Programme descriptions

Annex to the Education and Examination Regulations (EER)
2023-2024
Graduate School of Natural Sciences
# Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Data Science</td>
<td>3</td>
</tr>
<tr>
<td>Artificial Intelligence</td>
<td>9</td>
</tr>
<tr>
<td>Chemical Sciences</td>
<td>20</td>
</tr>
<tr>
<td>Computer Science</td>
<td>32</td>
</tr>
<tr>
<td>Computing Science</td>
<td>32</td>
</tr>
<tr>
<td>Data Science</td>
<td>43</td>
</tr>
<tr>
<td>Game and Media Technology</td>
<td>49</td>
</tr>
<tr>
<td>History and Philosophy of Science</td>
<td>58</td>
</tr>
<tr>
<td>Information Science</td>
<td>67</td>
</tr>
<tr>
<td>Business Informatics</td>
<td>67</td>
</tr>
<tr>
<td>Human Computer Interaction</td>
<td>79</td>
</tr>
<tr>
<td>Mathematical Sciences</td>
<td>87</td>
</tr>
<tr>
<td>Physics</td>
<td>98</td>
</tr>
<tr>
<td>Climate Physics</td>
<td>98</td>
</tr>
<tr>
<td>Experimental Physics</td>
<td>107</td>
</tr>
<tr>
<td>Theoretical Physics</td>
<td>119</td>
</tr>
<tr>
<td>Profiles</td>
<td>130</td>
</tr>
<tr>
<td>Applied Data Science Profile</td>
<td>130</td>
</tr>
<tr>
<td>Communication Profile</td>
<td>135</td>
</tr>
<tr>
<td>Complex Systems Profile</td>
<td>137</td>
</tr>
<tr>
<td>Da Vinci Programme</td>
<td>142</td>
</tr>
<tr>
<td>Educational Profile</td>
<td>147</td>
</tr>
<tr>
<td>Science-based Entrepreneurship profile</td>
<td>153</td>
</tr>
<tr>
<td>Honours programme Q-Biology</td>
<td>162</td>
</tr>
</tbody>
</table>
Applied Data Science

Admission to the degree in Applied Data Science

Applicants should possess solid knowledge at an academic level of at least the following two topics:

Statistics (at least 7.5 EC), in particular knowledge and skills in descriptive and inferential statistics, knowing basic concepts in statistics such as analysis of variance, correlation and regression analysis, and knowing how to apply these concepts.

Programming (at least 7.5 EC), in particular knowledge of data analysis and statistics applied in R and Python.

Applicants must be able to demonstrate that they have acquired this knowledge through formal university courses. Online courses (e.g. Datacamp, Coursera, Udemy, etc.) are not accepted.

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.

The programme aims for a diverse inflow of students from all sorts of domains, not limited to the five focus domains (health science; geoscience; social and behavioural science; humanities, namely media studies and linguistics; and economics) of the programme itself, hence any completed academic bachelor programme, or university of applied sciences (HBO) programme, will suffice. However, the programme builds on knowledge of statistics and programming in Python and R, which is therefore a prerequisite as mentioned above. The Admissions Committee reviews all requests for admission and selects students that meet the entry requirements, based on an analysis of their academic background, grades and their motivation.
Pre-Master’s programme

There is no Pre-Master’s programme. Large deficiencies in statistics and/or programming knowledge can be repaired, for example, by following (a part of) the Utrecht bachelor minor Applied Data Science (30 EC, https://students.uu.nl/en/academics/minors/applied-data-science) during the bachelor phase or through non-degree education. The mandatory courses for this minor programme are taught in English, as are most elective courses. However, the pre-minor course (compulsory for HBO students) and some electives are exclusively offered in Dutch.

In case students satisfy most of the formal prerequisites but have specific gaps in their knowledge, they may be admitted conditionally. In these cases, students can address their specific gaps by attending relevant courses, such as those offered by the Utrecht University Summer School (https://utrechtsummerschool.nl/). Note that places on these courses are on a “first come, first served” basis and therefore cannot be guaranteed in advance.

Learning outcomes

The graduate of the master’s programme in Applied Data Science:

Knowledge and understanding

- K1. Can use their knowledge of Applied Data Science to contribute to the development and/or application of scientific concepts and methods.

- K2. Is able to understand important recent developments in Applied Data Science, and of indicating their implications for society and the research field.

- K3. Is able to interpret and use literature in the field of Applied Data Science.

- K4. Has insight into the role that ethical and legal issues play in the field of Applied Data Science.

Applying knowledge and understanding
- A1. Is able to translate a problem from the area of Applied Data Science to an approach relevant to a product or service.

- A2. Is able to independently design and execute a research plan with the required care and ethical responsibility and to process, interpret and evaluate the empirical data and outcomes thus obtained in the appropriate manner.

Making judgements

- M1. Is able to interpret and evaluate the results of another person's empirical or theoretical research.

- M2. Is able to indicate the relevance of research for the solution of questions and problems in the field of applied data science, from a societal point of view.

Communication skills

- C1. Is capable of clearly communicating the results of research, in writing as well as orally, to an audience of specialists and laymen, also in an international context.

- C2. Is capable of functioning effectively in a multidisciplinary team.

Learning skills

- L1. Has acquired an effective and results-driven way of working that allows them to function independently in a competitive labour market.

- L2. Has insight into employment opportunities and on the skills needed to make a successful start in the job market.

Contact hours

For the first period of the programme, the contact hours will be on average 14 hours per week. For the second and third period, with the standard enrolment in two 7.5 EC courses in parallel per period, the average number of contact hours for a student is 12 hours per week plus 2 hours for the colloquia. For the fourth period, the number of contact hours for a student in the research project is
determined between the student and the supervisor(s) and specified in the Osiris case for the thesis project.

**Contents**

- Mandatory courses: 16 EC
- Primary electives: 30 EC
- Research part: 14 EC
- Total: 60 EC

**Mandatory courses**

- *Data wrangling and data analysis* (INFOMDWR): 14 EC
- *Data science practice colloquium series* (INFOMDSPC): 1 EC
- *Data science ethics colloquium series* (INFOMDSEC): 1 EC

*Students must successfully pass INFOMDWR before they can continue with the electives and the thesis project. In special circumstances, the programme coordinator can make an exception to this rule in consultation with the study advisor and the Board of Examiners.

**Primary electives**

Four courses, each of 7.5 EC, adding up to a total of 30 EC*, have to be chosen from the following**:

- *Causal Inference Methods for Policy Evaluation* (INFOMCIMPE)
- *Data Ethics: Responsible data practices and value-sensitive design* (INFOMDE)
- *Dynamics and causality in the social and behavioural sciences* (INFOMDCSBS)
- *Epidemiology and Big Data* (INFOMEBD)
- *Human Network Analysis* (INFOMHNA)
Applied Data Science

- *Personalisation for (Public) Media* (INFOMPPM)
- *Spatial data analysis and simulation modelling* (INFOMSDASM)
- *Spatial Statistics and Machine Learning* (INFOMSSML)
- *Text and Media Analytics* (INFOMTMA)
- *Transformers: Applications in Language and Communication* (INFOMTALC)
- *Using data from routine care, registries, health devices and public repositories* (INFOMUDR)

* At least three out of four electives need to be completed successfully before the student can start with the thesis project (INFOMTADS).

** Some elective courses might have a quota. Students should be aware that they cannot be guaranteed a place in their preferred courses.

**Research part**


In the research part the student carries out a research project under the supervision of a scientific staff member of Utrecht University. Both the research project and the supervisor should be appointed in consultation with the thesis coordinator and approved by the Board of Examiners.

The research project should be done on a topic related to primary electives. The project normally falls within the field of applied data science and can be done in a research-and-development department of a company or institution, provided that such an external partner is approved by the programme coordinators.

Projects are provided by the programme and students will be assigned a project through a matching procedure based on their preferences and the requirements of the specific project. Students who have not yet passed all courses, excluding the colloquia series, can only start with the research part after approval by the programme coordinator.
Testing procedures

Courses within this programme apply standard testing practices as outlined in the "Model Regulations of the Board of Examiners" Article 3.1. Please note that written tests are marked based on predetermined, written standards, and possibly adjusted on the basis of a correction.

Testing provision in extraordinary circumstances (EER Art 5.8).

Students who, due to circumstances beyond their control, are unable to participate in a retake test – including when the retake test was offered as an alternative to an earlier absence at exam opportunity 1 – need to contact the study advisor and register a request with the exam committee for a third exam opportunity. The exam committee will communicate their decision to the student and the course coordinator (cc. Student Affairs). If the decision is positive, Student Affairs will register the student for an extra exam opportunity.

Cum Laude

To obtain a cum laude degree qualification, it is necessary to have a minimum grade of 7.0 on each course in addition to the requirements listed in the EER Art. 6.2, and a minimum grade of 8.5 for the research part (Thesis Applied Data Science, INFOMTADS).

Scientific integrity and labour market perspectives

Scientific integrity is addressed in the mandatory colloquium series data science ethics. The student can become familiar with labour market perspectives through the mandatory data science practice colloquium series, and through the final thesis project when done externally.
Artificial Intelligence

Admission to the degree in Artificial Intelligence

Applicants should possess solid background 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 artificial intelligence, and skills to develop and analyse programmes in these languages.

In addition, applicants should possess solid background knowledge of at least one of the following six topics:

- Artificial intelligence
- Mathematics as used in artificial intelligence
- Cognitive psychology
- Formal linguistics or natural language processing
- Philosophy of artificial intelligence
- Fundamentals of machine learning

Applicants holding one of the following bachelor's degrees 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
Artificial Intelligence

A BSc with a major in one of the following subjects, with some Computer Science or AI-related courses:

- Cognitive Science
- Linguistics
- Philosophy
- Psychology
- Data Science
- Mathematics

A Dutch HBO diploma in Computer Science or Artificial Intelligence, in both cases with a suitable programme

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

- Logica voor Informatica (INFOB1LI)
- Wiskunde voor KI (KIV13005)
- Inleiding Logica (KIV13001)
- Math and Statistics for Information and Computing Sciences (INFOB3MSIC)
- Intelligente Systemen (INFOB3IS)
- Inleiding Adaptieve Systemen (INFOB2IAS)
- Computationele Intelligentie (INFOB3CI)
- Modelleren en programmeren voor KI (KI1V13009)
- Imperatief Programmeren (INFOIMP)
Pre-Master’s programme

Students who fail to satisfy the above admission requirements may be admitted conditional on the completion of a Pre-Master’s programme of at most 30 EC, tailored by the board of admissions to the student's prior knowledge. The Pre-Master’s programme should be finished (i.e., all courses passed) before entry into the Artificial Intelligence programme is allowed. Please see article 2.4 of the GSNS EER for the exact regulations surrounding Pre-Master’s programmes.

Learning outcomes

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

Knowledge and understanding

- K1. Has mastery of artificial intelligence at an advanced academic level. This means mastery of a number of general subjects in the areas of autonomous systems, cognitive processing, language and reasoning, and in-depth knowledge and ability in at least one advanced subject in one of the above-mentioned areas. Mastery of the necessary logical, computational and experimental tools;
Artificial Intelligence

- **K2.** Has thorough experience with research in (pure or applied) artificial intelligence and a good awareness of the applicability of research in technological developments and organizational contexts;

- **K3.** Is able to read and understand research articles in artificial intelligence;

- **K4.** Understands the potential dilemmas related to scientific integrity in their research field.

**Applying knowledge and understanding**

- **A1.** Is capable of understanding a wide variety of different research problems in artificial intelligence and being able to formulate these at an abstract level. Can see, from the abstract level, the relation between diverse problems and to contribute creatively to their solution focused on practical applications;

- **A2.** Is able to find solutions for identified problems using the most advanced techniques from artificial intelligence;

- **A3.** Is capable of creating innovative Artificial Intelligence software and information system designs;

- **A4.** Has mastery of the necessary skills in theoretical analysis, modelling and experimentation.

**Making judgements**

- **M1.** Is capable of assessing and discussing research results and of taking part in discussions within the research group;

- **M2.** Is able to evaluate research results in the context of related research on artificial intelligence. Is capable of assessing the practical feasibility and usefulness of artificially intelligent designs;

- **M3.** Is capable of reflecting on their own activities as a researcher and is aware of social and ethical responsibilities concerning application of research.
Communication skills

- C1. 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;
- C2. Is capable of working in a (possibly interdisciplinary) team of experts performing the aforementioned activities and communicating easily in both written and oral English.

Learning skills

- L1. Is capable of working independently and of taking initiatives where necessary; is capable of identifying areas where expertise is lacking and remedying the situation;
- L2. Is capable of writing a research proposal and independently carrying out research in an area of artificial intelligence;
- L3. Has appropriate skills and preparation for a PhD position in the area of specialization or a key position outside of academia in the area of specialization. This includes but is not limited to working at R&D departments, working in (software) industry, consultancy, and government institutions;
- L4. Has an idea of the career opportunities after graduating, and of the skills that they need to successfully start a career.

Contact hours

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

Mandatory courses: 16 EC

Primary electives: 30 EC

Secondary electives: 30 EC

Research part: 44 EC

Total: 120 EC

Mandatory courses

- *Methods in AI Research* (INFOMAIR): 7.5 EC
- *Philosophy of AI* (WBMV05003): 7.5 EC
- *Introducing Natural Sciences* (GSNS-INTRO): 0.5 EC
- *Dilemmas of the scientist* (FI-MHPSDL1 + FI-MHPSDL2): 0.5 EC

Primary electives

Four courses (each 7.5 EC, total 30 EC) from the following seventeen courses must be chosen:

- *Intelligent Agents* (INFOIAG)
- *Multi-Agent Systems* (INFOMAS)
- *Multi-agent Learning* (INFOMAA)
- *Social Computing* (INFOMSOC)
- *Advanced Machine Learning* (INFOMAML)
- *Natural Language Processing* (INFOMNLP)
- *Cognitive Modelling* (INFOMCM)
- *Experimentation in Psychology, Linguistics, and AI* (INFOMEPL)
Artificial Intelligence

- Machine learning for human vision and language (INFOMLHVL)
- Logic and Language (TLMV13020)
- Computational Argumentation (INFOMCARG)
- Logic and Computation (WBMV13005)
- Data Mining (INFOMDM)
- Pattern Recognition (INFOMPR)
- Logics for Safe Artificial Intelligence (INFOMLSAI)
- Human-centered Machine Learning (INFOMHCML)
- Evolutionary Computing (INFOEA)

Secondary electives

A total of 30 EC in secondary electives must be chosen from the list below:

- Free choice of courses from the list of primary electives
- Research internship 7.5 EC (INFOMRIAI) or 15 EC (INFOMRIAI1)
- Free choice of mandatory and primary elective courses from the UU master's programmes Computing Science, Game and Media Technology and Human Computer Interaction (as far as their courses are open for students of other master programmes).

- The following courses from the UU master's programme Business Informatics: Method Engineering (INFOME), Software Architecture (INFOMSWA), Requirements Engineering (INFOMRE), Process Mining (INFOMPROM) Knowledge and Data Engineering (INFOMKDE), and Science-based entrepreneurship (INFOMSBE).

- The following courses from the UU research master's programme Neuroscience and Cognition: Neurocognition of Memory and Attention (BMB501603), Philosophy of Neuroscience (BMB501016), Social and Affective Neuroscience (BMB504907), Basic fMRI Analysis (BMB509117).

- The following courses from the UU research master programme Philosophy: Digital ethics (FRRMV16017), Topics in Philosophy of Mind
Artificial Intelligence

(FRRMV17007) and Topics in Epistemology and Philosophy of Science (FRRMV16011), Topics in Ethics of Technology (FRRMV22002).

- The following courses from the UU research master's programme Linguistics: Language and Information (TLRMV23101), Cognitive and Computational Aspects of Word Meaning (TLRMV19109), Foundations of Sound Patterns (TLRMV16105), Individual Assignment RMA: NLP (GWMIND1900). The individual assignment is only available when taken in tandem with one of the other three courses.

- The course Applied Cognitive Psychology II (201800484) from the Faculty of Social Sciences.

- The course Primate Social Behaviour (B-MPCEMD) from the Faculty of Science.

Other master courses, within or outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

Note that prescribed deficiency courses will be deducted from the credits available for secondary electives.

Research part

In the research part, the student carries out a research project under the responsibility of a scientific staff member of Utrecht University who is actively involved in the AI related research groups, on a topic related to the primary electives. The research part is split into the following courses:

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

Part I of a thesis project can only be started when the student has a total of at least 67.5 EC within their programme – an exception can be granted by the programme coordinator. Part II of the thesis project can only be started when Part I results in an approval to continue with Part II.
Cum Laude

The minimum grade required for the research part (INFOMAI2) to obtain a cum laude degree qualification is 8.5. Please note that additional requirements need to be met to obtain this qualification (see EER main document).

Scientific integrity and labour market perspectives

Career Services offers students a variety of activities related to labour market perspectives. In addition, students can become acquainted with the labour market by performing their final thesis project (part I and II) at an external organization.

Scientific integrity is addressed in the Master’s Introduction (GSNS-INTRO, 0.5 EC), the mandatory course Dilemmas of the Scientist (FI-MHPSDL1 and FI-MHPSDL2, 0.5 EC) and in the research part.

Profiles

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with one of the following profiles:

- Complex Systems
- Educational
- Science-based Entrepreneurship
- Communication

The contents and further description of these profiles, including entry requirements to specific courses, are described in the profile appendices. 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 conditions for secondary electives revert to the conditions for the regular (120 EC) AI programme.

Mandatory courses: 16 EC
Primary electives: 30 EC
Secondary electives: 0 EC
Artificial Intelligence

Research part: 44 EC

Total: 90 EC

The Board of Examiners will grant approval of a profile as part of the examination programme of the student if the student successfully finished the profile.

Note: The Applied Data Science Profile will not be accepted as part of this programme due to substantial overlap with courses in the programme.

Transitional Provisions

Students who enrolled before September 2022 who have successfully finished *ICT entrepreneurship* (INFOIE) or *Business Intelligence* (INFOMBIN) from the Business Informatics programme before September 2022 can count this course as a secondary elective.

Students who enrolled before September 2021 and who have been admitted to the ADS profile before 1 September 2021 are allowed to take the ADS profile as part of their examination programme.

