic and Extremal Combinatorics (WISL561; 8 EC; Diamant; AGNT, SC)
Complexity Theory (WISL325; 8 EC; Logica; L)
Mathematical Biology (WISL411; 8 EC; NDNS++; PA, AA)
Forensic probability and Statistics (WISL716; 8 EC; Multi; PS)

Spring 2018
Stochastic Differential Equations (WISL108; 6 EC; 4TU; PS)
Spacial 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)
Dynamics of Networks (WISL119; 6 EC; DISC; SC)
Category Theory and Topos Theory (WISL322; 8 EC; Logica; L)
Quantum Computing (WISL117; 8 EC; Multi; SC)
Nonlinear Waves (WISL409; 8 EC; NDNS++; SC, AA)
Inverse Problems in Imaging (WISL430; 8 EC; NDNS++; SC, AA)
Continuum Mechanics (WISL428; 8 EC; NDNS++; PA, AA)
Elliptic Curves (WISL303; 8 EC; Diamant; AGNT)
Selected Areas in Cryptology (WISL534; 8 EC; Diamant AGNT)
Modular Forms (WISL308; 8 EC; Diamant; AGNT)
Algorithmic Geometry of Numbers (WISL327; 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)
Time Series (WISL704; 8 EC; STAR; PS)
Statistical Theory for High- and Infinite Dimensional Models (WISL713; 8 EC; STAR; PS)
Perculation: from Introduction to Frontiers of Current Research (WISL715; 8 EC; STAR; PS)
Introduction to Numerical Bifurcation Analysis of ODE's and Maps (WISL606; 8 EC; Num.Wisk.; AA, SC)
Coding Theory (WISL306; 8 EC; Diamant; AGNT)
Semidefinite Optimization (WISL113; 8 EC; Diamant; SC)
Algorithms Beyond the Worst Case (WISL324; 8 EC; Diamant; AGNT, SC) Algebraic Geometry 2 (WISL539; 8 EC; GQT; AGNT, DGT)
Algebraic Topology 2 (WISL541; 8 EC; GQT; AGNT, DGT)
Foundations of General Relativity (WISL542; 8 EC; GQT; DGT)
Descriptive Set Theory (WISL326; 8 EC; Logica; L)
Algebraic Methods in Combinatorics (WISL540; 8 EC; Diamant; AGNT, PS)
Topology in Physics (WISL118; 8 EC; Multi; DGT)
Geschiedenis (WISL804, 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 2017-2018

Fall 2017:
Seminar Scientific Computing (WISM470; 7.5 EC; SC)
Seminar Selected Topics on Modern Methods in the Calculation of Variation (WISM540; 7.5 EC; PA, AA)
Introduction to Complex Systems (WISM484; 7.5 EC; CS)
Holomorphic Curves and Symplectic Topology (WISM547; 7.5 EC; DGT, PA)
Orientation on Mathematical Research (WISM102; 7.5 all specialisations, not open for students that have followed WISM556 in 2015-2016)

Spring 2018:
Laboratory Class Scientific Computing (WISM454; 7.5 EC; SC)
Seminar on Quadratic forms (WISM558; 7.5 EC; AGNT)
Seminar on Algebraic Topology (WISM565; 7.5 EC; PA, DGT, L)
Seminar on Logic (WISM551; 7.5 EC; L)
Seminar Ergodic Theory (WISM566; 7.5 EC; PS)
Applying mathematics in finance (WISM410; 7.5 EC; CS)
Seminar Modelling Health Effect of Ionizing Radiation (WISM409; 7.5 EC; CS, PS)
Mathematical Colloquium (WISM100; 3.75 EC; all specialisations)
Mathematics for Industry (WISM101; 3.75 EC; all specialisations)

Stochastics and Financial Mathematics (SFM) courses 2017-2018

Fall 2017:
Applied Analysis: Financial Mathematics (WISS117)
Applied Stochastic Modelling (WISS201)
Interest Rate Models (WISS135)
Portfolio Theory (WISS104)
Simulation Methods in Statistics (WISS113)
Statistical Models (WISS202)
Stochastic Optimization (WISS148)
Stochastics Processes for Finance (WISS101)
Stochastic Simulation (WISS149)

Spring 2018:
Computational Finance (WISS141)
Optimization of Business Processes (WISS150)
Queues & Levy Fluctuation Theory (WISS151)
Statistical Theory for High- and Infinite-Dimensional Models (WISS204)
Statistics for High-dimensional Data (WISS152)
Stochastic Integration (WISS105)

Industrial and Applied Mathematics (IAM) courses 2017-2018

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 (WISM101) 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 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.

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>15 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>45 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>0 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>30 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90 EC</strong></td>
</tr>
</tbody>
</table>

For students that have started before September 2016

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>0 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>52.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>30 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90 EC</strong></td>
</tr>
</tbody>
</table>

The research part is split into the following parts:

- Master introduction (0.5 EC, INTRO-GSNS)
- Dilemmas of the scientist (0.5 EC, FI-MHPSDIL)
- Research project: Proposal (9 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.
Honours programme Utrecht Geometry Centre

Admission and Selection Criteria

This programme, which is an extension of the master's programme Mathematical Sciences, provides students an opportunity to obtain a PhD-position on a topic of their own choice in the Utrecht Geometry Centre at the Mathematical Institute. 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.