Students who enrolled before September 2020 who have successfully finished *Data Science & Society* (INFOMDSS) from the Business Informatics programme before September 2020 can count this course as a secondary elective. Furthermore, students who enrolled before 2020 that have successfully finished any number of courses from the UU Master's programme Neuroscience and Cognition before September 2020 can count these courses as secondary electives.

Students who enrolled before September 2019 who have successfully finished any number of courses from the UU master's programme Philosophy (indicated in the Philosophy programme as “Programme electives”) or any course 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") before September 2019 can count these courses as secondary electives. Furthermore, these students may take Advanced Topics in Cognitive Science (INFOMATCS or 201300050) as a primary
Artificial Intelligence

elective instead of Machine Learning for Human Vision and Language (INFOMLHVL), *Social Simulations* (INFOMSOSI) as a primary elective instead of *Social Computing* (INFOMSOC) and *Commonsense Reasoning and Argumentation* (INFOCR) as a primary elective instead of *Computational Argumentation* (INFOMCARG).

Students who enrolled before September 2018 and have already passed Methods in Artificial Intelligence Research (INFOMAIR) for 15 EC can count INFOMAIR as the mandatory INFOMAIR course of 7.5 EC plus a primary elective of 7.5 EC.
Chemical Sciences

Nanomaterials Science

Admission to the degree in Chemical Sciences and the programme Nanomaterials Science

Applicants should possess:

- a sound basic knowledge and practical skills in physical, inorganic and/or organic chemistry and necessary mathematical skills; in particular skills and knowledge of at least three out of the following subjects is needed: physical chemistry (classical and statistical thermodynamics), inorganic and solid state chemistry, spectroscopy and structural analysis, advanced organic chemistry and/or organometallic chemistry combined with practical skills and quantum chemistry or applied density functional theory;

- the ability to work independently as well as in groups on solving chemical problems, to 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; this 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 chemical engineering
- A major in science with a strong component in chemistry.

Pre–Master’s programme

A Pre-Master’s programme of at most 30 EC is possible and will be tailored by the Board of Admissions depending on the student’s prior knowledge. The Pre-
Master's programme should be finished (i.e. all courses passed) before entry into the Nanomaterials Science programme is allowed.

Typically, students from a Dutch applied science university (so-called HBO institutions) follow this programme. Theoretical skills that will be trained in this programme are mathematics, physical and inorganic chemistry, quantum chemistry and spectroscopic analysis techniques. It is strongly advised to follow this programme as a minor within the third or fourth year of the HBO-degree programme. These courses could be combined i.e. with the HBO “afstudeerstage” in one of the Debye research groups.

The Pre-Master’s student will follow courses together with bachelor students of the chemistry programme. Bachelor courses at the level of a first and second year bachelor’s programme are taught in Dutch at Utrecht University. Students could also opt to remedy their deficiencies at another university of which the content and level of the courses will be examined by the board of examiners of the Graduate School of Natural Sciences. A Pre-Master’s 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.

Please see article 2.4 of the GSNS EER for the exact regulations surrounding Pre-Master’s programmes.

Learning outcomes

The graduate of the master's programme:

Knowledge and understanding

- K1. Has knowledge of and insight into nanomaterials with an emphasis on colloids, catalysts, and condensed matter;
- K2. Is able with this knowledge to contribute to scientific research in these areas using appropriate methods and instrumentation;
- K3. Is aware of recent developments in the research of colloids, catalysis and/or condensed matter and understands the relevance of these developments for the chosen field of specialization and society.
Nanomaterials Science

- K4. Has the skills to understand the professional literature in the area of colloids, catalysis, and condensed matter and to relate this to their own research.

- K5. Has insight into the potential dilemmas related to scientific integrity in their research field.

**Applying knowledge and understanding**

- A1. Is able to formulate an original research question for the synthesis of nanomaterials, or for obtaining new knowledge of the chemical or physical properties of such materials;

- A2. Is able to design a research plan that addresses this research question and that conforms to the methodological and scientific standards of the discipline;

- A3. Is able to analyse and to interpret the acquired materials and/or data according to the rules of good experimental practice and ethics.

**Making judgments**

- M1. Is able to discuss and to relate the obtained results with the actual state of the chosen research specialization and literature;

- M2. Is able to indicate the relevance of their research topic for the solutions and problems in the field of nanomaterials science, where possible from a societal point of view.

- M3. Is able to reflect critically upon their own contribution as a researcher in the field of nanomaterials research from a societal perspective.

**Communication skills**

- C1. Has the skills to discuss, both in spoken and written English, the obtained results of own research, including the underlying knowledge and background for a group of specialists and non-specialists in an international context;
- C2. Is able to participate critically and constructively in the scientific debate in the research group;

- C3. Is able to function effectively in a possibly multidisciplinary team of experts working in the area of chemistry and/or physics of nanomaterials.

**Learning skills**

- L1. Has the skills to evaluate their own learning and development process and to adjust this process if necessary;

- L2. Displays a professional and academic work attitude that enables them to work independently in a highly competitive labour market;

- L3. Has the qualifications to enrol in a PhD programme or to acquire a (research) position in a (semi) public or commercial organization;

- L4. Has a realistic idea of the career opportunities after graduating, and of the skills that they need 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 320 hours, or 16 hours per week, for the whole programme excluding the research part (52.5 EC) and the internship (30 EC). In the case that a student opts for 60 EC course work, the scheduled hours amount to 640 hours or 16 hours a week (excluding the research project of 52.5 EC).

**Contents**

Mandatory courses: 15 EC

Primary electives: 22.5 EC

Secondary electives: 30 EC

Research part: 52.5 EC
Nanomaterials Science

Total: 120 EC

**Mandatory courses**

- *Academic Context Course*  (SK-MACCO): 6.5 EC
- *Introducing natural sciences* (GSNS-INTRO): 0.5 EC
- *Dilemmas of the scientist* (FI-MHPSDL1 + FI-MHPSDL2): 0.5 EC
- *Advanced Spectroscopy*  (SK-MSPEC): 7.5 EC

**Primary electives**

There are five chemistry research groups participating in the Debye Institute for Nanomaterials Science. Each group requires one basic course to be taken by their 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>Solids and Surfaces (SK-MSOLS) or Photon Physics (NS-EX418M)</td>
</tr>
<tr>
<td>Inorganic Chemistry and Catalysis</td>
<td>Advanced Catalysis (SK-MCAT)</td>
</tr>
<tr>
<td>Materials Chemistry and Catalysis</td>
<td>Advanced Catalysis (SK-MCAT)</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>No mandatory course</td>
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</tbody>
</table>

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

- *Advanced Microscopy*  (NS-EX423M) 7.5 EC
- *Organometallic Chemistry and Homogeneous Catalysis* (SK-MOCHC) 7.5 EC
- *Colloidal Dispersions*  (SK-MCODI) 3.75 EC
- *Colloidal Analysis Techniques*  (SK-MCOAT) 3.75 EC
- *Advanced Organic Synthesis*  (SK-MOSS) 7.5 EC
Nanomaterials Science

- **Photon Physics** (NS-EX418M) 7.5 EC
- **Modelling and Simulation** (NS-TP432M) 7.5 EC
- Fundamentals of Soft Matter (NS-TP449M) 3.75 EC
- Experimental Soft Matter (NS-EX432M) 3.75 EC
- Theory of Soft and Active Matter (NS-TP458M) 3.75 EC
- **Photovoltaic Solar Energy Physics** (GEO4-2513) 7.5 EC
- **Solids & Surfaces** (SK-MSOLS) 7.5 EC
- **Synthesis of Catalysts and Energy Materials** (SK-MSCEM) 7.5 EC
- **Nonequilibrium Systems and Transport Phenomena** (SK-MNSTP) 7.5 EC
- **Atomistic Simulations and Machine Learning for Materials Chemistry** (SK-MASML) 7.5 EC
- **Quantum Materials** (SK-MQUMA) 7.5 EC
- **Toy Models** (BETA-MTOYM) 7.5 EC

*For students who have started their study before September 2022 and who have successfully followed the course NS-EX401M (Experimental Quantum Physics), this course may be included as a primary elective in their transcript; however, NS-EX401M and its replacement course NS-EX428M (Quantum Optics) may not be both included in the transcript. This replacement rules expires at the end of the academic year 2024/25.

**Secondary electives**

For the remaining 30 EC, several options are possible.

- Any MSc course offered by the Graduate School of Natural Sciences including the remaining primary elective courses, or courses offered by the Graduate School of Life Sciences.
- An internship of 15 to 30 EC (SK-MINTERN) outside Utrecht University. Internships can only start as soon as the mandatory, primary elective courses and the research project of 52.5 EC have been finished.
• A profile of 30 EC, of which there are six:
  - Applied Data Science
  - Complex Systems
  - Educational
  - Science-based Entrepreneurship
  - Communication
  - Management
  - Da Vinci Programme
  
  For more information see the ‘Profiles’ section below.

• One of the following 3rd year bachelor’s courses:
  - Advanced Physical Chemistry (SK-BFYC3)
  - Making modern science: a history of chemistry 1750-1950 BETA-B3MMS)
  - Condensed Quantum Matter (NS-380B)

Other master’s courses, within or outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

Note that prescribed deficiency courses (at most 15 EC) will be deducted from the credits available for secondary electives. When two deficiency courses have been prescribed, option three is not available.

**Deficiency courses**

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

- *Fysische chemie 2* (SK-BFYCH): 7.5 EC
- *Advanced Organic Chemistry* (SK-BORC3): 7.5 EC
- *Organometallic Chemistry* (SK-B3OMC): 7.5 EC
- *Quantumchemistry 2: Theory and DFT Simulations* (SK-B2QC2): 7.5 EC

If deficiency courses are taken, the EC for these courses count as EC for secondary electives.

**Research part**

The research part is split into the following courses:

1. **Part 1, Introduction to the research project** (15 EC, SK-MRES1): Introduction to research and initiating the research project
2. **Part 2, Research and thesis project** (37.5 EC, SK-MRES2): Finalizing the Research project and writing a thesis on the research topic

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

The entire research project of 52.5 EC will be performed at one of the research groups of the Debye Institute for Nanomaterials Science (including those belonging to the physics department, i.e. the Soft Condensed Matter group and Biophysics and the Nanophotonics group) or the Institute for Sustainable and Circular 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 first examiner. The student may start with their research project before the completion of the mandatory courses and the primary elective courses. 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.
Testing provision in extraordinary circumstances (Art 5.8).

Students who, due to circumstances beyond their control, are unable to participate in a retake test – also when the retake test was offered as an alternative to an earlier absence at exam opportunity 1 – need to approach the study advisor and register a request with the exam committee for an extra (third) exam opportunity. The exam committee will share their decision with the student and the course coordinator (cc. Student Affairs). If the decision is positive, Student Affairs will register the student for an extra exam opportunity.

Cum laude

The minimum grade for the course SK-MRES2 (*Research and thesis project*) a student needs to obtain a cum laude degree qualification is 8.5. Please note that additional requirements (as listed in the main text of the EER) need to be met to obtain this qualification.

Scientific integrity and labour market perspectives

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

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

Scientific integrity is covered in two courses: in the *Dilemmas of the scientist* (FI-MHPSDL1 and FI-MHPSDL2; 0.5 EC) and in a specific module (1.5 EC) as part of the *Academic Context Course*. Reflection on scientific integrity will further be part of the research project.

Profiles

The student may choose to fill the 30 EC secondary electives part with one of the following profiles:
Nanomaterials Science

- Applied Data Science
- Complex Systems
- Educational
- Science-based Entrepreneurship
- Communication
- Management
- Da Vinci Programme

The contents and further description of a profile, including entry requirements to specific courses, is described on the UU student website. 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.

The Board of Examiners will grant approval of a profile as part of the examination programme of the student if the student successfully finished the profile.

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 a complex systems profile course.

Transitional Provisions

For students who enrolled into the programme prior to 1 September 2016 the courses Introducing Natural Sciences (GSNS-INTRO) and Dilemmas of the scientist (FI-MHPSDL1 and FI-MHPSDL2) are not required.

The course code for the second part of Dilemmas of the scientist has been changed per September 2021. For students who started before this date, FI-MHPSDIL2 can be replaced by FI-MHPSDIL.
Honours

This Master’s programme offers the Double Degree Honours programme of 180 EC. For the double master of Nanomaterials Science and Experimental Physics, there is a prescribed programme available.

Nanomaterials Science and Experimental Physics

total length: at least 180 EC, 3 years
application: at any time after admission to the programmes coordination of the programme: coordinators of both programmes

Compulsory Courses (26.25 EC: 1 + 14 + 11.25)

School-Wide (1 EC)
Introducing natural sciences (GSNS-Intro) 0.5 EC
Dilemmas of the scientist (FI-MHPSDL1 + FI-MHPSDL2) 0.5 EC

Nanomaterials (14 EC)
Academic Context Course (SK-MACCO) 6.5 EC
Advanced Spectroscopy (SK-MSPEC) 7.5 EC

Experimental Physics (11.25 EC)
Computational Aspects of Machine Learning (NS-EX426M, 7.5 EC)
Open Science for Physics (NS-OS500M, 3.75 EC)

Primary Electives (60 EC: 22.5 + 37.5)

Nanomaterials (22.5 EC)
three courses from the list of primary electives of the Nanomaterials programme

Experimental Physics (37.5 EC)
students may choose courses from the list of primary electives in the Annex of Experimental Physics; two of those (minimum 15 EC) have to come from the Soft Matter and Biophysics specialisation, and at least one (minimum 7.5 EC) from one of the other specialisations.
With permission from the Exam Committee, at most one (EXPH) course may be exchanged for a mandatory or primary elective course of the Climate or Theoretical Physics programme.

**Secondary Electives (37.5 EC)**
- an internship of 15 EC (NS-NM515M1) or 30 EC (NS-NM515M3), or
- a profile (30 EC)
- for the remaining EC any courses from the programme of the GSNS or GSLS, or other master courses with permission of the Exam Committee, at most one deficiency as declared at admission to the programmes.

**Research Thesis (56.25 EC)**

requirement for thesis: the topic has to be suitable for both programmes; one examiner each from (Debye) Chemistry and Physics

Part 1: SK-MRES1 (15 EC)
Part 2: NS-EX550M (41.25 EC)
Admission to the degree in Computer Science

Applicants should possess:

- solid basic knowledge of computer science and logic;
- the ability to analyse 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
- A BSc with a major in Data Science, Artificial Intelligence, or Mathematics
- A BSc with a science major and a minor in Computer Science, or a comparable use of the non-major part (‘profileringsruimte’) of the bachelor programme
- An HBO diploma ‘Hogere Informatica Opleiding’ (HIO) or (Technical) Computer Science;

In addition, applications should meet either the requirements of the Computing Science programme or the Game and Media Technology programme.

Admission to the programme Computing Science

Students qualify for admission to the programme Computing Science if they possess the following skills and knowledge (in addition to the criteria for the degree programme Computer Science):
• have a reasonable experience in the use of several programming languages (amongst which both 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 a basic knowledge of computer science and logic;

• be able to reason formally;

• be able to communicate facts and findings in written and spoken English, 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 meet these requirements for entry in this master’s programme Computing Science. Suitable standards must be achieved in basic backgrounds, as in the Utrecht University 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, in all cases depending on the particular programme followed, that likely satisfy the entrance requirements include:

• a BSc in Mathematics or Artificial Intelligence

• an HBO-bachelor in the `HBO-opleiding Informatica’

• an HBO-bachelor in Informatics/Information Technology other than the `HBO-opleiding Informatica’

Pre-Master’s programme

Students who fail to satisfy the above admission requirements may be admitted conditional on the completion of a Pre-Master’s programme of at most 30 EC, tailored by the board of admissions to the student's prior knowledge. The Pre-Master’s programme should be finished (i.e. all courses passed) before entry into the Computing Science programme is allowed.
Computing Science

Please see article 2.4 of the GSNS EER for the exact regulations surrounding Pre-Master’s programmes.

A bachelor’s degree from an HBO in informatics does not meet the entrance requirements fully as a rule, a pre-master’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**
  - K1. Can use their 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.
  - K2. Is capable of understanding important recent developments in computer science, and of indicating their implications for society and the research field.
  - K3. Is capable of interpreting and using specialized literature in the field of computing science.
  - K4. Has insight into integrity related issues in computer science.

- **Applying knowledge and understanding**
  - A1. 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.
  - A2. Is capable of translating this research question into an appropriate research plan in accordance with the required scientific and methodological standards.
  - A3. 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**
  
  - M1. 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.
  
  - M2. 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.
  
  - M3. Has the capability to reflect critically on their own efforts as a researcher in the area of computer science from the viewpoint of society.

• **Communication skills**
  
  - C1. 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.
  
  - C2. Is capable of functioning effectively in a research team of possibly multi-disciplinary composition.

• **Learning skills**
  
  - L1. Has the capability to evaluate their own learning- and development process during the study, and if necessary to motivate and adjust themselves.
  
  - L2. Has acquired an effective and results-driven way of working that allows them to function independently in a competitive labour market.
  
  - L3. Has the qualification to obtain a PhD position as well as a job in business and industry.
  
  - L4. Has insight into employment opportunities and on the skills needed to make a successful start in the job market.

**Contact hours**

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

Contents

- Mandatory courses: 23.5 EC
- Primary electives: 22.5 EC
- Secondary electives: 30 EC
- Research part: 44 EC
- Total: 120 EC

Study paths

Students follow "study paths". A study path is a coherent set of courses tailored towards a general topic within the master’s programme. The following study paths (listed below) are pre-defined and set the standard for the programme.

- Programming technology
- Algorithm design and analysis
- Operations research
- Alternatively, an individual study path can be composed, under approval of the programme director. The courses that belong to each of the above study paths are listed in the "Primary electives" section below.