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

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>15 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>45 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>15 EC</td>
</tr>
<tr>
<td>PhD Research training</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>45 EC</td>
</tr>
<tr>
<td><strong>Total EC</strong></td>
<td><strong>127.5 EC</strong></td>
</tr>
</tbody>
</table>

For students that have started before September 2016:

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>7.5 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>50.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>15 EC</td>
</tr>
<tr>
<td>PhD Research training</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>47 EC</td>
</tr>
<tr>
<td><strong>Total EC</strong></td>
<td><strong>127.5 EC</strong></td>
</tr>
</tbody>
</table>

Mandatory Courses

- Orientation on Mathematical Research (WISM102, 7.5 EC)
- Mathematics for Industry (WISM101, 3.75 EC)
- Mathematical Colloquium (WISM100, 3.75 EC)

For students that have started before September 2016:

Students must follow the seminar Orientation on Research in Geometry (WISM556) in which staff give presentations about research topics of current interest, leading to semester-long interaction with at least four staff members of the UGC and exposure to research from different groups within the UGC.

Primary Electives

Students must follow two advanced seminars in Mathematics in which they themselves have to give oral presentations. For the year 2017-2018 the student can choose from WISM564, WISM558, WISM565, WISM540 and WISM551. 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

PhD Research Training (WISM111, 7.5 EC)

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. The student participates in the weekly research seminar in Geometry and Algebra and Geometry and Analysis (GAGA-seminar). The PhD Research Training will be graded on a pass/fail basis.

Research part

See the appendix of Mathematical Sciences

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.

Honours programme Utrecht Geometry Centre in combination with the Honours programme Mathematical Sciences and Theoretical Physics

If the two honours programmes are combined, the content of the programme of 187.5 EC is as follows:

<table>
<thead>
<tr>
<th>Course</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory Physics courses</td>
<td>30 EC</td>
</tr>
<tr>
<td>Primary elective Physics courses</td>
<td>30 EC</td>
</tr>
<tr>
<td>Mandatory Mathematics courses</td>
<td>15 EC</td>
</tr>
<tr>
<td>Primary electives Mathematics</td>
<td>45 EC</td>
</tr>
<tr>
<td>PhD Research training</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>60 EC</td>
</tr>
<tr>
<td>Total EC</td>
<td><strong>187.5 EC</strong></td>
</tr>
</tbody>
</table>

For students that have started before September 2016

<table>
<thead>
<tr>
<th>Course</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory Physics courses</td>
<td>30 EC</td>
</tr>
<tr>
<td>Primary elective Physics courses</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Mandatory Mathematics courses</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Primary electives Mathematics</td>
<td>45 EC</td>
</tr>
<tr>
<td>PhD Research training</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>60 EC</td>
</tr>
<tr>
<td>Total EC</td>
<td><strong>172.5 EC</strong></td>
</tr>
</tbody>
</table>

(1) See for the Research part for students already started before September 2016, the special provisions in the appendix of the Honours programme Mathematical Sciences and Theoretical Physics.

For all students irrespective of the start date:

- See for the mandatory and primary elective Physics courses the appendix of the Honours programme Mathematical Sciences and Theoretical Physics.
Programme descriptions

- See for the mandatory Mathematics courses the appendix of the Utrecht Geometry Centre Honours Programme.

- For the primary electives in Mathematics, students must follow one advanced seminar in Mathematics in which they themselves have to give oral presentations. For the year 2017-2018 the student can choose from WISM564, WISM558, WISM565, WISM540 and WISM551. All other primary elective courses are chosen from the course list given in the appendix of Mathematical Sciences.

- See for the PhD Research training the description above for the Honours programme Utrecht Geometry Centre.

- See for the Research part the appendix of the Honours programme Mathematical Sciences and Theoretical Physics.

**Mid-term reviews of honours students**

The progress of honours students will be reviewed by the selection committee of both honours programmes. Students who do not meet the 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 too 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 designed by the board of admissions depending on the student’s prior knowledge (deficiencies in physics and/or mathematics of more than 15 EC). The premasters programme should be finished (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:

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) has knowledge of the physics of the climate system, as is described in the specific aims of the courses of the programme;</td>
</tr>
<tr>
<td>b) has a thorough understanding of the dynamics of atmosphere, ocean and climate.</td>
</tr>
<tr>
<td>c) has knowledge of important 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;</td>
</tr>
<tr>
<td>d) has knowledge of the scientific literature in one of the five research themes of the programme.</td>
</tr>
</tbody>
</table>
e) Understands the potential dilemmas related to scientific integrity in his/her research field.

**Applying knowledge and understanding**

a) is able to define a scientific problem, formulate a research question and design a basic strategy to solve this problem;
b) is able to conduct research in climate physics under supervision of a scientific staff member and report on it in a manner that meets the customary standards of the discipline;
c) is able to analyse and interpret the acquired materials and/or data according to scientific standards.
d) is able to develop a numerical model, and to use and improve (parts of) existing numerical models of different degrees of complexity;
e) is able to analyse, process and interpret data from measurements and numerical modelling.

**Making Judgements**

a) is able to discuss scientific aspects of the climate at a professional level;
b) is able to indicate the relevance of the research field;
c) is able to critically reflect on his/her own results, as well as on published scientific literature in the field of climate dynamics.

**Communication**

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;
b) is able to professionally act in a (possibly multi-disciplinary and international) research team.

**Learning skills**

a) has the skills to reflect upon his/her learning process and, if necessary, adjust this process;
b) has developed an effective and result-driven working method that enables him/her to function in a self-reliant manner on the labour market;
c) has acquired sufficient scientific knowledge and skills to conduct independent scientific research, or to conduct other discipline-related work;
d) has the qualifications to enroll in a PhD programme in Climate Physics;
e) is qualified to acquire a position as a professional in a (semi) public or commercial organisation.
f) 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: **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**

<table>
<thead>
<tr>
<th>Category</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory courses</td>
<td>37.5</td>
</tr>
<tr>
<td>Primary Electives</td>
<td>22.5-37.5</td>
</tr>
<tr>
<td>Secondary Electives</td>
<td>0-15</td>
</tr>
<tr>
<td>Research part</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>
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 (NS-MO501M, 7.5 EC)
- Making, Analyzing and Interpreting Observations (NS-MO502M, 7.5 EC)

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* (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)

* Selection of this course requires permission of the programme director and of the exam committee.