Mandatory courses

- *Algorithms for decision support*  
  (INFOMADS): 7.5 EC
- *Concepts of programming language design*  
  (INFOMCPD): 7.5 EC
- *Scientific methods for Computing Science*  
  (INFOMSMC): 7.5 EC
- *Introducing Natural Sciences*  
  (GSNS-INTRO): 0.5 EC
- *Dilemmas of the scientist*  
  (FI-MHPSDL1 + FI-MHPSDL2): 0.5 EC
Primary electives

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

- **Programming technology, courses:**
  - *Advanced functional programming* (INFOAFP)
  - *Language based security* (INFOMLBS)
  - *Probabilistic Reasoning* (INFOPROB)
  - *Program semantics and verification* (INFOMPSV)

- **Algorithm design and analysis, courses:**
  - *Geometric algorithms* (INFOGA)
  - Advanced Algorithms (INFOAN)
  - *Scheduling and time-tabling* (INFOSTTT)
  - *Network science* (INFOMNWSC)
  - *Optimization for sustainability* (INFOMOFS)

- **Operations research, courses:**
  - *Optimization for sustainability* (INFOMOFS)
  - *Scheduling and time-tabling* (INFOSTTT)
  - Advanced Algorithms (INFOAN)
  - *Data mining* (INFOMDM)
  - *Evolutionary Computing* (INFOEA)

Secondary electives

Secondary electives can be chosen from the list below:
Computing Science

- Any primary elective from the Computer Science Master's curriculum (including the Game and Media Technology and Data Science programmes).

- An experimentation project of either 7.5 (INFOMEPCS) or 15 EC (INFOMEPCS1).

- A literature study under supervision of a CS staff member (capita selecta) of 7.5 EC.

- Another MSc course offered by Utrecht University such as:
  - Evolutionary computing (AI), Advanced machine learning (AI), Multi-agent systems, Multi-agent learning (AI), Natural language processing (INFOMNLP), or Technologies for Learning (INFOMTFL).

- Courses taken from the Mastermath programme such as: Continuous optimization, Queueing theory, or Parallel algorithms.

A student may take up other relevant courses outside of the regular Computer Science curriculum, within or outside the UU, upon approval in advance of the programme coordinator and upon request of the student. This choice is subject to approval by the Board of Examiners, who will take into account the advice of the programme coordinator. Of these, 7.5 EC worth of course can be chosen outside the Faculty of Science.

Note that prescribed deficiency courses will be deducted from the credits available for secondary electives.

**Deficiency courses**

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 (as stated in their Admission Letter). Each of the courses below is 7.5 EC. In contrast to MSc courses, these are usually taught in Dutch:

- Logica voor informatica (INFOB1LI)
- Databases (INFODB)
- Datastructuren (INFODS)
Computing Science

- *Functioneel programmeren* (INFOFP)
- *Modelleren en systeemontwikkeling* (INFOMSO)
- *Math and statistics for Information and Computing Sciences* (INFOB3MSIC)
- *Onderzoeksmethoden voor informatica* (INFOB3OMI)
- *Optimalisering en complexiteit* (INFOOPT)
- *Talen en compilers* (INFOB3TC)
- *Algoritmiek* (INFOAL)
- *Software testing en verificatie* (INFOB3STV)
- If deficiency courses are taken, the EC for these courses count as EC for secondary electives.

**Research part**

Research can be done in the following directions: all subjects related to the research programmes of the Software Technology chair, the Algorithms and Complexity chair, or other staff members teaching in a primary elective in any of the three tracks. Research projects can be done either internally or externally. In particular, research can be done in all subjects related to the list of Primary Elective courses.

The overall research part is split into the following parts:


Part I of a thesis project can only be started when the student has done enough mandatory courses, primary electives, 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.
Testing provision in extraordinary circumstances (Art 5.8).

Students who, due to circumstances beyond their control, are unable to participate in a retake test – also when the retake test was offered as an alternative to an earlier absence at exam opportunity 1 – need to approach the study advisor and register a request with the exam committee for an extra (third) exam opportunity. The exam committee will share their decision with the student and the course coordinator (cc. Student Affairs). If the decision is positive, Student Affairs will register the student for an extra exam opportunity.

Cum laude

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

Scientific integrity and labour market perspectives

Scientific integrity is a part of the Computing Science colloquium and consists of two sessions: one at the start of the programme during the GSNS-Intro and one during the programme (FI-MHPSDL1 and FI-MHPSDL2, Dilemmas of the scientist (0.5 EC)). A wide variety of activities related to labour market perspectives are offered by Career Services to the Computing Science students.

Profiles

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with one of the following profiles:

- Complex Systems
- Educational
- Science-based Entrepreneurship
- Communication
- The Da Vinci Master Programme

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

Inclusion of a profile in the examination programme of the student is subject to approval by the Board of Examiners. The Board of Examiners will grant approval of inclusion of a profile in the examination programme of the student if:

- There is a positive recommendation by the programme coordinator.
- The student has been admitted to the profile.

Note: The Applied Data Science Profile will not be accepted as part of this programme due to substantial overlap with courses in the programme.

**Transitional Provisions**

- For students who enrolled into the programme prior to 1 September 2016 the courses *Introducing Natural Sciences* (GSNS-INTRO) and *Dilemmas of the scientist* (FI-MHPSDL1 and FI-MHPSDL2) are not required.

- Students enrolled into this programme prior to 1 September 2023 can do the study path Algorithmic Data Analysis with the primary electives:
  - *Data mining* (INFOMDM)
  - *Multimedia retrieval* (INFOMR)
  - *Pattern recognition* (INFOMPR)
  - *Data intensive systems* (INFOMDIS)
  - *Data Visualization* (INFOMDV)
  - *Knowledge and data engineering* (INFOKDE)

- Students enrolled into this programme prior to 1 September 2020 can do the study path Advanced planning and decision making, courses:
  - *Probabilistic reasoning* (INFOPROB)
  - *Algorithms and networks* (INFOAN)
- **Evolutionary computing** (INFOEA)
- **Scheduling and time-tabling** (INFOSTT)

- Students enrolled into this programme prior to 1 September 2019 who have taken the course **Compiler construction** (INFOMCCO) should not take the course **Automatic program analysis** (INFOAPA) due to their overlapping content. Students enrolled in the programme prior to 1 September 2022 who are in the Programming Tech track may take **Automatic program analysis** (INFOAPA) and **Technologies for learning** (INFOMTFL) in addition to the primary electives listed above.

- Students enrolled in the programme prior to 1 September 2022 may replace **Scientific Methods for Computing Science** (INFOMSMC) with **Big Data** (INFOMBD) in their list of mandatory courses.

- Students enrolled in the programme prior to 1 September 2022 may choose the course **Pattern Set Mining** (INFOMPSM) as a primary elective in the Operations Research and Algorithmic Data Analysis track.

- Students enrolled in the programme prior to 1 September 2022 may choose the course **Crowd Simulation** (INFOMCRWS) as a primary elective in the Algorithm Design and Analysis track.

- The course code for the second part of **Dilemmas of the scientist** has been changed per September 2021. For students who started before this date, FI-MHPSDIL2 can be replaced by FI-MHPSDIL. For students who have been admitted to the ADS profile before 1 September 2021, the ADS profile will be accepted as part of their examination programme.

- Students enrolled in the programme prior to 1 September 2022 who have taken the course on **Domain Specific Languages** (INFOMDSL) should not take the course on **Language based Security** (INFOMLBS).

- Students enrolled in the programme prior to 1 September 2022 who have taken the course on **Algorithms and Networks** (INFOAN) should not take the course on **Advanced Algorithms** (INFOAN).
Data Science

Admission to the programme

To be eligible for application to the programme, one must have:

- A Bachelor's in Computer Science, Data Science, Computer Engineering, or Artificial Intelligence
- A Bachelor's degree with a major in the above disciplines
- A Bachelor’s with a Science major and a minor in the above disciplines, or a comparable use of the non-major part ('profileringsruimte') of the bachelor programme
- An HBO diploma ‘Hogere Informatica Opleiding’ (HIO) or (Technical) Computer Science, with a score of at least 7.0 on the Dutch score scale from 0 to 10.
- A Master’s degree in Applied Data Science (or Data Science) in the Netherlands with score of at least 7.0 on the Dutch score scale from 0 to 10.

(The first four points subsume Point 1 of article 2.1 in Section 2 of the Education and Examination Regulations (EER).)

For being admitted to the programme, an applicant should possess the following competences:

- Ability to analyze and model computer science problems.
- Experience in the use of programming languages, both functional and object-oriented.
- Adequate working knowledge with computer systems and information networks.
- Familiarity with modern software development.
- Proficiency in algorithms and data structures.
- Competency in Data Management Systems.
- Knowledge of basic mathematics such as: statistics, probability, logic, and linear algebra.
- Communication ability in English.

The latter requirement derives from article 2.2 of Section 2, while the rest are specializations of the admissions requirements set by the degree Computer Science, hence are subsumed by them.
**Pre-Master’s programme**

In compliance to article 2.4, a pre-master's programme of at most 30 ECTS (European Credit Transfer System) (4 courses) is possible for applicants that have multiple minor deficiencies in their prior education. The exact contents of the track are decided by the admission committee on a student per student case. The courses are from the Bachelor's in Computing or Information Sciences. All the courses must be successfully completed (passed) before courses from the Master's in Data Science programme can be taken. These courses are selected among the following:

- (BETA-B1PYT) Programmeren in Python \( P_3 \)
- (INFOFP) Functioneel programmeren \( P_1 \)
- (INFOB1LI) Logica voor informatica \( P_1 \)
- (INFOAL) Algoritmiek \( P_3 \)
- (INFODB) Databases \( P_3 \)
- (INFODS) Datastructuren \( P_4 \)
- (INFOB2DA) Data Analytics \( P_1 \)

**Learning outcomes**

The study program has the following learning outcomes. Each outcome is a specialization of the learning outcome of the degree of Computer Science with the respective numbering. Those in bold, however, constitute additional learning outcomes that are particularly for the programme in Data Science.

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
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<tbody>
<tr>
<td><strong>K1.</strong> Graduates can use their knowledge to make a substantial contribution to the development and/or application of scientific concepts and methods, in Data Science.</td>
</tr>
<tr>
<td><strong>K2.</strong> Graduates can understand important recent developments in Data Science, and of indicating their implications for society and the research field.</td>
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<tr>
<td><strong>K3.</strong> Graduates are capable of interpreting and using specialized literature in the field of Data Science.</td>
</tr>
<tr>
<td><strong>K4.</strong> Graduates have insight into integrity-related issues related to the application of Data Science for solving business and societal issues.</td>
</tr>
<tr>
<td><strong>K5.</strong> Graduates have the foundational knowledge of theories, principles, methods, for data storage, integration, cleaning, understanding, exploration.</td>
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<tr>
<td><strong>K6.</strong> Graduates have in-depth knowledge and understanding of data analytics.</td>
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<tr>
<td><strong>K7.</strong> Graduates are familiar with advanced visualization techniques for massive data presentation, interaction, and analysis.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Applying knowledge and understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1.</strong> Graduates can translate a problem from the area of Data Science or an application into a research question that is relevant to and suited for scientific development, product development or education.</td>
</tr>
</tbody>
</table>
A2. Graduates can translate a research question into an appropriate research plan in accordance with the required scientific and methodological standards.

A3. Graduates are capable of independently performing the 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.

A4. Graduates can solve well-defined business problems from an interdisciplinary perspective using data science tools, techniques, and expertise.

A5. Graduates know how to collect, store, and process datasets to make them ready for exploration and analysis.

A6. Graduates can apply a broad range of data analytic techniques.

Making judgements

J1. Graduates can discuss the outcomes of empirical and theoretical research and to relate them to the current scientific Data Science state-of-the-art and literature.

J2. Graduates can indicate the relevance of their research to the solution of problems in Data Science, also from the viewpoint of society wherever possible.

J3. Graduates have the capability to reflect critically on his or her own efforts as a researcher in Data Science from the viewpoint of society.

J4. Graduates can assess the content, context, size, quality, limitations, and potential of datasets for solving a specific challenge at hand.

J5. Graduates can identify research challenges that can be addressed through the exploitation of specific datasets and the employment of specific Data Science methods.

Communication

C1. Graduates are capable of clearly communicating the results of research, in writing as well as orally, to an audience of specialists and non-professionals, in an international context.

C2. Graduates are capable of functioning effectively in a research team of multi-disciplinary composition.

Learning skills

L1. Graduates have the capability to evaluate his or her own learning- and development process during the study, and if necessary to motivate and adjust himself or herself.

L2. Graduates have acquired an effective and result driven way of working that allows him or her to function independently in a competitive labour market.

L3. Graduates have the qualification to obtain a PhD position as well as a job in business and industry.

L4. Graduates have insight into employment opportunities and on the skills needed to make a successful start in the job market.

Contact hours

In general, 1 ECTS corresponds to approximately 28 study hours, which, if multiplied by the total number of ECTS required by the program overall, gives an indicative quantification of the expected contact hours.
Content

The programme consists of several mandatory and elective training through courses, alongside a research project, that all together provide 120 ECTS.

Analytically, the program consists of:

- 4 Mandatory Courses (7,5 EC each) : 30 EC
- 5 Primary Electives (7,5 EC each) : 37,5 EC
- 1 Secondary Elective : 7,5 EC
- 3 Research Introductory Courses : 1 EC
- Research Project : 44 EC
- Total : 120 EC

Study paths

N/A

Research Introductory Courses

- Introducing Natural Sciences (GSNS-INTRO)
- Dilemmas of the scientist workshop 1 (FI-MHPSDL1)
- Dilemmas of the scientist workshop 2 (FI-MHPSDL2)

Mandatory Courses

- Data Mining (INFOMDM)
- Knowledge and Data Engineering (INFOMKDE)
- Data Intensive Systems (INFOMDIS)
- Scientific Methods for Computing Science (INFOMSMC)

Primary Elective Courses

- Multimedia Retrieval (INFOMR)
- Probabilistic Reasoning (INFOPROB)
- Pattern Recognition and Deep Learning (INFOMPRDL)
- Advanced Machine Learning (INFOMAML)
- Data Visualization (INFOMDV)
- Machine Learning in Dynamics Data Environments (INFOMLDDE)
- Network Science (INFOMNWSC)
- Process Mining (INFOMPROM)
- Cloud and Edge Computing (INFOMCEC)
- Algorithmic Data Analysis (INFOMADA)
- Algorithms for Decision Support (INFOMADS)
**Secondary Elective Courses**

As secondary elective can be considered any master course offered by any department of the university with at least 7,5 ECTS, that has not been used as mandatory or primary elective.

**Deficiency courses**

In compliance to point 7 of article 3.6 of the EER, in the case in which an applicant has a minor deficiency in some of the subjects needed for admission, as mentioned earlier, a course on that subject should be taken as part of the programme to remedy this deficiency (at most 7.5 EC, which counts as a secondary elective). The admission committee decides which courses need to be followed on a case-by-case basis. The courses are among those mentioned in the pre-master programme.

**Research part**

The research project consists of the research introductory courses and 2 more parts:

- **Data Science Project Proposal (INFOMDASC1 and INFOMCDASC):** Consisting of a literature review, a problem specification, and a planning for Phase II. The phase ends with a colloquium and a document. This part can start only after all the mandatory, primary electives, secondary electives, and deficiency courses have been completed. Exceptions need to be approved by the programme coordinator.

- **Data Science Thesis (INFOMDASC2):** Research Work, ending with a thesis document and a presentation. It can start only if Part I has been completed.

**Testing provision in extraordinary circumstances (Art 5.8).**

Students who, due to circumstances beyond their control, are unable to participate in a retake test – also when the retake test was offered as an alternative to an earlier absence at exam opportunity 1 – need to approach the study advisor and register a request with the exam committee for an extra (third) exam opportunity. The exam committee will share their decision with the
student and the course coordinator (cc. Student Affairs). If the decision is positive, Student Affairs will register the student for an extra exam opportunity.

**Cum laude**

The minimum grade for the research assignment to achieve cum laude as specified in par 3b of article 6.2 is 8,5 (8 and a half) out of 10. Additional requirements (as listed in the main text of the EER) need to be met to obtain the judicium.

**Profiles**

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme's with a Complex Systems, Education "profile". The 30 EC are formed by replacing one primary elective and the secondary elective of the regular programme (15 EC), and 15 EC from the regular research program. The contents and further description of a profile, including entry requirements to specific courses, is described in a separate appendix. 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.

**Transitional Provisions**

1. Students who, in September 2023, were already admitted in the Algorithmic Data Analysis track of the Master’s programme in Computer Science, can, if they choose so, be transferred to the programme in Data Science, with the courses taken in the former recognized in the latter. Those students cannot take the course INFOMPRDL (respectively, the course INFOMADA), if they have already taken the course INFOMPR (respectively, the course INFOMPSM).

2. Course names and/or codes may change over the years. A student is not allowed to have in the study programme two courses with the same name or code.

3. Students of this program cannot take the Applied Data Science Profile due to substantial overlapping in the content.

4. The Algorithmic Data Analysis (INFOMADA) course will not be taught in the academic year 2023/2024.
Admission to the degree in Computer Science

Applicants should possess

- Solid basic knowledge of computer science and logic;
- The ability to analyse 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, Data Science, or Artificial Intelligence
- A BSc with a major in Computer Science, Data Science, or Artificial Intelligence
- A BSc with a science major and a minor in Computer Science, Data Science, or Technical Artificial Intelligence or a comparable use of the non-major part ('profileringsruimte') of the bachelor programme
- An HBO (Higher professional education) diploma ‘Hogere Informatica Opleiding’ (HIO) or (Technical) Computer Science;

In addition, applications should meet either the requirements of the Computing Science programme or the Game and Media Technology programme (see below).

Admission to the programme Game and Media Technology

Students qualify for admission to the programme Game and Media Technology if they possess the following skills and knowledge (in addition to the criteria for the degree programme Computer Science):
the ability to make a computer programme of reasonable complexity and size, in an object-oriented programming language such as Java, C++ or C#;

knowledge of data structures, algorithms and related concepts of reasonable complexity, such as sorting algorithms, O(.-)-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;
- An HBO BSc programme in HIO (Higher Computer Science Education) 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.

Pre-Master’s programme

Students who fail to satisfy the above admission requirements may be admitted conditional on the completion of a Pre-Master’s programme of at most 30 EC, tailored by the board of admissions to the student’s prior knowledge. The Pre-Master’s programme should be finished (i.e. all courses passed) before entry into the Game and Media Technology programme is allowed.

Please see article 2.4 of the GSNS EER for the exact regulations surrounding Pre-Master’s programmes. A Pre-Master’s programme is currently only offered to Dutch speaking students from the EU.

Learning outcomes

The graduate of the master’s programme in Game and Media Technology:
Knowledge and understanding

- K1. Can use their 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.

- K2. Is capable of understanding important recent developments in computer science and its applications in the field of game and media technology, and of indicating their implications for society and the research field.