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 course 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 and by the exam committee 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 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.

The research part is split as follows:
Master introduction (introducing natural sciences; GSNS-INTRO): 0.5 EC,
Dilemmas of the scientist (FI-MHPSDIL): 0.5 EC,
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.

Students must have concluded at least two of the three mandatory courses:

1. Dynamical Oceanography (NS-MO401M),
2. Dynamical Meteorology (NS-MO402M)
3. Atmospheric Composition and Chemical Processes (NS-MO405M)

before commencing the master research project.

**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.

<table>
<thead>
<tr>
<th>profiles</th>
<th>37.5 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>0 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>30 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90 EC</strong></td>
</tr>
</tbody>
</table>

The research is split into master introduction (0.5 EC), Dilemmas of the scientist (0.5 EC), 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 (30 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-MHP5DL; 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, 2018.
Physics

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.

Specifically, at a minimum they must possess the following skills and knowledge:

**Quantum Mechanics:**
- The student knows the Schrödinger equation in one and three dimensions and can solve it for the usual potentials (infinite square well, harmonic oscillator, hydrogen atom).
- The student knows the concept of spin and orbital angular momentum and can apply the rules for addition of angular momenta.
- The student understands and can apply time independent first and second order perturbation theory.

**Statistical Physics:**
- The student can work in the canonical and the grand canonical ensemble.
- The student knows the free energies associated with these ensembles.
- The student can calculate the density of states in typical systems (massive/massless particles in a box).
- The student knows quantum statistics (Fermi-Dirac and Bose-Einstein) and can for instance apply it to calculate typical solid state problems, like the heat capacity in the Debye model.

**Electromagnetism and Optics:**
- The student knows and can apply important integral theorems (Green's, Stokes' and Gauss') to typical problems in electrostatics.
- The student knows the Maxwell equations.
- The student knows the constitutive relations between E and D, B and H.
- The student can derive the wave equation and solve it for simple cases.
- The student is familiar with the wave description of light and its application in optics, and preferably also in microscopy.

Furthermore, they should have the following skills and knowledge in either condensed matter physics or particle physics:

**Condensed Matter Physics:**
- The student knows the relation between the crystal lattice and the reciprocal lattice.
Programme descriptions

- The student can calculate how phonons and electrons contribute to the heat capacity and heat/electrical conductivity.
- The student understands the concepts of band structure and effective mass.
- The student can derive optical properties from simple classical microscopic theories (Drude, Lorentz).
- The student knows the concepts of superconductivity, Bose-Einstein condensation and the phases that make up soft matter: colloids (including quantum dots), polymers, surfactants and liquid crystals, as well as photonic crystals.

Particle Physics:
- The student understands the relation between symmetry and conserved quantities.
- The student knows how radiation interacts with matter (Bethe-Bloch Equation, interactions of photons and electrons) and understands how the most widely used particle detectors work (Time Projection Chamber, Silicon Detectors, Electromagnetic and Hadronic Calorimeters).
- The student can calculate scattering cross-sections (Rutherford, Mott).
- The student has a basic knowledge about the fundamental constituents of matter and their interactions (Feynman diagrams).

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

-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 designed by the board of admissions depending on the student’s prior knowledge. The premasters programme must be finished (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:

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>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 &amp; Biophysics (SCMB);</td>
<td></td>
</tr>
<tr>
<td>b) has knowledge on and experience with state-of-the-art experimental and data analysis techniques in at least one of the following fields: Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter &amp; Biophysics;</td>
<td></td>
</tr>
<tr>
<td>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 &amp; Biophysics; and to relate this to his/her own research</td>
<td></td>
</tr>
<tr>
<td>d) Understands the potential dilemmas related to scientific integrity in his/her research field.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Applying knowledge and understanding</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) is able to identify, formulate, analyse and design a basic strategy to solve problems in at least one of the following fields: Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter &amp; Biophysics;</td>
<td></td>
</tr>
<tr>
<td>b) is able to conduct research in at least one of the following fields: Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter Physics and Biophysics</td>
<td></td>
</tr>
</tbody>
</table>
under supervision of a scientific staff member, carry out the research plan 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 apply knowledge and insight in original experimental research projects in at least one the areas Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter & Biophysics, at the level of international scientific journals;

d) is able to analyse and interpret the acquired 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 work independently and take initiatives where necessary;
b) has the skills to evaluate his/her own learning and development process and to adjust this process if necessary;
c) is able to apply knowledge and insight in a way that demonstrates a professional approach to his or her work or profession;
d) 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;
e) is qualified to acquire a position as a professional in a (semi) public or commercial organisation.
f) 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

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<tr>
<td>Mandatory courses</td>
<td>21-22.5 EC</td>
</tr>
<tr>
<td>Primary electives</td>
<td>22.5-24 EC*</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>15 EC*</td>
</tr>
<tr>
<td>Research part</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120 EC</strong></td>
</tr>
</tbody>
</table>

* 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, a priori permission of the programme director and the board of examiners is required. Internships can only start after the mandatory and primary elective courses and the research project have been finished, or sooner with the permission of the programme director.
Mandatory courses

There are 5 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 3 which may be chosen out of the following list of 4:

- 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, one will be counted as a primary elective.

Primary electives

A choice from the following list of courses: For research in either of the 3 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.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>EC</th>
<th>PP</th>
<th>AMO</th>
<th>SCMB</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-EX404M</td>
<td>Particle Physics 2</td>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-EX417M</td>
<td>Physics of Light &amp; Electron Microscopy</td>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-EX431M</td>
<td>Computational Quantum Mechanics</td>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-TP432M</td>
<td>Modelling and Simulation</td>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-TP401M</td>
<td>Quantum Field Theory</td>
<td>10 EC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-TP402M</td>
<td>Statistical Field Theory</td>
<td>10 EC</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SK-MASPN</td>
<td>Adv. Spectroscopy of Nanomaterials</td>
<td>7.5</td>
<td></td>
<td></td>
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<tr>
<td>SK-MCS</td>
<td>Colloid Science</td>
<td>7.5</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>NS-EX415M</td>
<td>CP violation and Flavor Physics</td>
<td>3 EC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-EX432M</td>
<td>Gravitational Waves</td>
<td>3 EC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-EX428M</td>
<td>Particle Detection</td>
<td>6 EC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-EX433M</td>
<td>Programming C++</td>
<td>3 EC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-EX405M</td>
<td>Computational Methods</td>
<td>6 EC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-EX427M</td>
<td>Astroparticle Physics</td>
<td>6 EC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-EX434M</td>
<td>Statistical Data Analysis</td>
<td>6 EC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS-EX429M</td>
<td>Nikhef project</td>
<td>6 EC</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>NS-EX406M</td>
<td>CERN Summer Student Programme</td>
<td>6 EC</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

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

The course ‘Statistical Data Analysis’ is labelled as Data Science course.

The courses NS-EX417M and NS-EX419M (Physics- and Application of Light and Electron Microscopy) are held every other year, and not in the period 2017/2018.

Secondary electives

For the remaining 15 EC, several options are possible such as any MSc course offered by the Graduate Schools of Natural and Life Sciences, the course GEO4-2513 Solar Energy Physics, or other courses with permission from the programme director, 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 courses and 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. The programme director decides which courses need to be followed during the master’s programme. Deficiencies will be stated in the Letter of Admission. If no deficiencies were stated in this letter, on request by the student the programme director may grant permission for at most one course of 7.5 EC from the level 3 bachelor physics courses to be counted as a secondary elective.

**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.

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 Debye Institute 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.

**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.

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>22.5 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>0 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>45 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90 EC</strong></td>
</tr>
</tbody>
</table>

The research is split into, thesis part 1 (NS-EX551M, 15 EC) and thesis part 2 (NS-EX552M, 30
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.
Note: the Data Science profile in this programme includes a research part of 15 EC.

**Special provisions for students who enrolled in the programme Experimental Physics 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, 2018.
Physics

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 too 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 education. The premasters programme must be successfully concluded before admission into the master's is possible.

Learning outcomes

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

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) has basic knowledge of field-theoretic and mathematical methods in theoretical physics, and has insight into its use in high-energy physics and/or condensed matter physics and/or statistical physics;</td>
<td></td>
</tr>
<tr>
<td>b) can employ this knowledge to contribute to ongoing research in one of those areas;</td>
<td></td>
</tr>
<tr>
<td>c) is aware of recent development in theoretical physics, and can put this into perspective of physics as a whole;</td>
<td></td>
</tr>
<tr>
<td>d) is able to understand the international literature on at least one branch of theoretical physics, and to relate this to his/her own research.</td>
<td></td>
</tr>
<tr>
<td>e) has the skills to understand the professional literature in the area of high energy physics and/or condensed matter physics and/or statistical physics, and relate this to his/her own research.</td>
<td></td>
</tr>
<tr>
<td>f) understands the role that scientific integrity plays in theoretical physics</td>
<td></td>
</tr>
</tbody>
</table>

Applying knowledge and understanding

a) is able, possibly guided by a staff member, to translate a problem of modern
Programme descriptions

Making judgements

a) can discuss the results of this theoretical research with the supervisor and fellow students, and possibly also with other researchers in the research group;

b) can indicate the meaning and content of this research for the particular branch of theoretical 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 obtained the ability to study focused and independently;

b) has an academic attitude towards the field of theoretical physics, which allows for further growth in this field or outside;

c) is qualified to be admitted to a PhD research project in the field of theoretical physics, physics in general, and/or mathematics;

d) is qualified to acquire a research position in a (semi) public or commercial organization.

e) 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

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>30 EC</th>
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<tbody>
<tr>
<td>Primary electives</td>
<td>30 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>15 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>45 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120 EC</strong></td>
</tr>
</tbody>
</table>

Mandatory courses (each 10 EC)

- Quantum Field Theory (NS-TP401M)
- Statistical Field Theory (NS-TP402M)
- Student seminar in Theoretical Physics
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
- Functionaal analyse WISB315
- Inl. Scientific Computing WISB356
- Inl. 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. The courses WISB333 and WISB331 will be given alternatingly and are considered equivalent as far as a replacement for the mandatory master level course is concerned.

**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 exam committee 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 director.
Programme descriptions

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.

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.

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>30 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>30 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>0 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>30 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90 EC</strong></td>
</tr>
</tbody>
</table>

The research is split into thesis part 1 (NS-TP5551M, 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.

Special provisions for students who enrolled in the programme Theoretical Physics in the year 2015-2016 and earlier

The courses Introducing Natural Sciences (GSNS-intro; 0.5 EC), Dilemmas of the scientist (FI-MHP5DL; 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, 2018
Honours programme Mathematical Sciences and Theoretical Physics

Admission Criteria

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

Selection

The application will be reviewed by a selection committee, consisting of representatives of the two master’s programmes. The selection committee will base its decision on previous study results, motivation and the CV of the applicant. Typically, an applicant will have completed a bachelor’s degree in Physics and one in Mathematics, both with high grades.