- K3. Is capable of interpreting and using specialized literature in the field of game and media technology.

- K4. Has insight into the integrity dilemmas that play a role in the field of game and media technology.

Applying knowledge and understanding

- A1. 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.

- A2. Is capable of translating this research question into an appropriate research plan in accordance with the required scientific and methodological standards.

- A3. 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

- M1. 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.
Game and Media Technology

- M2. Is capable of indicating the relevance of this research to the solution of problems in the area of computer science and its applications in the field of game and media technology, also from the viewpoint of society wherever possible.

- M3. Has the capability to reflect critically on their 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

- C1. 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.

- C2. Is capable of functioning effectively in a research team of possibly multi-disciplinary composition.

Learning skills

- L1. Has the capability to evaluate their own learning- and development process during the study, and if necessary, to motivate and adjust themselves.

- L2. Has acquired an effective and results-driven way of working that allows them to function independently in a competitive labour market.

- L3. Has the qualification to obtain a PhD position as well as a job in business and industry.

- L4. Has a good overview of the opportunities and necessary skills to make a successful transition to the labour market.

Contact hours

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

Contents

Mandatory courses: 16 EC
Primary electives: 45 EC
Secondary electives: 15 EC
Research part: 44 EC
Total: 120 EC

Mandatory courses

Computer Vision (INFOMCV): 7.5 EC
Scientific Perspectives on GMT (INFOMSCIP): 7.5 EC
Introducing Natural Sciences (GSNS-INTRO): 0.5 EC
Dilemmas of the Scientist (FI-MHPSDL1 + FI-MHPSDL2): 0.5 EC

Primary electives

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

AI for game technology (INFOMAIGT): 7.5 EC
Geometric Algorithms (INFOGA): 7.5 EC
Advanced Graphics (INFOMAGR): 7.5 EC
Computer Animation (INFOMCANIM): 7.5 EC
Game Physics (INFOMGP): 7.5 EC
Multimodal Interaction (INFOMMMI): 7.5 EC
Mobile Interaction (INFOMMOB): 7.5 EC
Motion and Manipulation (INFOMOMA): 7.5 EC
Game and Media Technology

- **Optimization and Vectorization** (INFOMOV): 7.5 EC
- **Crowd Simulation** (INFOMCRWS): 7.5 EC
- **Multimedia Retrieval** (INFOMR): 7.5 EC
- **Sound and Music Technology** (INFOMSMT): 7.5 EC
- **Pattern Recognition** (INFOMPR): 7.5 EC
- **Serious Games** (INFOMSEGA): 7.5 EC
- **Small Project GMT** (INFOMSPGMT): 15 EC

**Secondary electives**

Secondary electives can be chosen from the list below:

- Any of the not chosen primary electives.
- At most one Capita selecta (INFOCSM, 7.5 EC) on a subject approved by the programme coordinator.

Other master courses, within or outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

Note that prescribed deficiency courses will be deducted from the credits available for secondary electives.

**Deficiency courses**

Courses that remove deficiencies, as recommended by the programme coordinator. Note that some deficiency courses may be given in Dutch, since they are part of our (Dutch) bachelor program.

Examples of common deficiency courses include:

- **Beeldverwerking** (Image Processing) (INFOIBV): 7.5 EC
- **Gamification and Applied Games** (INFOB3APGA): 7.5 EC
Game and Media Technology

- **Algoritmiek (Algorithms)** (INFOAL): 7.5 EC
- **Datastructuren (Data structures)** (INFODS): 7.5 EC
- **Interactie-technologie (Interaction Technology)** (INFOB3IT): 7.5 EC
- **Driedimensionaal Modelleren (Three-Dimensional Modelling)** (INFODDM): 7.5 EC

If deficiency courses are taken, the EC for these courses count as EC for secondary electives.

**Research part**

The research part is split into the following courses:

- **Game and Media Technology Project Proposal** (INFOMGMT1): 15 EC
- **Game and Media Technology MSc Thesis** (INFOMGMT2): 25 EC
- **Colloquium Game and Media technology** (INFOMCGM4): 4 EC

Part I of a thesis project can only be started when the student has completed enough of 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.

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

**Testing provision in extraordinary circumstances (Art 5.8).**

Students who, due to circumstances beyond their control, are unable to participate in a retake test – also when the retake test was offered as an alternative to an earlier absence at exam opportunity 1 – need to approach the study advisor and register a request with the exam committee for an extra (third) exam opportunity. The exam committee will share their decision with the student and the course coordinator (cc. Student Affairs). If the decision is positive, Student Affairs will register the student for an extra exam opportunity.
Cum laude

The minimum grade for the course INFOMGMT2 a student needs to obtain a cum laude degree qualification is 8.5. Please note that additional requirements (as listed in the main text of the EER) need to be met to obtain this qualification.

Scientific integrity and labour market perspectives

Scientific Integrity is a part of the colloquium (INFOMCGM4), the Master’s Introduction (GSNS-INTRO, 0.5 EC) and the course Dilemmas of the Scientist (FI-MHPSDL1 and FI-MHPSDL2, 0.5 EC). A wide variety of activities related to labour market perspectives is offered by Career Services to the GMT students.

Profiles

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with one of the following profiles:

- Complex Systems
- Educational
- Science-based Entrepreneurship
- Communication
- Da Vinci profile on Sustainability

The contents and further description of a profile, including entry requirements to specific courses, is described in the profile appendices. To still meet the learning outcomes of the master’s programme, the remaining 90 EC must be filled in as described below. Note, if the student fails to successfully complete the profile, that 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 GMT cannot be selected. The mandatory courses (16 EC) and the research part (44 EC) do not change.

Mandatory courses: 16 EC

Primary electives: 30 EC
Game and Media Technology

Secondary electives: 0 EC
Research part: 44 EC
Total: 90 EC

Inclusion of a profile in the examination programme of the student is subject to approval by the Board of Examiners. The Board of Examiners will grant approval of inclusion of a profile in the examination programme of the student if:

There is a positive recommendation by the programme coordinator.
The student has been admitted to the profile.

Note: The Applied Data Science Profile will not be accepted as part of this programme due to substantial overlap with courses in the programme.

Transitional Provisions

For students who enrolled into the programme prior to 1 September 2016 the courses Introducing Natural Sciences (GSNS-INTRO) and Dilemmas of the scientist (FI-MHPSDL1 and FI-MHPSDL2) are not required.

For students who enrolled in the programme Game and Media Technology in the year 2017-2018 and earlier, the course Scientific Perspectives on GMT is not mandatory. However, the course Motion and Manipulation is mandatory. For students who started in September 2017, Motion and Manipulation is mandatory and Scientific Perspectives on GMT is not allowed (unless special permission is given). Students who have enrolled in February 2018 can either choose Scientific Perspectives on GMT or Motion and Manipulation as a mandatory course.

The course code for the second part of Dilemmas of the scientist has been changed per September 2021. For students who started before this date, FI-MHPSDL2 can be replaced by FI-MHPSDIL. For students who have been admitted to the ADS profile before 1 September 2021, the ADS profile will be accepted as part of their examination programme.
History and Philosophy of Science

Admission to the degree in History and Philosophy of Science

Applicants should possess:

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

Pre-Master’s Programme

Students who fail to satisfy the above admission requirements may be admitted conditional on the completion of a Pre-Master's programme of at most 30 EC, tailored by the board of admissions to the student's prior knowledge. The Pre-Master's programme should be finished (i.e. all courses passed) before entry into the History and Philosophy of Science programme is allowed.

Please see article 2.4 of the GSNS EER for the exact regulations surrounding Pre-master's programmes.

Learning outcomes

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

Knowledge and understanding
History and Philosophy of Science

- K1. Has a basic knowledge and understanding of the main themes and debates in history and philosophy of the sciences and the humanities.

- K2. Can reflect critically on the nature and practice of different kinds of knowledge and how they relate to political, social and cultural contexts.

- K3. Has detailed knowledge of one of the areas of history and/or philosophy of knowledge.

- K4. Is able to contribute to scholarly research in one of these areas.

- K5. Is aware of important recent developments in one of these areas and can reflect on their relevance, both within and outside academia.

- K6. 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.

- K7. Understands the potential dilemmas related to academic integrity in their research field.

Applying knowledge and understanding

- A1. Is able to formulate an original research question in one of these areas relevant for scientific development, education, or public understanding.

- A2. Is able to formulate a fitting research plan in accordance with scientific and methodological standards.

- A3. Is able to apply their understanding to critically reflect on current issues in academia and society, and to relate this to social, cultural and political developments.

- A4. Is aware of the possibilities and pitfalls in applying their knowledge to social questions, and can specifically relate this to their own work.
- A5. Is able to carry out a research plan according to the rules of good practice of academic integrity and ethics.

**Making judgements**

- M1. Is able to participate critically and constructively in scholarly debates in history and philosophy of the sciences and the humanities.

- M2. Is able to assess the scientific and possible social relevance of their research.

- M3. Is able to reflect critically upon their own historiographical or philosophical position within the chosen area, also from a social and cultural perspective.

**Communication skills**

- C1. Is able to write papers, based on their own research, on an academic level.

- C2. Is able to cooperate effectively with fellow researchers.

- C3. Is able to present complex issues in a clear way, both written and orally, to academic and non-academic audiences.

**Learning skills**

- L1. Has the skills to work self-reliantly, to evaluate their own learning and development process and to adjust this process if necessary.

- L2. Has the qualifications to enrol in a PhD programme in the field of history and philosophy of science and/or is qualified to acquire a position as a professional in fields related to history and philosophy of science, e.g. science publishing, science communication, public policy, science management, or science museums.

- L3. Has a realistic idea of the career opportunities after graduating, and of the skills that they need to successfully start a career.
Contact hours
The average number of contact hours for a student of the programme (number of scheduled contact hours for the different courses and, in addition, the scheduled or standardised supervision time) is: 412 hours, or approximately 9 hours per week, for the whole programme excluding the research part. The number of contact hours for a student in the research part of the programme is specified in individual application forms.

Contents

- Mandatory courses: 30 EC
- Primary electives: at least 22,5 EC
- Secondary electives: at most 15 EC
- Research part: 52,5 EC
- Total: 120 EC

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

Master’s courses outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

Mandatory Courses

History of Knowledge 1 (GKRMV22006): 7,5 EC
History of Knowledge 2 (FI-MHPSHK2): 7,5 EC
Philosophy of Science (FI-MHPSPS): 7,5 EC
- Research Seminar, consisting of: (FI-MHPSSR): 6,5 EC
History and Philosophy of Science

- reading group (history of science, philosophy of science, philosophy of physics)
- colloquium attendance (a minimum of 20)

Introducing Natural Sciences

Dilemmas of the scientist

Primary Electives

At least 22.5 EC, to be chosen out of the following list (not every course is offered every year):

<table>
<thead>
<tr>
<th>Title</th>
<th>EC</th>
<th>code</th>
</tr>
</thead>
<tbody>
<tr>
<td>20th century German Philosophy</td>
<td>5</td>
<td>FRRMV16015</td>
</tr>
<tr>
<td>Art History I: Knowledge, Technologies, and Material Culture</td>
<td>5 or 10</td>
<td>GKRMV16051</td>
</tr>
<tr>
<td>Digital Ethics</td>
<td>5</td>
<td>FRRMV16017</td>
</tr>
<tr>
<td>Ethics and Technology</td>
<td>5</td>
<td>FRRMV22002</td>
</tr>
<tr>
<td>Foundations of Quantum Mechanics</td>
<td>5</td>
<td>FI-MHPSQM</td>
</tr>
<tr>
<td>History and Philosophy of Objectivity</td>
<td>5</td>
<td>FRRMV16014</td>
</tr>
<tr>
<td>History of Magic</td>
<td>7,5</td>
<td>FI-MHPSMAG</td>
</tr>
<tr>
<td>History of Medicine</td>
<td>7,5</td>
<td>BMB507812</td>
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<tr>
<td>History and Philosophy of the Modern Life Sciences</td>
<td>7,5</td>
<td>FI-MHPSHLS</td>
</tr>
<tr>
<td>History of the Early Modern Book</td>
<td>5</td>
<td>GKRMV17007</td>
</tr>
<tr>
<td>HPS Summer School</td>
<td>2</td>
<td></td>
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<tr>
<td>Investigative Journalism</td>
<td>5 or 7,5</td>
<td>FI-MHPSIJ</td>
</tr>
<tr>
<td>Law as an Academic Discipline</td>
<td>7,5</td>
<td>RGMURWOM08</td>
</tr>
<tr>
<td>Logic and Computation</td>
<td>7,5</td>
<td>WBMV13005</td>
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<tr>
<td>History and Philosophy of the Earth and Climate Sciences</td>
<td>7,5</td>
<td>FI-MHPSMCE</td>
</tr>
<tr>
<td>Pharmaceutical Humanities</td>
<td>7,5</td>
<td>FA-MA214</td>
</tr>
<tr>
<td>Philosophy of Artificial Intelligence</td>
<td>7,5</td>
<td>WBMV05003</td>
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<tr>
<td>Philosophy of Space and Time 1</td>
<td>5</td>
<td>FI-MHPSST</td>
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<tr>
<td>Philosophy of Space and Time 2</td>
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<td>FI-MHPSST2</td>
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History and Philosophy of Science

<table>
<thead>
<tr>
<th>Course</th>
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<th>Code</th>
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<tr>
<td>Philosophy of Space and Time</td>
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<td>FI-MHPSPST</td>
</tr>
<tr>
<td>Philosophy of the Social Sciences</td>
<td>5 or 7,5</td>
<td>201600160</td>
</tr>
<tr>
<td>Professional Skills and Identity</td>
<td>5</td>
<td>FI-MSECPSI</td>
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<tr>
<td>Research Seminar History of Mathematics</td>
<td>7,5</td>
<td>WISM481</td>
</tr>
<tr>
<td>Science and the Dilemmas of Modernity</td>
<td>7,5</td>
<td>FI-MHPSDM</td>
</tr>
<tr>
<td>Science and the Public</td>
<td>7,5</td>
<td>FI-MHPSSP</td>
</tr>
<tr>
<td>Science in Society</td>
<td>5</td>
<td>FI-MSECSSIS</td>
</tr>
<tr>
<td>Summer School: Science and Values: Historical and Philosophical Perspectives</td>
<td>2</td>
<td>FI-MHPSSUM</td>
</tr>
<tr>
<td>The Quantum World</td>
<td>5</td>
<td>FI-MHPSQW</td>
</tr>
<tr>
<td>The Quantum World</td>
<td>7,5</td>
<td>FI-MHPSTQW</td>
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<tr>
<td>Topics in Early Modern Philosophy</td>
<td>5</td>
<td>FRRMV16010</td>
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<tr>
<td>Topics in Epistemology and Philosophy of Science</td>
<td>5</td>
<td>FRRMV16011</td>
</tr>
<tr>
<td>Topics in German Idealism</td>
<td>5</td>
<td>FRRMV17006</td>
</tr>
<tr>
<td>Topics in Metaphysics</td>
<td>5</td>
<td>FRRMV16008</td>
</tr>
<tr>
<td>Topics in Moral Psychology</td>
<td>5</td>
<td>FRRMV16013</td>
</tr>
<tr>
<td>Topics in Philosophy of Language and Logic</td>
<td>5</td>
<td>FRRMV17003</td>
</tr>
<tr>
<td>Topics in Philosophy of Mind</td>
<td>5</td>
<td>FRRMV17007</td>
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<td>Tutorial HPS</td>
<td>5 or 7,5</td>
<td>FI-MHPSTUT, FI-MHPSTU2</td>
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<tr>
<td>Tutorial Philosophy</td>
<td>5</td>
<td>FRRMV17009, FRRMV17010</td>
</tr>
</tbody>
</table>

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

**Secondary electives**

As a secondary elective, students can choose:

- any UU-master’s course (including not yet chosen courses from the list of primary electives).
- the bachelor’s courses *Living Pasts* (BETA-B3LH); *Geschiedenis en Filosofie van de Biologie* (B-B3GESB05); *Geschiedenis van de Wiskunde* (WISB382); and
History and Philosophy of Science

Making Modern Science (BETA-B3MMS), as long as the total amount of bachelor level credits in the student’s programme does not exceed 15 EC.

Note that prescribed deficiency courses will be deducted from the credits available for secondary electives.

**Research part**

The research part consists of:

- Research Project: proposal (FI-MHPSRPP): 15 EC, and;

- Research Project: thesis (FI-MHPSRP): 22,5 or 37,5 EC, or 45 EC in case of a twin degree programme

And, in case of a 22,5 EC thesis:

- Internship (FI-MHPSINT): 15 EC, 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 coordinator. 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 compulsory courses, with the exception of the research seminar FI-MHPSSR and Dilemmas of the Scientist part 2.

**Cum laude**

The minimum grade for the thesis (FI-MHPSRP) a student needs to obtain a cum laude degree qualification is 8.5. Please note that additional requirements (as listed in the main text of the EER) need to be met to obtain this qualification.
Scientific integrity and labour market perspectives

Scientific integrity: reflection on the values of science, both in theory and in practice, is a key part of this programme. Students are encouraged to discuss values and practices in historical and philosophical contexts, and to relate this to their own research. These issues are included in the assessment criteria for the research project. Scientific integrity is also addressed in the Master's Introduction (GSNS-INTRO, 0,5 EC), the mandatory course Dilemmas of the Scientist (FI-MHPSDL1 and FI-MHPSDL2, 0,5 EC) and in the research part.

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.
- The course FI-MHPSPSI focuses on labour market orientation.
- Personal counselling by the tutor.
- UU Career Services.

Profiles

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with one of the following profiles:

- Complex Systems
- Educational
- Science-based Entrepreneurship
- Communication
- Da Vinci Programme

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

- Mandatory courses: 30 EC
- Primary electives: 22.5 EC
- Secondary electives: 0 EC
- Research part: thesis proposal and small thesis: 37.5 EC
- Total: 90 EC

The Board of Examiners will grant approval of a profile as part of the examination programme of the student if the student successfully finished the profile.

**Transitional Provisions**

- Students who enrolled into the programme before September 2022 have to do the mandatory courses FI-MHPSHNS History of the Natural Sciences and GKRMV18001 History of the Humanities instead of History of Knowledge 1 and 2.