Contact hours

The average number of contact hours for a student of this programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: 984 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

<table>
<thead>
<tr>
<th>Mandatory Physics courses</th>
<th>30 EC</th>
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</thead>
<tbody>
<tr>
<td>Primary electives Theoretical Physics</td>
<td>30 EC*</td>
</tr>
<tr>
<td>Mandatory Mathematics courses</td>
<td>15 EC</td>
</tr>
<tr>
<td>Primary electives Mathematics</td>
<td>45 EC*</td>
</tr>
<tr>
<td>Research Part</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>180 EC</strong></td>
</tr>
</tbody>
</table>

* Alternatively, students may take 22.5 EC of optional Physics courses and 37.5 EC of optional Mathematics courses, and conduct an additional 15 EC internship or research project. The topic of this internship/research project should be different from that of the Research Part in the table above, and requires approval of both programme directors.

Mandatory Physics courses

<table>
<thead>
<tr>
<th>Quantum Field Theory</th>
<th>10 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical Field Theory</td>
<td>10 EC</td>
</tr>
<tr>
<td>Student Seminar in Theoretical Physics</td>
<td>9 EC</td>
</tr>
<tr>
<td>Master introduction/Dilemmas for the scientist</td>
<td>0.5 EC/0.5 EC</td>
</tr>
</tbody>
</table>

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

Primary electives Theoretical Physics (7.5 EC each)

- Advanced Topics in Theoretical Physics I,
• Advanced Topics in Theoretical Physics II,
• Cosmology,
• Field Theory in Particle Physics,
• Field Theory in Condensed Matter,
• General Relativity,
• Modelling and Simulation,
• String Theory,
• Soft Condensed Matter Theory,
• Theory for Technology.

Mandatory Mathematics courses

<table>
<thead>
<tr>
<th>Course</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation on Mathematical Research - WISM102</td>
<td>7.5</td>
</tr>
<tr>
<td>Mathematics for Industry - WISM101</td>
<td>3.75</td>
</tr>
<tr>
<td>Mathematical Colloquium - WISM100</td>
<td>3.75</td>
</tr>
</tbody>
</table>

Primary electives Mathematics

See the programme appendix of Mathematical Sciences. The requirement of the seminar is fulfilled by the Students Seminar in Theoretical Physics.

Research part

Students who are registered (1) for both the master’s programme in Theoretical Physics and the master’s programme in Mathematical Sciences, and (2) are registered for the honours programme in Theoretical Physics and Mathematics and (3) fulfill all of the other requirements to successfully complete the honours programme, can do a thesis project of 60 EC, co-supervised by staff members of the ITP and the Mathematics Institute.

The research part is split as follows:

• Thesis project part 1 Mathematical Sciences & Theoretical Physics (WISM105 or NS-TP551M, depending on the student’s primary programme of registration): 15 EC;
• Thesis project part 2 Mathematical Sciences & Theoretical Physics (WISM106 or NS-TP552M, depending on the student’s primary programme of registration): 45 EC.

Such a thesis has to contain sufficient mathematics and theoretical physics, such that it meets the standard of both programmes.

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

Mid-term reviews of honours students

The progress of honours students will be reviewed by the selection committee after 1 year of study and after completion of part 1 of the research project. Honours students should have obtained a minimum of 60 EC after 1 year and should be in their second year after completing research part 1. Students who do not meet one of these criteria may be denied from the honours programme by the selection committee.
Special provisions for students who enrolled in the honours programme Mathematical Sciences and Theoretical Physics 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. The total credit load of the programme remains 165 EC:

<table>
<thead>
<tr>
<th>Mandatory Physics courses</th>
<th>30 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives Theoretical Physics</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Primary electives Mathematics</td>
<td>52.5 EC</td>
</tr>
<tr>
<td>Research Part</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>165 EC</strong></td>
</tr>
</tbody>
</table>

This provision ends 31 August, 2018
Honours programme Climate Physics and Mathematical Sciences

Admission Criteria

The applicant should satisfy the admissions criteria for the master’s programmes Climate Physics and Mathematical Sciences, which are stated in the corresponding programme descriptions. Moreover, the application will be reviewed by a selection committee, consisting of representatives of the two master’s programmes. The selection committee will base its decision on previous study results, motivation and the CV of the applicant.

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

Contents

For students starting in September 2016:

<table>
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<tr>
<th>Mandatory Physics courses</th>
<th>37.5 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory Mathematics courses</td>
<td>15 EC</td>
</tr>
<tr>
<td>Primary electives Climate Physics</td>
<td>22.5 EC*</td>
</tr>
<tr>
<td>Primary electives Mathematics</td>
<td>45 EC*</td>
</tr>
<tr>
<td>Research Part</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>180 EC</strong></td>
</tr>
</tbody>
</table>

* Alternatively, students may take 15 EC of optional Physics courses and 37.5 EC of optional Mathematics courses, and conduct an additional 15 EC internship or research project. The topic of this internship/research project should be different from that of the Research Part in the table above, and requires approval of both programme directors.