- FI-MHPSST Philosophy of Space and Time (7.5 EC, offered from 2022-23) cannot be combined with the older courses FI-MHPSST or FI-MHPSST2, Philosophy of Space and Time 1 or 2; similarly, FI-MHPSTQW The Quantum World (7.5 EC, offered from 2022-23) cannot be combined with FI-MHPSQW The Quantum World.

- The course code for the second part of Dilemmas of the scientist has been changed per September 2021. For students who started before this date, FI-MHPSDIL2 can be replaced by FI-MHPSDIL.

- For students who enrolled into the programme prior to 1 September 2016 the courses Introducing Natural Sciences (GSNS-INTRO) and Dilemmas of the scientist (FI-MHPSDL1 and FI-MHPSDL2) are not required.
Admission to the degree in Information Science

Applicants should possess the following solid knowledge of and solid skills in core Dutch WO bachelor Information Science competencies, including:

- information system design, including analysis, data and process modelling, evaluation and development methods;
- programming; and
- research methods and statistics.

It is of vital importance that applicants have a strong interest in research, as both Human Computer Interaction (HCI) and Business Informatics are research masters. A strong motivation and knowledge, skills, and competencies need to be shown via the applicant's CV, course grades, and motivation letter. Additionally, a very good level of English proficiency is expected.

In case not all requirements are met, a deficiency course (7.5 EC) needs to be followed, which replaces a secondary elective course. Alternatively, in case of substantial deficiencies, for Dutch-speaking students, a tailored Pre-Master's programme of at most 30 EC can be considered, as is defined in article 2.4 of the Education and Examination Regulations (EER). For international students, no Pre-Master's programme is available.

It is required to have finished the bachelor programme within the maximum of $n+1$ years, where $n$ is the number of years the bachelor programme is supposed to take. This is independent of whether it concerns a bachelor programme of a research university or of a university of applied sciences (e.g., a Dutch HBO). Additionally, the following Dutch score thresholds (scale: 0-10) are set:
Business Informatics

- For students with a bachelor from a research university, it is **highly recommended** to have an average score of 7.0 or higher for their bachelor programme. Additionally, for the final bachelor graduation project, a 7.0 or higher is **required**.

- For students with a bachelor degree from a university of applied sciences (e.g., a Dutch HBO), an average score of at least 7.5 is **required** for their professional bachelor programme. Moreover, a score of at least 7.5 is **required** for their graduation project, where an 8.0 is **highly recommended**.

If desired, as part of their motivation letter, a candidate can explain why their study duration, curriculum, course grades, or the grade of their graduation project would not adequately reflect their academic potential.

**Admission to the programme Business Informatics**

In addition to the general criteria for the degree in Information Science, students qualify for admission to the programme Business Informatics if they possess basic knowledge and basic skills in:

- organization science, including structure, strategy, and culture; and

- mathematical logic.

Dutch WO research bachelor and equivalent degrees that are likely to satisfy either all or the majority of the general and specific MBI requirements include; but, are not limited to:

- Information Science;

- Computer Science;

- Information Technology; and

- Artificial Intelligence (AI).

Dutch WO research bachelor and equivalent degrees that are likely to partially satisfy the general and specific MBI requirements include; but, are not limited to:

- Mathematics and Physics;

- Engineering disciplines, including Computer Engineering and Industrial Design Engineering.
Students with a bachelor degree from a university of applied sciences (e.g., a Dutch HBO) or an equivalent degree in Business IT & Management, Computer Science, and Engineering disciplines will also be considered.

Students with a bachelor degree from a university of applied sciences or an equivalent degree in subjects such as psychology, communication, and design will normally not meet the admission criteria.

**Deficiency courses and Pre-Master’s programme**

A deficiency course of 7.5 EC or a Pre-Master’s programme of at most 30 EC is possible and will be tailored by the Board of Admissions depending on the student's prior knowledge. Unlike a deficiency course, the Pre-Master’s programme should be finished (i.e., all courses passed) before entry into the Business Informatics programme is allowed. Please see article 2.4 of the GSNS EER for the exact regulations surrounding Pre-Master’s programmes.

Possible deficiency and Pre-Master’s courses include (but are not limited to):

- *Architecture of Digital Ecosystems* (INFOB2ADE)
- *Data Analytics* (INFOB2DA)
- *Information Security* (INFOB3INSE)
- *Knowledge-Intensive Process Analysis* (INFOB3KMPA)
- *Product Software* (INFOB3PS)
- *Programmeren in Python* (BETA-B1PYT)
- *Responsible Data Science* (INFOB3RDS)
- *Strategisch Management van Organisaties en ICT* (INFOB3SMI)
- *Wetenschappelijke Onderzoeksmethoden* (INFOWO)

**Learning outcomes**

The graduate of the Master's programme in Business Informatics:
**Knowledge and understanding**

- **K1.** Has theoretical and practical knowledge of advanced general subjects such as methodology of development, implementation and adoption of software products, business process management, and science-based entrepreneurship.

- **K2.** Is able with this knowledge to contribute to scientific research in these areas using an appropriate research method.

- **K3.** Is aware of important recent developments on subjects such as methodology of development, implementation and adoption of software products, business process management, and science-based entrepreneurship.

- **K4.** Understands the relevance of these developments for their scientific discipline.

- **K5.** Has the skills to understand the specialised literature on at least one area in the field of: software product development methodology; implementation and adoption of systems; science-based entrepreneurship.

- **K6.** Has the skills to relate this literature to their own research.

- **K7.** Has insight into the integrity dilemmas that occur in the domain.

**Applying knowledge and understanding**

- **A1.** Is able to formulate an original research question in the field of Business Informatics together with the supervisor.

- **A2.** Is able to design, under the 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.

- **A3.** 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 analyse and
interpret the acquired materials and/or data according to scientific standards.

- A4. Is able to create a plan for the implementation of an academic artefact in society and valorise the artefact.

Making judgements

- M1. Is able to participate critically and constructively in the scientific debate.

- M2. Is able to indicate the relevance of their research to solve problems and issues in the field of Business Informatics, both from a scientific and a societal point of view.

- M3. Is able to reflect critically upon their 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 skills

- C1. Has the skills to communicate research results, both in written and spoken English, to an audience of specialists or non-specialists.

- C2. Is able to function effectively in a possibly multidisciplinary team of experts working in the field of Business Informatics.

Learning skills

- L1. Has the skills to evaluate their own learning and development process and to adjust this process if necessary.

- L2. Has a result-oriented working attitude that enables them to work as a professional in the field of information technology.

- L3. Has the qualifications to enrol in a PhD programme in the field of Information Science.

- L4. Is qualified to acquire a position as a professional in the field of information technology.
Contact hours

For the whole programme, excluding the two graduation parts, with the standard enrolment in two 7.5 EC courses in parallel per period, the average number of contact hours for a student is 600 hours, which is equivalent to 12 hours per week. For the two graduation parts, the number of contact hours for a student is specified in individual application forms.

Contents

Mandatory courses: 32 EC
Primary electives: 22.5-45 EC
Deficiency course\(^1\): 0-7.5 EC
Secondary electives: 0-22.5 EC
Research: 43 EC
Total: at least 120 EC

Mandatory courses

- Data Science and Society (INFOMDSS)
- Advanced Research Methods (INFOARM)
- Business Process Management (INFOMBPM)
- Method Engineering (INFOME)
- Introduction to MBI (INFOSPMIBI): 1 EC
- Introducing Natural Sciences (GSNS-INTRO): 0.5 EC
- Dilemmas of the Scientist (FI-MHPSDL1 + FI-MHPSDL2): 0.5 EC

\(^1\) Deficiency courses are courses that fill in gaps in the knowledge of students, typically from the Information Science Bachelor programme. Possible deficiency courses (at most 7.5 EC) are selected from the same list of courses as found under ‘deficiency courses and Pre-master’s programme’ (see above).
Primary electives

- Responsible ICT (INFOMRICT)
- Technologies for Learning (INFOMTFL)
- Software Ecosystems Security (INFOMSSE)
- Digital Transformation and Architecture (INFOMDTA)
- Software Architecture (INFOMSWA)
- Natural Language Generation (INFOMNMLG)
- Science-Based Entrepreneurship (INFOMSBE)
- Requirements Engineering (INFOMRE)
- Process Mining (INFOMPROM)
- Data Intensive Systems (INFOMDIS)
- Knowledge and Data Engineering (INFOMKDE)
- Information Visualization (INFOMVIS)
- ICT Start-ups (INFOMICTS)
- Cloud and Edge Computing (INFOMCEC)

Primary electives (Seminars)

- Seminar Software Production (INFOMSPR)
- Seminar Theories in Information Systems (INFOMTIS)

Secondary electives

Secondary electives can be chosen from the list below:

Any of the remaining primary electives in the Business Informatics programme;
Any of the 7.5 EC mandatory courses and primary electives from the programmes Human Computer Interaction, Computing Science, and Game and Media Technology;

*Capita Selecta* (INFOISM): 7.5 EC. A Capita Selecta is not a standard course option and needs to be agreed to by a supervisor before entry to the course;

A deficiency course (if assigned as a requirement);

Other master courses, within or outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

Note that prescribed deficiency courses will be deducted from the credits available for secondary electives.

**Limitations**

- It is not allowed to follow both courses *ICT Start-ups* (INFOMICTS) and *Capita Selecta* (INFOCSM) in one MBI programme;

- Bachelor courses are not allowed in the master's programme, unless they are deficiency courses, prescribed during the admission process;

- For some courses, the course names and / or codes have been changed over the years. It is not allowed to have such a course with its old name and new name in one MBI programme, nor is it allowed to have courses with identical names but different course codes in one MBI programme.

**Research Part**

The research part consists of the following:

- *MBI Colloquium* (INFOMCBI): 3 EC
The thesis project can be started when all mandatory courses, primary electives, secondary electives, and deficiency courses have been completed. Exceptions need to be approved by the programme coordinator.

*The Research Part or Thesis Project* includes participation in the bi-weekly MBI Colloquium.

Research can be done in the following directions: the research programmes of the Organization and Information chair and the Business Process Management & Analytics chair (internally or externally). In addition, all subjects should be related to the list of courses. It is also possible to do research on a subject related to the interests of departmental staff residing in different chairs within the department than the aforementioned two, but only after reaching an agreement with a supervisor from such a different chair and with a focus on business informatics.

**Testing provision in extraordinary circumstances (Art 5.8).**

Students who, due to circumstances beyond their control, are unable to participate in a retake test – also when the retake test was offered as an alternative to an earlier absence at exam opportunity 1 – need to approach the study advisor and register a request with the exam committee for an extra (third) exam opportunity. The exam committee will share their decision with the student and the course coordinator (cc. Student Affairs). If the decision is positive, Student Affairs will register the student for an extra exam opportunity.

**Cum Laude**

The minimum grade for the course *Thesis Project Part 2* a student needs to obtain a cum laude degree qualification is 8.5. Please note that additional requirements (as listed in the main text of the EER) need to be met to obtain this qualification.
Scientific integrity and labour market perspectives

Students are supported in entering the labour market effectively by means of the following ways:

- Company visits in a number of courses;
- Guest lectures by industry experts in many of the courses;
- Collaborations with large organisations during research projects, such as technology vendors and consultancy firms;
- Training of professional and entrepreneurial skills in the courses of Science-Based Entrepreneurship and ICT Start-ups;
- Workshops and personal advice from Career Services, made available by the university.

Scientific integrity is covered in the following courses:

- *Introduction to Business Informatics* (INFOSPMBI);
- *Advanced Research Methods* (INFOARM);
- *Responsible ICT* (INFOMRICT);
- *Dilemmas of the Scientist* (FI-MHPSDL1 + FI-MHPSDL2).

In addition, plagiarism detection tools are used in the courses.

Profiles

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with one of the following profiles:

- Educational
- Science-Based Entrepreneurship
- Communication

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

successfully complete a profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

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

The Board of Examiners will grant approval of a profile as part of the examination programme of the student if the student successfully finished the profile.

Note: The Applied Data Science Profile will not be accepted as part of this programme due to substantial overlap with courses in the programme.

Mandatory courses: 32 EC
Primary electives: 7.5-15 EC
Deficiency course: 0-7.5 EC
Profile courses and projects: 30 EC
Research: 43 EC
Total: at least 120 EC

Transitional provisions

- For students who enrolled in the programme before September 2016 the courses Introducing Natural Sciences (GSNS-INTRO) and Dilemmas of the scientist (FI-MHPSDL1 and FI-MHPSDL2) are not required.

- Students who enrolled in 2017-2018 or earlier can have Knowledge Management (INFOKMT) as a mandatory course.

- Students who enrolled in the programme in 2018-2019 can have Knowledge Management (INFOKMT) and/or Data Science and Society (INFOMDSS) as a mandatory course;

- Students who enrolled in the programme before September 2019 can submit only three mandatory courses of 7.5 EC each plus one additional primary elective.
• Students who enrolled in the programme before September 2020 can have *ICT Advisory* (INFOMICTA), *Mobile Interaction* (INFOMMOB), *Seminar Foundations of Information Science* (INFOMFIS), and *Seminar Medical Informatics* (INFOMSMI) as primary electives;

• For students who enrolled in the programme before September 2021 the course code for the second part of *Dilemmas of the scientist* has been changed per September 2021. For students who started before this date, FI-MHPSDIL2 can be replaced by FI-MHPSDIL.

• For students who have been admitted to the ADS profile before 1 September 2021, the ADS profile will be accepted as part of their examination programme.

• Students who enrolled before September 2021 can have *Seminar Theories in Information Systems* (INFOMFIS), *Seminar Multimedia Discourse Interaction* (INFOMMDI), *Data Mining* (INFOMDM), *Pattern Recognition* (INFOMPR), *Business Intelligence* (INFOMBIN), *Enterprise Architecture* (INFOEAR), *Knowledge Management* (INFOKMT), *ICT Entrepreneurship* (INFOIE), and *Data Analysis and Visualisation* (201600038) as primary elective.

• Students who enrolled before September 2022 can have *Big Data* (INFOMBD) as primary elective.

• Students who enrolled before September 2023 can have *Adaptive Interactive Systems* (INFOMAIS) as primary elective.
Human Computer Interaction

Admission to the degree in Information Science
Applicants should possess the following solid knowledge of and solid skills in core Dutch WO bachelor Information Science competencies, including:

- information system design, including analysis, data and process modelling, evaluation, and development methods;
- programming; and
- research methods and statistics.

It is of vital importance that applicants have a strong interest in research, as both Human Computer Interaction (HCI) and Business Informatics are research masters. A strong motivation and knowledge, skills, and competencies need to be shown via the applicant's CV, course grades, and motivation letter. Additionally, a very good level of English proficiency is expected.

In case not all requirements are met, a deficiency course (7.5 EC) needs to be followed, which replaces a secondary elective course. Alternatively, in case of substantial deficiencies, for Dutch speaking students, a tailored Pre-Master’s programme of at most 30 EC can be considered, as is defined in article 2.4 of the Education and Examination Regulations (EER). For international students, no Pre-Master’s programme is available.

It is required to have finished the bachelor programme within the maximum of n+1 years, where n is the number of years the bachelor programme is supposed to take. This is independent of whether it concerns a bachelor programme of a research university or of a university of applied sciences (e.g., a Dutch HBO). Additionally, the following Dutch score thresholds (scale: 0-10) are set:

- For students with a bachelor from a research university, it is highly recommended to have an average score of 7.0 or higher for their bachelor programme. Additionally, for the final bachelor graduation project, a 7.0 or higher is required.
- For students with a bachelor degree from a university of applied sciences (e.g., a Dutch HBO), an average score of at least 7.5 is required for their
Human Computer Interaction

professional bachelor programme. Moreover, a score of at least 7.5 is required for their graduation project, where an 8.0 is highly recommended.

If desired, as part of their motivation letter, a candidate can explain why their study duration, curriculum, course grades, or the grade of their graduation project would not adequately reflect their academic potential.

Admission to the programme Human Computer Interaction (HCI)

In addition to the general criteria for the degree in Information Science, students qualify for admission to the programme Human-Computer Interaction (HCI) if they possess basic knowledge and/or skills in:

- cognition and communication
- and in at least one of subjects:
- mathematics, in particular calculus and linear algebra, and
- design methods.

Dutch WO research bachelor and equivalent degrees that are likely to satisfy either all or the majority of the general and specific HCI requirements include; but, are not limited to:

- Information Science;
- Artificial Intelligence (AI);
- Mathematics and Physics;
- Computer Science, Computer Engineering, and Information Technology;
- Engineering disciplines; and
- Biomedical Sciences.

Students with a bachelor degree from a university of applied sciences (e.g., a Dutch HBO) or an equivalent degree in Computer Science and Engineering disciplines (e.g., electrical engineering) will also be considered.

Students with a bachelor degree from a university of applied sciences (e.g., a Dutch HBO) or an equivalent degree equivalent degree in subjects such as psychology, communication, management, and design will normally not meet the admission criteria.

Learning outcomes

The graduate of the Master’s programme in Human-Computer Interaction (HCI):
**Knowledge and understanding**

K1. is capable of making an essential contribution to the development and/or application of scientific concepts and methods, predominantly in relation to research in HCI;
K2. is capable of considering recent developments within HCI (e.g., novel sensor-based interfaces) and of specifying the implications of those developments for the discipline;
K3. is capable of appropriately utilising and interpreting specialist professional literature relevant to HCI, using systematic reviews (e.g., PRISMA);
K4. understands the potential dilemmas related to ethics (scientific integrity, privacy and security) in the research field of HCI.
K5. understands the psychological aspects underlying human behaviour that are relevant to HCI
K6. understands the computing and information science aspects underlying system behaviour that are relevant to HCI
K7. is capable of explaining and advocating where and how human-centred design and user experience research fits within organizations.

**Applying knowledge and understanding**

A1. is capable of critically analysing, defining, and using a problem within the HCI domain and use this to formulate relevant appropriate research questions for either HCI educational, scientific, or engineering purposes;
A2. is capable of formulating a research design, which is appropriate for that research question and is in line with the HCI methodological and scientific standards,
A3. is capable of conducting that research with the prerequisite degree of care and ethical responsibility, and to process, analyse, interpret and evaluate empirical data or other findings obtained in the process appropriately;
A4. is capable of analysing the computing and information science aspects underlying system behaviour and apply these in HCI research and design;
A5. is capable of analysing the psychological aspects underlying human behaviour and apply these in HCI research and design;
A6. is capable of analysing possible future HCI designs and methods, critically analyse their pros and cons, conduct a requirement analysis, and suggest implementation strategies, taking the latest HCI developments in consideration.