Mandatory Climate Physics

<table>
<thead>
<tr>
<th>Course</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamical Oceanography</td>
<td>7.5</td>
</tr>
<tr>
<td>Dynamical Meteorology</td>
<td>7.5</td>
</tr>
<tr>
<td>Atmospheric Composition and chemical Processes</td>
<td>7.5</td>
</tr>
<tr>
<td>Simulation of Ocean, Atmosphere and Climate</td>
<td>7.5</td>
</tr>
<tr>
<td>Making, Analyzing and Interpreting Observations</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Primary Electives Climate Physics

All of the courses below are 7.5 EC, except the Marine Masters Course (3.75 EC)

Boundary Layers, Transport and Mixing,
Current Themes in Climate Change,
Ice and Climate,
Marine Masters Course,
Ocean Waves,
Turbulence in Fluids (requires permission of programme director and exam committee),

One of the following courses:
Morphodynamics of Tidal Systems,
Morphodynamics of Wave-dominated Coasts.
Programme descriptions

Mandatory Mathematics courses

<table>
<thead>
<tr>
<th>Course</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation on Mathematical Research - WISM102</td>
<td>7.5</td>
</tr>
<tr>
<td>Mathematics for Industry - WISM101</td>
<td>3.75</td>
</tr>
<tr>
<td>Mathematical Colloquium – WISM100</td>
<td>3.75</td>
</tr>
</tbody>
</table>

Optional Mathematics courses

See the programme appendix of Mathematical Sciences.

Research part

Students who are registered (1) for both the master’s programme in Climate Physics and the master’s programme in Mathematical Sciences, and (2) are registered for the honours programme in Climate Physics and Mathematics and (3) fulfill all of the other requirements to successfully complete the honours programme, can do a thesis project of 60 EC, co-supervised by staff members of IMAU and the Mathematics Institute. Such a thesis has to contain sufficient mathematics and climate physics, such that it meets the standard of both programmes.

The research part is split as follows:

- Master introduction (introducing natural sciences; INTRO-GSNS): 0.5 EC,
- *Dilemmas of the scientist*; FI-MHPSDIL: 0.5 EC,
- Thesis project part 1 Climate Physic & Math. Sciences (NS-MO551M or WISM105, depending on the student’s primary programme of registration): 14 EC,
- Thesis project part 2 Climate Physic & Math. Sciences (NS-MO552M or WISM106, depending on the student’s primary programme of registration): 45 EC.

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

Mid-term reviews of honours students

The progress of honours students will be reviewed by the selection committee after 1 year of study and after completion of part 1 of the research project. Honours students should have obtained a minimum of 60 EC after 1 year and should be in their second year after completing research part 1. Students who do not meet one of these criteria may be denied from the honours programme by the selection committee.

Special provisions for students who enrolled in the honours programme Meteorology, Physical Oceanography & Climate and Mathematical Sciences 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 are not mandatory for students enrolled into this programme prior to 1 September 2016. The total credit load of the programme remains 165 EC.

This provision ends 31 August, 2018
Honours programme Nanomaterials: Chemistry & Physics

Admission Criteria

The applicant should satisfy the admissions criteria for the master’s programmes Nanomaterials Science and Experimental Physics, which are stated in the corresponding programme descriptions. Moreover, the application will be reviewed by a selection committee, consisting of representatives of the two master’s programmes. The selection committee will base its decision on previous study results, motivation and the CV of the applicant.

Typically, an applicant will have completed a bachelor’s degree in Physics and or in Chemistry, both with high grades. Two degrees in Chemical Sciences and in Physics will be awarded after successfully having finished this honours programme.

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</thead>
<tbody>
<tr>
<td>Mandatory Experimental Physics courses</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Primary electives Nanomaterials Science</td>
<td>30 EC</td>
</tr>
<tr>
<td>Primary electives Experimental Physics</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Internship</td>
<td>30 EC</td>
</tr>
<tr>
<td>Thesis</td>
<td>60 EC</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>180 EC</strong></td>
</tr>
</tbody>
</table>

Mandatory Nanomaterials Science courses

<table>
<thead>
<tr>
<th>Academic Context Course (SK-ACCO)</th>
<th>6.5 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introducing natural sciences (GSNS-INTRO)</td>
<td>0.5 EC</td>
</tr>
<tr>
<td>Dilemmas of the scientist (FI-MHPSDIL)</td>
<td>0.5 EC</td>
</tr>
<tr>
<td>Adsorption Kinetics and Catalysis</td>
<td>7.5 EC</td>
</tr>
</tbody>
</table>

Primary elective Nanomaterials Science courses

See the annex of the programme Nanomaterials Science. Note that the courses labeled exclusively with a P can not be taken.

Mandatory Experimental Physics courses

<table>
<thead>
<tr>
<th>Soft Condensed Matter Theory</th>
<th>7.5 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Quantum Physics</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Photon Physics</td>
<td>7.5 EC</td>
</tr>
</tbody>
</table>

Primary Electives Experimental Physics

See the programme appendix of Experimental Physics. Note that the courses Colloid Science and Advanced Spectroscopy of Nanomaterials can not be taken as primary electives in this programme.

Internship

Internships can start only after all courses and the research part have been finished, or sooner with permission of the programme directors.
Research part

Students who are registered (1) for both the master’s programme in Nanomaterials Science and the master’s programme Experimental Physics, and (2) are registered for the honours programme in Nanomaterials: Chemistry & Physics and (3) fulfill all of the other requirements to successfully complete the honours programme, must do a thesis project of 60 ECTS, co-supervised by staff members of the Debye Institute. Such a thesis has to contain sufficient chemistry and physics, such that it meets the standard of both programmes.

The research part is split as follows:
Thesis project part 1 (SK-MRES1 or NS-EX552M, depending on the student’s primary programme of registration): 15 EC
Thesis project part 2 (SK-MRES2 or NS-EX552M, depending on the student’s primary programme of registration): 45 EC.

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

Mid-term reviews of honours students

The progress of honours students will be reviewed by the selection committee after 1 year of study and after completion of part 1 of the research project. Honours students should have obtained a minimum of 60 EC after 1 year and should be in their second year after completing research part 1. Students who do not meet one of these criteria may be denied from the honours programme by the selection committee.
Complex Systems Profile

Description
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 crises, a sudden epidemic or climate change are studied from a modelling perspective. Students will get an understanding of the various models used in the complexity field and the dynamics (i.e. transitions, predictability) that play an important role. Students applying for this master’s profile should have an affinity for this quantitative approach and will learn how to work in interdisciplinary teams.

Curriculum
The master’s profile comprises 30 EC and consists of the following parts:

- Thesis on a Complex Systems topic (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 a complex system subject, it is for certain master’s programmes permitted to combine the thesis of the master’s profile Complex Systems (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 steering group member of the Foundations of Complex systems focus area who is involved and by the programme director of the master programme for which the student is admitted.

- Two electives (15 EC)
  A choice from the following courses:
  - Introduction to Complex Systems (WISM484)
  - Applying Mathematics in Finance (WISM410)
  - Seminar Modelling Health Effects of Ionizing Radiation (WISM409)
  - Understanding Complexity: Economy and the Planet (NS-MO450M)
  - 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.

  Some programmes require one of their own primary elective courses, labelled as complex Systems course to be taken. More information is given in the specific programme description section of the Education and Examination Regulations.

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.

Participating Master’s programmes
- Climate Physics
- Computing Science
- Energy Science
- Experimental Physics
- Game and Media Technology
- Mathematical Sciences
- Nanomaterials Science
- Sociology and Social Research
• Sustainable Development
• Theoretical Physics

Students can also take a course at the Utrecht University School of Economics.

List of courses labelled as a complex systems course

<table>
<thead>
<tr>
<th>Master’s programme</th>
<th>Course</th>
<th>Osiris code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Physics</td>
<td>Wave attractors</td>
<td>NS-MO447M</td>
</tr>
<tr>
<td>Computing Science</td>
<td>Data mining</td>
<td>INFOMDM</td>
</tr>
<tr>
<td></td>
<td>Pattern recognition</td>
<td>INFOMPR</td>
</tr>
<tr>
<td></td>
<td>Evolutionary algorithms</td>
<td>INFOEA</td>
</tr>
<tr>
<td>Energy Science</td>
<td>Energy systems modelling</td>
<td>GEO4-2515</td>
</tr>
<tr>
<td>Experimental Physics</td>
<td>Modelling and simulation</td>
<td>NS-TP432M</td>
</tr>
<tr>
<td>Game and Media Technology</td>
<td>Pattern recognition</td>
<td>INFOMPR</td>
</tr>
<tr>
<td></td>
<td>Games and agents</td>
<td>INFOMGMAG</td>
</tr>
<tr>
<td></td>
<td>Crowd simulation</td>
<td>INFOMCRWS</td>
</tr>
<tr>
<td>Mathematical Sciences</td>
<td>Seminar mathematical epidemiology*</td>
<td>WISM436</td>
</tr>
<tr>
<td></td>
<td>Introduction to numerical bifurcation analysis of ODEs and maps</td>
<td>WISL606</td>
</tr>
<tr>
<td></td>
<td>Mathematical biology, VU Amsterdam**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonlinear waves, VU Amsterdam**</td>
<td></td>
</tr>
<tr>
<td>Multidisciplinary Economics</td>
<td>Advanced behavioural and experimental finance</td>
<td>ECRMABEF</td>
</tr>
<tr>
<td>Nanomaterials Science</td>
<td>Toy models</td>
<td>SK-MTOYM</td>
</tr>
<tr>
<td></td>
<td>Modelling and simulation</td>
<td>NS-TP432M</td>
</tr>
<tr>
<td>Sustainable Development</td>
<td>Sustainability modelling and indicators</td>
<td>GEO4-2331</td>
</tr>
<tr>
<td>Theoretical Physics</td>
<td>Modelling and simulation</td>
<td>NS-TP432M</td>
</tr>
</tbody>
</table>

* Every other year, please check Osiris
** Registration via elo.mastermath.nl
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 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 a specific domain. The foundations of applied data science include relevant statistical methods, machine learning techniques and programming. 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.

Learning outcomes of the profile

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
- Is able to work in interdisciplinary teams.

Curriculum

The master’s profile comprises 2 mandatory multidisciplinary courses (15 EC) complemented with either a research project (15 EC) OR a selection of 2 elective courses (15 EC) from the elective courses table listed under B2. The illustration below visualises the Master’s profile Applied Data Science.

(A) Two mandatory courses (15 EC)

- Data Science & Society
  (coord: dept. Computer science / GSNS; in 2016-17 in period 3)
- Data Modeling & Visualisation

(B) Two mandatory courses (15 EC)

- Data Science & Society
  (coord: dept. Computer science / GSNS; in 2016-17 in period 3)
- Data Modeling & Visualisation
  (coord: dept. Methods & Statististics / GSSBS; in 2016-17 in period 4)

(B1) Research project (15 EC)

(B2) Two elective courses (15 EC)

- Elective course 1
- Elective course 2
(B) Research project on an Applied Data Science topic (15 EC) OR Two elective courses (15 EC)

- (B1) Research project on an Applied Data Science topic (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 a member of the Applied Data Science steering committee who is involved, and by the programme director of the master programme for which the student is admitted.

- (B2) Two elective courses (15 EC)

The elective courses list below is still incomplete. Please refer to the Applied Data Science profile web page for up to date information.