**Making judgements**

M1. is capable of discussing the findings of HCI research, relating it to the state of the art and relevant literature, and participating critically and constructively in the scientific debate;
M2. is capable of specifying the relevance of such research for the resolution of questions and problems in the field of HCI, both from a research and a societal point of view;
M3. is capable of critically reflecting on their own efforts as a researcher in the field of HCI and that of others from a societal perspective, including ethical perspectives such as privacy, scientific integrity, and information security.

**Communication skills**

C1. is able to clearly communicate research findings in both written and oral form to varying audiences and stakeholders (e.g., specialists, managers, and end-users), within both a national and international context;
C2. is able to function effectively and creatively as part of possibly multidisciplinary teams, and communicate effectively with clients, end-users and other stakeholders (e.g., engineers);
C3. is able to showcase a portfolio of industrial and research projects in which their competencies have been applied;
C4. is able to implement prototype systems that support effective and efficient communication of HCI solutions.

**Learning skills**
Human Computer Interaction

1. has the skills to evaluate their own learning and development process, and to motivate and correct themselves during their studies where necessary;
2. has developed their own effective, performance-oriented methodology to enable them to perform independently in the field of Interaction Technology;
3. has the qualifications to enrol in a PhD programme in the field of Information Science;
4. is qualified to acquire a position as a professional in the field of Information Technology;
5. has a realistic idea of the career opportunities after graduating, and of the skills that they need to successfully start a career.

Contact hours
For the whole programme, excluding the two graduation parts, with the standard enrolment in two 7.5 EC courses in parallel per period, the average number of contact hours for a student is 600 hours, which is equivalent to 12 hours per week. For the two graduation parts, the number of contact hours for a student is specified in individual application forms.

Contents

<table>
<thead>
<tr>
<th>Mandatory courses</th>
<th>32.0 EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Secondary electives</td>
<td>22.5 EC</td>
</tr>
<tr>
<td>Research part</td>
<td>43.0 EC</td>
</tr>
<tr>
<td>Total</td>
<td>120.0 EC</td>
</tr>
</tbody>
</table>

Notes:
- Note that prescribed a deficiency course will replace a secondary elective.
- It is encouraged to choose the 22.5+22.5 EC electives in such a way that it gives a clear, largely homogeneous profile (e.g., a Human-Centered AI-profile or the Complex Systems profile).
- Choosing the Complex Systems profile replaces the 22.5 EC of secondary electives and one 7.5 EC primary elective.

Mandatory courses
- Introducing Natural Sciences (GSNS-INTRO 0.5 EC)
- Dilemmas of the scientist (FI-MHPSDL1+ FI-MHPSDL2, 0.5 EC)
- Introduction to HCI (INFOIHCI 1.0 EC)
- Advanced Cognitive and Social Psychology for HCI (INFOMCSP 7.5 EC)
- Advanced HCI Qualitative Research Methods (INFOMQLM 7.5 EC)
- Interaction Technology Innovation (INFOMITI 7.5 EC)
- Advanced HCI Quantitative Research Methods (INFOMQNM 7.5 EC)
Primary electives

Period 1
- Adaptive Interactive Systems (INFOMAIS 7.5 EC)
- Multimedia Retrieval (INFOMR 7.5 EC)
- Data Mining (INFOMDM 7.5 EC)
- Technologies for Learning (INFOMTFL 7.5 EC)
- Machine Learning for Human Vision and Language (INFOMLHVL 7.5 EC)

Period 2
- Requirements Engineering (INFOMRE 7.5 EC)
- Cognitive Modeling (INFOMCM 7.5 EC)
- Information Visualization (INFOMVIS 7.5 EC)
- Pattern Recognition and Deep Learning (INFOMPR 7.5 EC)
- Knowledge and Data Engineering (INFOMKDE 7.5 EC)
- Sound and Music Technology (INFOMSMT 7.5 EC)

Period 3
- Natural Language Generation (INFOMNLG 7.5 EC)
- Multimodal Interaction (INFOMMMI 7.5 EC)
- Computer Vision (INFOMCV 7.5 EC)
- Software Architecture (INFOMSWA 7.5 EC)
- Data Visualization (INFOMDV 7.5 EC)

Period 4
- Mobile Interaction (INFOMMOB 7.5 EC)
- Serious Gaming (INFOMSEGA 7.5 EC)
- Human-Centered Machine Learning (INFOMHCML 7.5 EC)
- Natural Language Processing (INFOMNLP 7.5 EC)

Secondary electives

Secondary electives can be chosen from the list below:

- Any of the remaining primary electives;
- Courses offered by the UU Graduate School of Natural Sciences (GSNS);
- If assigned as a requirement, a deficiency course;
- If well-motivated (e.g., no equivalent GSNS-course is available), supported by the programme coordinator and/or programme leader, and approved by the board of exams, one BSc-course (e.g., Persuasive technologies, INFOB3PET and Machine Learning, INFOB3ML).

Other master courses, within or outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of
the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

**Deficiency and Pre-Master’s courses**

Possible deficiency and Pre-Master’s courses include:

- Math and Statistics for Information and Computing Sciences (INFOB3MSIC 7.5 EC)
- Imperatief programmeren (INFOIMP 7.5 EC)
- Informatieuitwisseling (INFOB1IUW 7.5 EC)
- Data analytics (INFOB2DA 7.5 EC)
- Datamodelleren (INFOB1DM 7.5 EC)
- Programming with data (INFOB2PWD 7.5 EC)
- Databases (INFODB 7.5 EC)
- Datastructures (INFODS 7.5 EC)
- Computational Thinking (INFOMCTH 7.5 EC)
- Modelleren en Programmeren (INFOB1MNP 7.5 EC)
- Wetenschappelijke onderzoeksmethoden (INFOWO 7.5 EC)
- Usability Engineering en User Experience (INFOUE 7.5 EC)
- Procesmodelleren (INFOB1PROM 7.5 EC)
- Persuasive technologies (INFOB3PET 7.5 EC)

**Research part**

- Thesis Human-Computer Interaction, part 1 (INFOMHC1 15.0 EC)
- Thesis Human-Computer Interaction, part 2 (INFOMHC2 25.0 EC)
- Colloquium HCI (INFOCHCI 3.0 EC)

Part I of the thesis project (INFOMHC1) can start as soon as the student has completed the mandatory courses and has completed at least 67.5 EC of primary and secondary electives. Part II of the thesis project (INFOMHC2) can only start after Part I (INFOMHC1) is completed.

**Testing provision in extraordinary circumstances (Art 5.8)**

Students who, due to circumstances beyond their control, are unable to participate in a retake test – also when the retake test was offered as an alternative to an earlier absence at exam opportunity 1 – need to approach the study advisor and register a request with the exam committee for an extra
(third) exam opportunity. The exam committee will share their decision with the student and the course coordinator (cc. Student Affairs). If the decision is positive, Student Affairs will register the student for an extra exam opportunity.

**Cum Laude**

To obtain a cum laude degree qualification, the average course grade needs to be an 8.0 or higher, excluding the thesis project (INFOMHC2). Additionally, the minimum grade for Part II of the thesis project (INFOMHC2) needs to be an 8.5. The complete list of requirements is provided in the main text of the EER.

**Scientific integrity and labour market perspectives**

Career Services offers HCI students a variety of activities related to labour market perspectives. In addition, via guest lectures, course assignments, and the two thesis parts, HCI students become acquainted with the labour market.

Scientific integrity is part of the research master HCI. It is treated within Dilemmas of the scientist (FI-MHPSDL1 and FI-MHPSDL2), Advanced HCI Qualitative Research Methods (INFOMQLM), Advanced HCI Quantitative Research Methods (INFOMQNM), Colloquium HCI (INFOMCHCI), Thesis Human-Computer Interaction, part 1 (INFOMHC1), and Thesis Human-Computer Interaction, part 2 (INFOMHC2). In addition, the HCI-staff uses plagiarism detection tools.

**Profiles**

Instead of the regular programme, the student may choose to replace 30 EC of the regular programme with the Complex Systems profile. The profile then replaces the 22.5 EC of secondary electives and one 7.5 EC primary elective. The contents and further description of the Complex Systems profile is described in the profile appendices, including entry requirements to specific courses. In case the student wishes to pursue this profile, approval needs to be granted by the programme coordinator. Moreover, to secure the learning outcomes of the master’s programme, the remaining 90 EC must be filled in as described under Contents. 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.
The Board of Examiners will grant approval of a profile as part of the examination programme of the student if the student successfully finished the profile.

Transitional provision for students who enrolled in the programme before September 2021

The course code for the second part of "Dilemmas of the scientist" has been changed per 1 September 2021. For students who started before this date, FI-MHPSDIL2 can be replaced by FI-MHPSDIL.

Transitional provision for students who enrolled in the programme before September 2022

The list of primary electives has been extended per 1 September 2022. For students who started before this date, all courses listed as primary electives in this Annex can serve as primary electives for them as well.

Transitional provision for students who enrolled in the programme before September 2023

The list of primary electives has been extended per 1 September 2023. For students who started before this date, all courses listed as primary electives in this Annex can serve as primary electives for them as well.
Mathematical Sciences

Admission to the degree in Mathematical Sciences

This is a selective Master’s program. An applicant will be considered for admission to the Master’s programme Mathematical Sciences if the applicant holds a bachelor’s degree in mathematics or physics or computer science with a strong component in mathematics, comparable with a major part of the Utrecht University bachelor of mathematics. Furthermore, the applicant can demonstrate a high level of knowledge and command of methods and skills in the relevant field.

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) and probability. Moreover we require more advanced knowledge (comparable with second- and third-year courses in the Mathematics bachelor’s program of Utrecht University) of at least three of the following subjects: differential equations and dynamical systems, complex analysis, probability theory and statistics, numerical analysis, functional analysis, mathematical modelling, geometry and topology, algebra and number theory, discrete mathematics, optimisation and logic.

• The ability to analyse mathematical problems;
• The ability to understand, reproduce and apply mathematical theorems and proofs
• The ability to communicate findings verbally and in writing, in an appropriate mathematical manner.

Pre-Master’s programme

Completion of a Pre-Master’s programme (in Dutch) of at most 30 EC may be imposed by the Board of Admissions as a pre-requisite for enrolment in the master programme. Such Pre-Master’s programme will be tailored by the Board
of Admissions depending on the student’s prior knowledge. Please see article 2.4 of the GSNS EER for the exact regulations surrounding Pre-Master’s programmes.

Learning outcomes

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

Knowledge and understanding

- K1. a theoretical and practical understanding of advanced general concepts, principles and techniques of fundamental and/or applied mathematics;

- K2. an overview of the area of scientific research and development in question;

- K3. 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;

- K4. an overview of the role of dilemmas of integrity and ethics in scientific research.

Applying knowledge and understanding

- A1. the ability to independently identify, formulate, analyse and suggest possible solutions to problems in the field of mathematical sciences;

- A2. the ability to assimilate complex mathematical ideas and arguments;

- A3. 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)

Making judgements

- M1. 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.

Communication skills

- C1. the ability to cooperate in a, possibly interdisciplinary, team of experts;

- C2. 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.

Learning skills

- L1. the ability to reflect on one's own research and on research of others;

- L2. the ability to enrol in a PhD programme in mathematics, or to embark on a professional career as a mathematician, including having an overview of their career options;

- L3. has a realistic idea of the career opportunities in industry as a mathematician after graduating, and of the skills that they need to successfully start a career.

Contact hours

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

Contents

The master programme in Mathematical Sciences has six tracks:

- Algebraic Geometry and Number Theory,

- Applied Mathematics, Complex Systems and Scientific Computing,

- Differential Equations and Dynamical Systems,
Mathematical Sciences

- Differential Geometry, Topology, and Lie Theory,
- Logic and discrete mathematics,
- Probability and Statistics.

These can be further varied by following a profile.
To complete the master programme, a student must obtain at least 120 EC and these must further fulfil at least the division below:

- Mandatory courses: 15 EC
- Primary electives: 45 EC
- Secondary electives: 15 EC
- Research part: 45 EC
- Total: 120 EC

Students following:

- the track Applied Mathematics, Complex Systems and Scientific Computing or Logic and discrete mathematics, or
- a profile

must fulfil variations of this rule as described in the respective session in this annex.

**Mandatory courses**

The mandatory courses for the master programme in Mathematical Sciences are:

- *Dilemmas of the Scientist* (FI-MHPSDL1 + FI-MHPSDL2): 0.5 EC
- *Master Introduction* (GSNS-INTRO): 0.5 EC
- *Mathematics Colloquium* (WISM103): 2.5 EC
- *Mathematics for Industry* (WISM104): 4 EC
• Orientation on Mathematical Research\textsuperscript{2} (WISM102): 7.5 EC

**Primary Electives**

A course qualifies as a primary elective if:

- It is listed under the heading Primary Elective List below, or
- It is approved by the Mathematical Sciences Executive Panel of the Board of Examiners. Examples of courses that may qualify for such approval include master level mathematics courses taken at other universities (see EER main text, Art 3.7 and 3.8).

One of the primary elective courses must be an advanced seminar in Mathematics (of at least 7.5 EC) in which the students themselves must give oral presentations. If approved by the programme director, this can be replaced by a seminar within UU or at another Dutch university with a strong mathematical content.

Seminar courses may account for no more than 15 EC among primary elective courses.

**Secondary Electives**

Secondary electives can be chosen from the list below:

- Any of the primary electives
- A bachelor course in mathematics taken to remedy deficiencies, and that is approved by the Admissions Board
- An internship (WISM408) of 15 EC approved by the programme director.

Other master courses, within or outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

\textsuperscript{2} not open for students who have followed WISM556 in 2015-2016
While open for enrolment for all master students in mathematics, the course PhD Research training (WISM111, 7.5 EC) does not count as primary or secondary elective.

Note that prescribed deficiency courses will be deducted from the credits available for secondary electives.

**Research part**

The research part is split into the following parts:


Students can start with the research part once they have obtained 45 EC among mandatory courses and primary electives, or if approved by the programme director.

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

The research part is done under the guidance of a researcher of the Mathematical Institute.

The research part can also be done as an internship.

**Cum laude**

The minimum grade for the Research project: Thesis a student needs to obtain a cum laude degree qualification is 8.5. Please note that additional requirements (as listed in article 6.2. of the EER) need to be met to obtain this qualification.

**Scientific integrity and labour market perspectives**

Scientific integrity is addressed in the *Master's Introduction* (GSNS-INTRO, 0.5 EC), the mandatory course *Dilemmas of the Scientist* (FI-MHPSDL1 and FI-MHPSDL2, 0.5 EC) and in the research part.
Labour market perspectives is the focus of *Mathematics for Industry* (WISM104) and of the Career Orientation event of Mathematical Sciences.

**Variations on the main programme: Tracks Applied Mathematics, Complex Systems and Scientific Computing and Logic and discrete mathematics,**

Students following the tracks *Applied Mathematics, Complex Systems and Scientific Computing* or Logic and discrete mathematics have the freedom to choose up to 30 EC of secondary elective courses in other disciplines, provided mathematics is applicable there. A list of courses outside of mathematics that fit the 30 EC of courses in other disciplines is published on the students.uu.nl webpage of Mathematical Sciences.

Therefore, to complete the master programme, a student following these tracks must obtain at least 120 EC and these must further fulfil at least the division below:

- Mandatory courses: 15 EC
- Primary electives: 30 EC
- Secondary electives: 30 EC
- Research part: 45 EC
- Total: 120 EC

**Profiles**

The student may choose to replace 30 EC of the main programme with one of the following profiles:

- Applied Data Science
- Complex Systems
- Educational
- Science-based Entrepreneurship
The contents and further description of these profiles, including entry requirements to specific courses, is described in the respective sections of this annex.

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 curriculum conditions for the student revert to the regular (120 EC) programme structure.

- Mandatory courses: 15 EC
- Primary electives: 45 EC
- Secondary electives: 0 EC
- Research part: 30 EC
- Total: 90 EC

The research part is split into the following parts:

- *Research project: Proposal* (WISM107): 10 EC

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

The Board of Examiners will grant approval of a profile as part of the examination programme of the student if the student successfully finished the profile.

**Transitional Provisions**

For students who enrolled into the programme prior to 1 September 2016 the courses *Introducing Natural Sciences* (GSNS-INTRO), *Dilemmas of the scientist* (FI-MHPSDL1 and FI-MHPSDL2), *Orientation on Mathematical Research* (WISM102), *Mathematical Colloquium* (WISM103) and *Mathematics for Industry* (WISM104) are not required. The research project for this group of students is 47 EC in total (15 EC proposal, 32 EC thesis).
For students who enrolled in the academic year 2016-2017 in the programme the courses Orientation on Mathematical Research (WISM102), Mathematical Colloquium (WISM100) and Mathematics for Industry (WISM101) are mandatory. For this group of students the courses Introducing Natural Sciences (GSNS-INTRO), Dilemmas of the scientist (FI-MHPSDL1 and FI-MHPSDL2) are part of the research part and the Research part: Proposal is 14 EC, or combined with a profile, the proposal is 9 EC.

The course code for the second part of Dilemmas of the scientist has been changed per September 2021. For students who started before this date, FI-MHPSDL2 can be replaced by FI-MHPSDL.

Students who enrolled into the honours programme Utrecht Geometry Center must complete 127.5 credits. These include a 45 EC research part, 60 EC primary electives, 15 EC secondary electives, the obligatory courses of the usual programme and the course PhD Research Training (WISM111, 7.5 EC), which contributes towards the 127.5 EC of the programme.

**Primary electives list**

The list of primary elective courses 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 jointly offered by the University of Amsterdam (UvA), the Free University (VU) and 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](https://elo.mastermath.nl).

**Mastermath courses 2023-2024**

**Fall 2023**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISL525</td>
<td>Advanced Algebraic Geometry: Rational Points</td>
<td>8 EC</td>
</tr>
<tr>
<td>WISL509</td>
<td>Algebraic Geometry 1</td>
<td>8 EC</td>
</tr>
<tr>
<td>WISL305</td>
<td>Algebraic Number Theory</td>
<td>8 EC</td>
</tr>
</tbody>
</table>
## Mathematical Sciences

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISL508</td>
<td>Algebraic Topology 1</td>
<td>8</td>
</tr>
<tr>
<td>WISL702</td>
<td>Asymptotic Statistics</td>
<td>8</td>
</tr>
<tr>
<td>WISL338</td>
<td>Bayesian Statistics</td>
<td>8</td>
</tr>
<tr>
<td>WISL336</td>
<td>Category Theory</td>
<td>8</td>
</tr>
<tr>
<td>WISL526</td>
<td>Commutative Algebra</td>
<td>8</td>
</tr>
<tr>
<td>WISL325</td>
<td>Complexity Theory</td>
<td>8</td>
</tr>
<tr>
<td>WISL103</td>
<td>Continuous Optimization</td>
<td>6</td>
</tr>
<tr>
<td>WISL503</td>
<td>Differential Geometry</td>
<td>8</td>
</tr>
<tr>
<td>WISL302</td>
<td>Diophantine Approximation</td>
<td>8</td>
</tr>
<tr>
<td>WISL101</td>
<td>Discrete Optimization</td>
<td>6</td>
</tr>
<tr>
<td>WISL404</td>
<td>Dynamical Systems</td>
<td>8</td>
</tr>
<tr>
<td>WISL716</td>
<td>Forensic Probability and Statistics</td>
<td>8</td>
</tr>
<tr>
<td>WISL401</td>
<td>Functional Analysis</td>
<td>8</td>
</tr>
<tr>
<td>WISL322</td>
<td>Infinity-Categories</td>
<td>8</td>
</tr>
<tr>
<td>WISL519</td>
<td>Lie Groups</td>
<td>8</td>
</tr>
<tr>
<td>WISL411</td>
<td>Mathematical Biology</td>
<td>8</td>
</tr>
<tr>
<td>WISL701</td>
<td>Measure Theoretic Probability</td>
<td>8</td>
</tr>
<tr>
<td>WISL304</td>
<td>Modern Cryptography</td>
<td>8</td>
</tr>
<tr>
<td>WISL601</td>
<td>Numerical Linear Algebra</td>
<td>8</td>
</tr>
<tr>
<td>WISL603</td>
<td>Parallel Algorithms</td>
<td>8</td>
</tr>
<tr>
<td>WISL402</td>
<td>Partial Differential Equations</td>
<td>8</td>
</tr>
<tr>
<td>WISL564</td>
<td>Poisson Geometry</td>
<td>8</td>
</tr>
<tr>
<td>WISL561</td>
<td>Probabilistic and Extremal Combinatorics</td>
<td>8</td>
</tr>
<tr>
<td>WISL117</td>
<td>Quantum Computing</td>
<td>8</td>
</tr>
<tr>
<td>WISL316</td>
<td>Set Theory</td>
<td>8</td>
</tr>
<tr>
<td>WISL707</td>
<td>Statistical Mechanics</td>
<td>8</td>
</tr>
<tr>
<td>WISL108</td>
<td>Stochastic Gradient Techniques in Optimization and Learning</td>
<td>6</td>
</tr>
<tr>
<td>WISL201</td>
<td>Systems and Control</td>
<td>6</td>
</tr>
</tbody>
</table>

## Mastermath Spring 2024.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISL330</td>
<td>Additive Combinatorics</td>
<td>8</td>
</tr>
<tr>
<td>WISL105</td>
<td>Advanced Linear Programming</td>
<td>6</td>
</tr>
<tr>
<td>WISL539</td>
<td>Algebraic Geometry 2</td>
<td>8</td>
</tr>
<tr>
<td>WISL541</td>
<td>Algebraic Topology 2</td>
<td>8</td>
</tr>
<tr>
<td>WISL313</td>
<td>Causality</td>
<td>8</td>
</tr>
<tr>
<td>WISL306</td>
<td>Coding Theory</td>
<td>8</td>
</tr>
<tr>
<td>WISL529</td>
<td>Computational Finance</td>
<td>8</td>
</tr>
<tr>
<td>WISL303</td>
<td>Elliptic Curves</td>
<td>8</td>
</tr>
<tr>
<td>WISL112</td>
<td>Graph Symmetries and Combinatorial Designs</td>
<td>8</td>
</tr>
<tr>
<td>WISL420</td>
<td>Homotopy Type Theory</td>
<td>8</td>
</tr>
<tr>
<td>WISL606</td>
<td>Introduction to Numerical Bifurcation Analysis of ODEs and Maps</td>
<td>8</td>
</tr>
</tbody>
</table>
### Local courses Fall 2023.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISM484</td>
<td>Introduction to Complex Systems</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM566</td>
<td>Seminar Ergodic Theory</td>
<td>7.5 EC</td>
</tr>
</tbody>
</table>

### Local courses Spring 2024

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISM520</td>
<td>Multiscale Methods with Application to Climate</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM555</td>
<td>Differential Topology</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM453</td>
<td>Seminar Algebraic Geometry</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM471</td>
<td>Seminar Algebraic Topology</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM556</td>
<td>Seminar Differential Geometry</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM455</td>
<td>Seminar High-Dimensional Probability Theory in Data Science</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM481</td>
<td>Seminar History of Mathematics</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM551</td>
<td>Seminar Logic</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM559</td>
<td>Seminar Number Theory</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM469</td>
<td>Seminar on Neural Networks and Finance</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM538</td>
<td>Seminar Symmetry and Bifurcations</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>WISM501</td>
<td>Sheaves in Topology</td>
<td>7.5 EC</td>
</tr>
</tbody>
</table>
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.

In addition, applications should meet the requirements of either:

- the Climate Physics programme or

- the Theoretical Physics programme, or

- the Experimental Physics programme.

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 Climate Physics

Students qualify for admission to the programme Climate Physics if they possess the following skills and knowledge (in addition to the criteria for the degree programme Physics):

- 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.
- The ability to work independently as well as in groups on solving physical problems and to present results.
- 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.

Pre-Master’s programme

Students who fail to satisfy the above admission requirements may be admitted conditional on the completion of a Pre-Master’s programme of at most 30 EC, tailored by the board of admissions to the student's prior knowledge. The Pre-Master’s programme should be finished (i.e. all courses passed) before entry into the Climate Physics programme is allowed.

Please see article 2.4 of the GSNS EER for the exact regulations surrounding Pre-Master’s programmes.

Learning outcomes

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

Knowledge and understanding
- K1. has in-depth knowledge of and insight into the physics of the climate system, i.e., the dynamics of atmosphere, ocean and climate;

- K2. is aware of recent developments in the field of global climate models, process-oriented models, and experimental techniques in climate research, and is able to state the relevance of these developments for the research field and society;

- K3. can read and understand the professional literature in the field of at least one of the five research themes of the programme, and is able to relate this to the graduate's own research;

- K4. understands the potential dilemmas related to scientific integrity in research.

**Applying knowledge and understanding**

- A1. can define, under the supervision of a staff member, a scientific problem in Climate Physics; to formulate a research question, and to design a basic strategy to solve this problem;

- A2. can carry out this research plan under supervision of a member of the scientific staff 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;

- A3. can analyse and interpret, under the supervision of a staff member, the acquired results, materials and/or data according to scientific standards.

**Making judgements**

- M1. can participate critically and constructively in the scientific debate in the research group;

- M2. can indicate the relevance of the graduate's research for the advancement of physics;

- M3. can critically reflect on the graduate's own results, as well as on published scientific literature in the field of climate dynamics.
Climate Physics

**Communication skills**

- C1. 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;

- C2. is able to professionally act in a (possibly multi-disciplinary and international) research team.

**Learning skills**

- L1. has the skills to reflect upon their learning process and, if necessary, adjust this process; has acquired sufficient scientific knowledge and skills to conduct independent scientific research, or to conduct other discipline-related work;

- L2. can apply knowledge and insight in a way that demonstrates a professional approach to their work or profession;

- L3. is qualified to be admitted to a PhD research project in the field of Climate Physics, and is qualified to acquire a position as a professional in a (semi) public or commercial organization;

- L4. Has a realistic idea of the career opportunities after graduating, and of the skills that the graduate needs to successfully start a career.

**Contact hours**

The average number of contact hours for a student of the programme is 900 hours for the whole programme excluding the research part.

**Contents**

- Mandatory courses: 38.5 EC
- Primary Electives: 22.5-37.5 EC
- Secondary Electives: 0-15 EC
- Research part: 44 EC
- Total: 120 EC
**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
- *Earth System Modelling* (NS-MO448M): 7.5 EC
- *Open science for physicists* (NS-PH500M): 3.75 EC
- *Graduate school's master introduction* (GSNS-INTRO): 0.5 EC
- *Dilemmas of the scientist* (FI-MHPSDL1 + FI-MHPSDL2): 0.5 EC

**Primary Electives**

22.5 EC of courses have to be chosen from the following list of courses:

- *Boundary Layers* (NS-MO413M): 3.75 EC
- *Ice and Climate* (NS-MO427M): 7.5 EC
- *Current Themes in Climate Change* (NS-MO434M): 7.5 EC
- *Advanced Topics in Climate Dynamics* (NS-MO436M): 7.5 EC
- *Marine Masters Summer Course* (NS-MO446M): 3.75 EC
- *Waves in Geophysical Fluids* (NS-MO447M): 7.5 EC

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3 Students enrolled in February 2021 or earlier may also list the following discontinued courses as primary elective: Remote Sensing (NS-MO424M), Ocean Waves (NS-MO428M).

4 Students who completed NS-MO412M (Boundary layers, transport and mixing) cannot also receive credits for NS-MO413M (Boundary layers).

5 This course will count either as core course of the profile Complex Systems or as primary elective, but not as both.

6 Prior the academic year of 2021/2022, this course was called Wave Attractors.
• *Turbulence in Fluids*\(^7\) (NS-376B): 7.5 EC
• *Stable isotopes in Earth Sciences* (GEO4-1443): 7.5 EC
• *Morphodynamics of Wave-Dominated Coasts* (GEO4-4434): 7.5 EC
• *Morphodynamics of Tidal Systems* (GEO4-4435): 7.5 EC

**Secondary electives**

For the remaining 15 EC, there are several possible options:

- Any remaining course from the list of primary electives,
- Any other course offered by the Graduate School of Natural Sciences.
- Courses required to fulfil the admission requirements in the case of deficiencies.
- After approval by the programme director or programme coordinator:
  - Master courses offered by the Gradual School of Geosciences.
  - The following bachelor courses:
    - *Geophysical Fluid Dynamics* (NS-353B)
    - *Mathematical modelling* (WISB357)

Other master courses, within or outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

Note that prescribed deficiency courses will be deducted from the credits available for secondary electives.

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\(^7\) Selection of this course requires permission of the programme director or programme coordinator.
Deficiency courses

If deficiency courses are taken, the EC for these courses count as EC for secondary electives.

Research part

Before starting the research project, a meeting with the programme coordinator is mandatory to check the (planned) study programme. Students who lack in total more than 15 ECTS of mandatory courses, primary and secondary electives 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-MO551M): 14 EC
- Thesis project part 2 (NS-MO552M): 30 EC

In case of a double master, the 30 EC of the Climate Physics half of the research part can be split in thesis part 1 (NS-MO551M, 14 EC) and thesis part 2 (NS-MO554M, 16 EC). Please note that the regulations for research projects for double master are described in the general EER, section 3.9.1.b.

Research is done under the supervision of a staff member of the Institute for Marine and Atmospheric Research. In case of a reduced research project as part of a profile, a second examiner remains mandatory. This research is concluded with a written master’s thesis.

Research can be done in the following directions:

- Ice and Climate;
- Ocean Circulation and Climate;
- Atmospheric Physics and Chemistry;

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8 Incoming exchange students are allowed to do a smaller research project of 15 EC (Thesis project part 2, NS-MO553M), if their exchange period at Utrecht University is one semester or less.
Climate Physics

- Atmospheric Dynamics and the Hydrological Cycle;
- Coastal and Shelf Sea Dynamics.

Cum laude
The minimum grade for the course Thesis project part 2 a student needs to obtain a cum laude degree qualification is 9.0. Please note that additional requirements (as listed in the main text of the EER) need to be met to obtain this qualification.

Scientific integrity and labour market perspectives
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
Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with one of the following profiles:

- Applied Data Science
- Complex Systems
- Educational
- Science-based Entrepreneurship
- Communication

The contents and further description of a profile, including entry requirements to specific courses, is described in the profile appendices. 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.
Climate Physics

- Mandatory courses: 38.5 EC
- Primary electives: 22.5 EC
- Secondary electives: 0 EC
- Research part: 29 EC
- Total: 90 EC

The research part is split into thesis part 1 (NS-MO551M, 14 EC) and thesis part 2 (NS-MO553M, 15 EC).

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

The Board of Examiners will grant approval of a profile as part of the examination programme of the student if the student successfully finished the profile.

Transitional Provisions

- The course code for the second part of Dilemmas of the scientist has been changed per September 2021. For students who started before this date, FI-MHPSDIL2 can be replaced by FI-MHPSDIL.

- The courses NS-MO504M and NS-PH500M replace the former course NS-MO502 from 1 September 2023 onwards. Completion NS-MO502M fulfils the required courses NS-MO504M and NS-PH500M. Students that have completed NS-MO502M are not allowed to follow NS-MO504M or NS-PH500M.

- Students enrolled in September 2020 or earlier may use NS-MO501M as replacement for Earth System Modelling (NS-MO448M), which had before 1 September 2023 the course code NS-MO503M. Both NS-MO501M and NS-MO503M can replace NS-MO448M, and students that have completed one of these two courses are not allowed to follow NS-MO448M.
Experimental Physics

Admission to the programme Experimental Physics

Students qualify for admission to the programme Experimental Physics if they possess the following skills and knowledge (in addition to the criteria for the degree programme Physics):

- skills and knowledge in Quantum Mechanics, Statistical Physics, and Electrodynamics at an advanced bachelor level, – typically, “advanced implies the second course on these topics in a physics curriculum – and

- solid basic knowledge on the subject of Subatomic Physics, Solid State Physics/Condensed Matter Physics, and in Soft Condensed Matter Physics.

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

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

Pre-Master’s Programme

Students who fail to satisfy the above admission requirements may be admitted conditional on the completion of a Pre-Master's programme of at most 30 EC, tailored by the board of admissions to the student's prior knowledge. The Pre-Master's programme should be finished (i.e. all courses passed) before entry into the Experimental Physics programme is allowed.

Please see article 2.4 of the GSNS EER for the exact regulations concerning Pre-Master's programmes.

Learning outcomes

The graduate of the master's programme in Experimental Physics:
• **Knowledge and understanding**
  
  - K1. has in-depth knowledge of and insight into modern experimental physics with an emphasis on at least two of the following topics: Gravitational Waves, Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter & Biophysics;
  
  - K2. is aware of recent developments in experimental and theoretical physics, and is able to state the relevance of these developments for the research field and society;
  
  - K3. can read and understand the professional literature in the field of at least one of the following topics: Gravitational Waves, Particle Physics, Atomic, Molecular and Optical Physics, Soft Condensed Matter & Biophysics; and to relate this to the graduate's own research;
  
  - K4. understands the potential dilemmas related to scientific integrity in research.

• **Applying knowledge and understanding**
  
  - A1. is able to define, under the supervision of a staff member, a scientific problem in Gravitational Waves, Particle Physics, Atomic, Molecular and Optical physics or Soft Condensed Matter & Biophysics, formulate a research question, and design a basic strategy to solve this problem;
  
  - A2. is able to carry out this research plan under supervision of a member of the scientific staff according to the rules of good practice and ethics, and report on it in a manner that meets the customary standards of the discipline;
  
  - A3. is able to analyse and interpret, under the supervision of a staff member, the acquired results, materials and/or data according to scientific standards.

• **Making judgements**
  
  - M1. is able to participate critically and constructively in the scientific debate in the research group;
Experimental Physics

- M2. is able to indicate the relevance of their research for the advancement of physics;

- M3. is able to reflect critically upon their 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 skills

  - C1. has the skills to present and discuss, in spoken and written English, the results of their research, including the underlying knowledge and background, to a target group composed of specialists or non-specialists.

  - C2. is able to work together in a constructive way in an international (possibly interdisciplinary) team of experts and use modern means of scientific communication.

- Learning skills

  - L1. has the skills to evaluate their own learning and development process and to adjust this process if necessary; has the skills to work independently and take initiatives where necessary;

  - L2. is able to apply knowledge and insight in a way that demonstrates a professional approach to their work or profession;

  - L3. has the qualifications to enrol in a PhD programme in at least one of the following fields: Gravitational Waves, Particle Physics, Atomic, Molecular and Optical physics, Soft Condensed Matter & Biophysics; is qualified to acquire a position as a professional in a (semi) public or commercial organisation.

  - L4. Has a realistic idea of the career opportunities after graduating, and of the skills that they need to successfully start a career.

Contact hours

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

Contents

- Mandatory courses: ............................... 12.25 EC
- Primary electives: ................................. 37.5 EC
- Secondary electives or Internship: ....... 15 EC
- Research part: ......................................... 55.25 EC
- Total: ........................................................ 120 EC

The total credits for elective courses (primary + secondary) has to be 52.5 EC, with at least 37.5 EC from the list of primary electives. In addition to courses, it is possible to combine 15 EC of primary electives and 15 EC of secondary electives to carry out a 30 EC internship (NS-EX516M). For the latter, permission of the Board of Examiners is required before the start of the internship.

Internships can only start after the mandatory courses and primary elective courses have been finished, unless explicit permission to start earlier is given by the programme director.

Mandatory courses

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

- Graduate school's master introduction (GSNS-INTRO, 0.5 EC)
- Dilemmas of the scientist (FI-MHPSDL1 + FI-MHPSDL2, 0.5 EC)
- Computational Aspects of Machine Learning (NS-EX426M, 7.5 EC)
- Open Science for Physicists (NS-PH500M, 3.75 EC)
Primary electives

- Students can choose from the following list of primary elective courses;
- Some courses are listed with a specialization (PG: Particles & Gravity, QN: Quantum Matter & Nanophotonics, SB: Soft Matter & Biophysics). Students must choose at least 15 EC from one specialization and 7.5 EC from a different specialization. If a course is listed with multiple specializations, the student can choose which specialization to count it in.