<table>
<thead>
<tr>
<th>Master’s programme</th>
<th>Elective course</th>
<th>Osiris code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Informatics</td>
<td>Business intelligence</td>
<td>INFOMBIN</td>
</tr>
<tr>
<td></td>
<td>Software architecture</td>
<td>INFOMSWA</td>
</tr>
<tr>
<td>Artificial Intelligence</td>
<td>Multi-agent learning</td>
<td>INFOMAA</td>
</tr>
<tr>
<td></td>
<td>Cognitive Modeling</td>
<td>INFOMCM</td>
</tr>
<tr>
<td></td>
<td>Experimentation in Psychology and Linguistics</td>
<td>TLMV13020</td>
</tr>
<tr>
<td></td>
<td>Logic and Language</td>
<td>INFOMEPL</td>
</tr>
<tr>
<td></td>
<td>Logic and Computation</td>
<td>WBMV13005</td>
</tr>
<tr>
<td>Climate Physics</td>
<td>Measuring, Analyzing and Interpreting Observations</td>
<td>NS-MO501M</td>
</tr>
<tr>
<td>Computing Science</td>
<td>Data mining</td>
<td>INFOMDM</td>
</tr>
<tr>
<td></td>
<td>Pattern set mining</td>
<td>INFOPROB</td>
</tr>
<tr>
<td></td>
<td>Big data</td>
<td>INFOMBDO</td>
</tr>
<tr>
<td></td>
<td>Pattern recognition</td>
<td>INFOMPR</td>
</tr>
<tr>
<td>Experimental Physics</td>
<td>Statistical Data Analysis</td>
<td>NS-EX434M</td>
</tr>
<tr>
<td>Game and Media Technology</td>
<td>Multimedia Retrieval</td>
<td>INFOMRM</td>
</tr>
<tr>
<td></td>
<td>Pattern Recognition</td>
<td>INFOMPR</td>
</tr>
<tr>
<td>Mathematical Sciences</td>
<td>Seminar Scientific Computing</td>
<td>WISM470</td>
</tr>
<tr>
<td></td>
<td>Parallel Algorithms</td>
<td>WISL603</td>
</tr>
<tr>
<td></td>
<td>Network Dynamics</td>
<td>WISL116</td>
</tr>
<tr>
<td></td>
<td>Complex Networks</td>
<td>WISL115</td>
</tr>
<tr>
<td></td>
<td>Computational inference with R</td>
<td>MSBBSS04</td>
</tr>
</tbody>
</table>

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.
Honours programme Q-Biology

This honours programme is open to all natural science students. Extended information about admission, deadlines, 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.

The description of this honours programme is given by art 3.8 clause 3 and 4 (translation will follow due summer):

**Art 3.8.3:**
Het honours programma QBio bestaat uit een QBio introductiecursus, een journal club, een research project en een onderzoeksvoorstel.
Jaarlijks wordt door de coördinatoren van QBio een aantal studenten geselecteerd voor deelname aan het honoursprogramma. Daarbij gelden de volgende criteria:
- motivatie van de student;
- aanbeveling van de begeleiders van het huidige masterprogramma;
- cijfers en relevante cursussen in het bachelor programma;
- cijfers en gekozen richting op de middelbare school.

Op basis hiervan worden studenten geselecteerd voor de QBio introductiecursus. De tweede selectie vindt plaats na de cursus. De coördinatoren selecteren maximaal 12 studenten per jaar die het complete honoursprogramma vervolgen. Deze selectie is op basis van bovenstaande criteria en:
- algemene prestaties tijdens de QBio introductie cursus;
- competentie om interdisciplinaire kwantitatief biologisch onderzoek te verrichten;
- deelname aan ‘lab rotations’ en discussies van artikelen.

De selectieprocedure wordt gepubliceerd via de website van QBio (http://theory.bio.uu.nl/qbio/honours.html).

**Art 3.8.4:**
De kandidaat ontvangt een toelatings- c.q. afwijzingsbeslissing tot het honoursprogramma. Hierin wordt gewezen op de bezwaarmogelijkheid bij het college van bestuur.
Educational Profile

Description and aims

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

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.

Programme

The programme consists of the following parts:

• 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)

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.

Entry requirements

- 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.

Educational profile for students without a prior educational qualification

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.

Programme
The programme consists of the following parts:

- Teaching practice 1 (15 EC, GSTMS1)
- Teaching Methodology 1 (3.75 EC, GSTALGD1)
- Subject Teaching Methodology 1 – [subject] (3.75 EC, GSTVD1IN/GSTVD1NK/GSTVD1SK/GSTVD1WK)
- Introduction Educational research (3.75 EC, GSTPGO1)
- Elective specialization course (3.75 EC, choice from GSTKO01 – GSTKO23, FI-MSECDES, FI-MSECCHPS, FI-MSECSS)

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. For this qualification it is required to extend the Teaching practice course (GSTMS1) until an amount of 18.75 EC instead of an elective course.

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

Entry requirements

- 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.

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, for non-native students who have a basic proficiency in Dutch, there will be limited placement opportunities in bilingual or international schools. If you would be interested, please send an email to inquire about your eligibility.

 Transitional arrangements

See below for the correspondence table.

<table>
<thead>
<tr>
<th>Old course</th>
<th>EC</th>
<th>New course</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSTID1 Methodology 1</td>
<td>7.5</td>
<td>GSTALGD1 Teaching Methodology 1</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GSTVD1IN Subject Teaching Methodology 1 – Informatics OR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>GSTVD1NK Subject Teaching Methodology 1 – Physics OR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>GSTVD1SK Subject Teaching Methodology 1 – Chemistry OR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>GSTVD1WK Subject Teaching Methodology 1 – Mathematics</td>
<td></td>
</tr>
<tr>
<td>GSTID2 Methodology 2</td>
<td>7.5</td>
<td>GSTALGD2 Teaching Methodology 2</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GSTVD2IN Subject Teaching Methodology 2 – Informatics OR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>GSTVD2NK Subject Teaching Methodology 2 – Physics OR</td>
<td></td>
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<td>GSTVD2SK Subject Teaching Methodology 2 – Chemistry OR</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>GSTVD2WK Subject Teaching Methodology 2 – Mathematics</td>
<td></td>
</tr>
</tbody>
</table>