- Utrecht Courses:
  - Modelling and Simulation (NS-TP432M, 7.5EC): PG/QN/SB
  - Fundamentals of Soft Matter (NS-TP449M, 3.75 EC): SB
  - Theory of Soft and Active Matter\(^9\) (NS-TP458M, 3.75 EC): SB
  - Experimental Soft Matter\(^9\) (NS-EX432M, 3.75 EC): SB
  - Advanced Microscopy (NS-EX423M, 7.5 EC): SB
  - Fundamentals of Biophysics (NS-TP464M, 3.75 EC): SB
  - Advanced Methods in Biophysics\(^10\) (NS-EX433M, 3.75 EC): SB
  - Stochastic Processes in Biophysics\(^10\) (NS-TP465M, 3.75 EC): SB
  - Statistical Field Theory (NS-TP404M, 7.5 EC): QN/SB
  - Quantum Optics (NS-EX428M, 7.5 EC): QN
  - Photon Physics (NS-EX418M, 7.5 EC): QN
  - Quantum Materials\(^11\) (SK-MQUMA, 7.5 EC): QN
  - Quantum Field Theory (NS-TP403M, 7.5 EC): PG/QN

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\(^9\) These courses are continuations of “Fundamentals of Soft Matter” for Theoretical and Experimental Physics, respectively; students can choose either or both courses.

\(^10\) These courses are continuations of “Fundamentals of Biophysics” for Theoretical and Experimental Physics, respectively; students can choose either or both courses.

\(^11\) Students can only take one of SK-MQUMA (Quantum Materials) or NS-TP456M (Field Theory in Condensed Matter I).
Experimental Physics

- **Particle Physics I** (NS-EX416M, 7.5 EC): PG
- **Particle Physics II** (NS-EX429M, 7.5 EC): PG
- **Gravitational Waves Theory & Observations** (NS-EX427M, 7.5 EC): PG
- **Experiment Design** (NS-EX422M, 7.5 EC)
- **Cosmology** (NS-TP430M, 7.5 EC)
- **General Relativity** (NS-TP428M, 7.5 EC)
- **Advanced Spectroscopy** (SK-MSPEC, 7.5 EC)
- **Colloidal Dispersions** (SK-MCODI) 3.75 EC
- **Colloidal Analysis Techniques** (SK-MCOAT) 3.75 EC
- **Atomistic Simulations for Materials Science** (SK-MASMS, 7.5 EC)
- **Toy Models** (BETA-MTOYM, 7.5 EC)
- **Field Theory in Particle Physics** (NS-TP533M, 3.75 EC)
- **Non-Equilibrium Physics** (NS-TP462M, 3.75EC)
- **Field Theory in Condensed Matter I** (NS-TP460M, 3.75EC)
- **Field Theory in Condensed Matter II** (NS-TP461M, 3.75EC)
- **Advanced Quantum Field Theory** (NS-TP459M, 7.5EC)
- **Quantum Chromodynamics** (NS-TP463M, 3.75EC)
- **Advanced Topics in Physics I or** (NS-EX557M, 1.5 EC)

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12 Students can only take one of SK-MQUMA (Quantum Materials) or NS-TP456M (Field Theory in Condensed Matter I).

13 NS-EX557M and NS-EX556M, which cover the visit of a relevant conference, workshop, or school, are meant for students who have taken courses at NIKHEF and are thus short 1.5 or 3 EC in the Utrecht system; students can only choose one of the two options and need permission from the programme director or programme coordinator, who shall name a staff member to act as supervisor.
Experimental Physics

- **Advanced Topics in Physics II** *(NS-EX556M, 3 EC)*

- **External NIKHEF Master Courses:**
  - **Beyond the standard model** *(NS-EX425M, 6 EC)*
  - **Flavour Physics and CP violation** *(NS-EX415M, 3 EC)*
  - **Programming C++** *(NS-EX413M, 3 EC)*
  - **Astroparticle Physics** *(NS-EX407M, 6 EC)*
  - **Statistical Data Analysis** *(NS-EX414M, 6 EC)*
  - **CERN Summer Student Programme** *(NS-EX406M, 6 EC)*

With permission from the Board of Examiners, one primary elective (maximum 7.5 EC) may be replaced with a course which is either a compulsory or a primary elective in the other two physics master’s programmes.

**Secondary electives**

For the remaining 15 EC, there are several possible options:

- any remaining course from the list of primary electives,
- any other course offered by the Graduate School of Natural Science and the Graduate School of Life Sciences;
- with prior permission from the programme director or coordinator, any course offered by the Graduate School of Geosciences;
- the course **Photovoltaic Solar Energy Physics and Technology** *(GEO4-2513)*,
- an internship of 15 EC *(NS-EX515M)*.

Other master courses, within or outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.9 of the EER.

Selection of courses should be discussed with the programme director or programme coordinator. Internships can start as soon as all mandatory courses
and primary elective courses, as well as the research part have been finished, or sooner with permission of the programme director or the programme coordinator.

Note: Not all courses offered are 7.5 EC. It is possible that the student follows a 6.0 EC course as a secondary elective, under the condition that the individual requirement for the primary and secondary electives are met and the sum total of the obtained ECs is at least 52.5 EC, i.e. leftover EC from the primary part spill over into the secondary electives.

**Deficiency courses**

If a student is required to take deficiency courses, the EC for these courses count as EC for secondary electives.

**Research part**

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

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-EX553M): 14 EC
- Thesis project part 2 (NS-EX550M): 41.25 EC

Students who have started their study before September 1\textsuperscript{st}, 2023, may choose:

- Thesis project part 1 (NS-EX553M): 14 EC
- Thesis project part 2 (NS-EX554M): 45 EC

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

Research is done at either the Gravitational Waves and Subatomic Particles (GRASP) section or at one of the research groups of the Debye Institute. The
latter also includes the groups belonging to the chemistry department (Condensed Matter & Interfaces, Physical & Colloid Chemistry). With the permission of the programme director or programme coordinator, the project can take place in a closely related research lab, provided that at least one staff member of the department of physics is willing to act as the primary responsible supervisor and/or as a second examiner. The student may start with their research project before the completion of mandatory courses and the primary elective courses with the permission of the programme director or the programme coordinator. 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.

**Cum laude**

The minimum grade for the course Thesis project part 2 a student needs to obtain a cum laude degree qualification is 9.0. Please note that additional requirements (as listed in the main text of the EER) need to be met to obtain this qualification.

**Scientific integrity and labour market perspectives**

Both aspects are discussed during the master introduction days. In addition, 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 in courses as well as during research projects and internships.

**Profiles**

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with one of the following profiles:

- Applied Data Science
- Complex Systems
- Educational
- Science-based Entrepreneurship
- Communication
The contents and further description of a profile, including entry requirements to specific courses, is described in the profile appendices. In order to still meet the learning outcomes of the master’s programme, the remaining 90 EC must be filled in as described below. Note that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120 EC) programme structure.

- Mandatory courses: 12.25 EC
- Primary electives: 37.5 EC
- Secondary electives: 0 EC
- Research part: 40.25 EC\(^{14}\)
- Total: ......................... 90 EC

The research is split into thesis part 1 (NS-EX553M, 14 EC) and thesis part 2 (NS-NS-EX558M, 26.25 EC)\(^7\).

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 in the table above, but the two research parts will be separately assessed. The total research project is thus broken down in a first part NS-EX553M (14 EC) and a second part containing the profile thesis GSNS-CSRP (15 EC).

The Board of Examiners will grant approval of a profile as part of the examination programme of the student if the student successfully finished the profile.

**Transitional Provision**

The course code for the second part of *Dilemmas of the scientist* has been changed per September 2021. For students who started before this date, FI-MHPSDIL2 can be replaced by FI-MHPSDIL.

- Students who have started their study prior to September 1\(^{st}\), 2023, can finish their study according to the OER Annex of the academic year 2022/23; this provision expires at the end of the academic year 2025/26.

\(^{14}\) For students who have started their study before September 1\(^{st}\), 2023: 44 EC (NS-EX553M + NS-EX555M)
Experimental Physics

The following table shows the equivalence between former and current courses; the column “replaced with” shows courses which are considered completely equivalent to the former course and may be used interchangeably – and thus not both – on the transcript for obtaining the degree; the column “restrictions” shows courses that overlap so significantly with a former course that both may not be included in the transcript.

Former courses which have not been replaced with a new course may still be used as primary electives until the expiration date given in the table.

<table>
<thead>
<tr>
<th>Former Course</th>
<th>Replaced with</th>
<th>Restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-EX401M (Experimental Quantum Physics)</td>
<td>None</td>
<td>NS-EX428M (Quantum Optics) expires 2024/25</td>
</tr>
<tr>
<td>NS-EX424M (Soft Condensed Matter Experiment)</td>
<td>NS-TP449M (Fundamentals of Soft Matter) and NS-EX432M (Experimental Soft Matter)</td>
<td>None expires 2025/26</td>
</tr>
<tr>
<td>NS-TP453M (Soft Condensed Matter Theory)</td>
<td>NS-TP449M (Fundamentals of Soft Matter) and NS-TP458M (Theory of Soft and Active Matter)</td>
<td>None expires 2025/26</td>
</tr>
<tr>
<td>Biophysics Experiment (NS-EX430M)</td>
<td>NS-TP464M (Fundamentals of Biophysics) and EX433M (Advanced Methods in Biophysics)</td>
<td>None expires 2025/26</td>
</tr>
<tr>
<td>SK-MCS (Colloid Science)</td>
<td>SK-MCODI (Colloidal Dispersions) and SK-MCOAT (Colloidal Analysis Techniques)</td>
<td>None expires 2025/26</td>
</tr>
<tr>
<td>Former Course</td>
<td>Replaced with</td>
<td>Restrictions</td>
</tr>
<tr>
<td>------------------------------------------------------</td>
<td>-----------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>NS-TP401M (Quantum Field Theory, 10 EC)</td>
<td>None</td>
<td>NS-TP403M (Quantum Field Theory, 7.5 EC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>expires 2025/26</td>
</tr>
<tr>
<td>NS-TP402M (Statistical Field Theory, 10 EC)</td>
<td>None</td>
<td>NS-TP404M (Statistical Field Theory, 7.5 EC)</td>
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<td>expires 2025/26</td>
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<tr>
<td>NS-TP457M (Field Theory in Condensed Matter, 7.5EC)</td>
<td>NS-TP460M (Field Theory in Condensed Matter I) and NS-TP461M (Field Theory in Condensed Matter II)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>expires 2025/26</td>
</tr>
</tbody>
</table>
Theoretical Physics

Admission to the programme Theoretical Physics

Students qualify for admission to the programme Theoretical Physics if they possess the following skills and knowledge (in addition to the criteria for the degree programme Physics):

- solid physical understanding of and analytic-calculation skills in Quantum Mechanics, Statistical Physics, Classical Field Theory, and Electrodynamics at an advanced bachelor level — typically, “advanced” implies the second course on these topics in a physics curriculum — and
- general knowledge on solid-state or condensed-matter physics. For example, obtained through successful completion of a course on quantum matter.

Pre-Master’s programme

Students who fail to satisfy the above admission requirements may be admitted conditional on the completion of a Pre-Master’s programme of at most 30 EC, tailored by the board of admissions to the student’s prior knowledge. The Pre-Master’s programme must be finished (i.e. all courses passed) before entry into the Theoretical Physics programme is allowed.

Please see article 2.4 of the GSNS EER for the exact regulations concerning the Pre-master’s programmes.

Learning outcomes

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

Knowledge and understanding

a) has in-depth knowledge of and insight into field-theoretic and mathematical methods in theoretical physics and their use in string theory, cosmology,
Theoretical Physics

elementary particle physics, (soft-)condensed matter physics, biophysics, and/or statistical physics;

b) is aware of recent developments in theoretical and experimental physics, and is able to state the relevance of these developments for the research field and society;

c) can read and understand the professional literature in the field of at least one of the following topics: string theory, cosmology, and elementary particle, (soft-)condensed-matter, bio- and statistical physics, and to relate this to the graduate’s own research;

d) understands the potential dilemmas related to scientific integrity in research.

Applying knowledge and understanding

e) is able to define, under the supervision of a staff member, a scientific problem in modern theoretical physics, formulate a research question, and design a basic strategy to solve this problem;

f) is able to carry out this research plan under supervision of a member of the scientific staff according to the rules of good scientific practice and ethics, and report on it in a manner that meets the customary standards of the discipline;

g) can analyse and interpret, under the supervision of a staff member, the acquired results, materials and/or data according to scientific standards.

Making judgements

h) is able to participate critically and constructively in the scientific debate in the research group;

i) is able to indicate the relevance of the graduate’s research for the advancement of physics;

j) can critically reflect on this theoretical-physics research.

Communication skills

k) can explain the results of the graduate’s research to an audience of specialists as well as fellow students, both orally and in writing, in English;
Theoretical Physics

l) can conduct a theoretical-physics research project, supervised by a member of the scientific staff, possibly as part of a (multidisciplinary) research team.

Learning skills

m) has the skills to evaluate the graduates’ own learning and development process and to adjust this process if necessary; has obtained the ability to study independently;

n) is able to apply knowledge and insight in professional way;

o) is qualified to be admitted to a PhD research project in the field of theoretical physics, physics in general, and/or mathematics; is qualified to perform research in a (semi) public or commercial organization.

p) 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 is 950 hours for the whole programme excluding the research part.

Contents

- Mandatory courses: 25.0 EC
- Primary electives: 30.0 EC
- Secondary electives: 15.0 EC
- Research part: 50.0 EC
- Total: 120.0 EC

Mandatory Courses

- Quantum Field Theory (NS-TP403M): 7.5 EC
- Statistical Field Theory (NS-TP404M): 7.5 EC
- Dilemmas of the Scientist (FI-MHPSDL1 + FI-MHPSDL2): 0.5 EC
Theoretical Physics

- *Graduate School’s Master Introduction* (GSNS-INTRO): 0.5 EC
- *Student Seminar: Open Science for Theoretical Physics* (NS-TP506M): 3.75 EC
- *Open Science for Physicists* (NS-PH500M): 3.75 EC
- *Student Seminar: Topics in Theoretical Physics* (NS-TP507M): 3.75 EC
- *Theoretical Physics Colloquium* (NS-TP508M): 1.5 EC

Note: Student of the Theoretical Physics programme can choose to take either *Student Seminar: Open Science for Theoretical Physics* (NS-TP506M) or *Open Science for Physicists* (NS-OS500M) toward completing their Mandatory component. The option exists to take the other component as a primary and secondary elective, respectively. If a student opts to take NS-TP506M, NS-PH500M, and NS-TP507M, the maximum number of credits that is awarded to the combination is 9.0 EC, and NS-TP506M + NS-TP507M count toward the mandatory component of the Theoretical Physics program, while NS-PH500M is a secondary awarded 1.5 EC.

**Primary electives**

At least 30.0 EC to choose out of the following list:

- *Advanced Methods in Biophysics* (NS-EX433M): 3.75 EC
- *Advanced Quantum Field Theory* (NS-TP459M): 7.5 EC
- *Advanced Topics in Theoretical Physics I* (NS-TP433M): 7.5 EC
- *Advanced Topics in Theoretical Physics II* (NS-TP530M): 7.5 EC
- *Cosmology* (NS-TP430M): 7.5 EC
- *Experimental Soft Matter* (NS-EX432M): 3.75 EC
- *Field Theory in Condensed Matter I* (NS-TP460M): 3.75 EC
- *Field Theory in Condensed Matter II* (NS-TP461M): 3.75 EC
- *Field Theory in Particle Physics I* (NS-TP533M): 3.75 EC
- *Field Theory in Particle Physics II* (NS-TP535M): 3.75 EC
Theoretical Physics

- *Fundamentals of Biophysics* (NS-TP464M): 3.75 EC
- *Gravitational Waves Theory and Observation* (NS-EX427M): 7.5 EC
- *General Relativity* (NS-TP428M): 7.5 EC
- *Kramer's College* (NS-TP451M): 7.5 EC
- *Modelling and Simulation* (NS-TP432M): 7.5 EC
- *Non-Equilibrium Physics* (NS-TP462M): 3.75 EC
- *Quantum Chromodynamics* (NS-TP463M): 3.75 EC
- *Stochastic processes in Biophysics* (NS-TP465M): 3.75 EC
- *String Theory* (NS-TP526M): 7.5 EC
- *Theory of Soft and Active Matter* (NS-TP458M): 3.75 EC
- *Theory for Technology* (NS-TP531M): 7.5 EC

Note: The following additional considerations and conditions hold:

- Several experimental course codes are present in this list. They contribute to courses shared between the programs Theoretical Physics and Experimental Physics and consequently count as primary electives toward completing the Theoretical Physics program.

- Students are only allowed to follow either *Advanced Topics in Theoretical Physics* course once, i.e., a student can graduate with NS-TP433M and NS-TP530M on their list, but not two versions of NS-TP433M.

- If a student takes *Field Theory in Condensed Matter I* together with Quantum Materials (SK-MQUMA; 7.5 EC) the maximum number of credits that the student can obtain, cannot exceed 7.5 EC.

- The *Kramer's College* is taught infrequently.

*Theory for Technology* is typically taught in conjunction with the Eindhoven University of Technology and can be started at any point throughout the year, following a discussion with the course coordinator.
Secondary electives

15.0 EC to choose out of the following list:

- Any M.Sc. course offered by the Graduate School of Natural Sciences (including the primary elective theoretical physics courses listed above).
- Any M.Sc. course from the national programme MasterMath.
- Any of the Bachelor level Mathematics courses from the list below, also see the accompanying note.
- With the consent of the programme director and of the Board of Examiners other Master’s level courses may be selected, see note.

Note: Courses from the national Mathematics Master’s programme MasterMath may have a non-standard number of EC. It is the student’s responsibility to obtain at least 15.0 EC for their secondary electives. Additionally, students are allowed to take one course only from the following Bachelor’s level Mathematics courses toward completion of their secondary electives:

- *Analysis on Manifolds* (WISB342): 7.5 EC
- *Distributions* (WISB314): 7.5 EC
- *Functional Analysis* (WISB315): 7.5 EC
- *Introduction to Algebraic Varieties* (WISB326): 7.5 EC
- *Introduction Nonlinear Dynamical Systems* (WISB333): 7.5 EC
- *Measure and Integration* (WISB312): 7.5 EC
- *Modeling with ODEs and PDEs* (WISB357): 7.5 EC
- *Stochastic Processes* (WISB362): 7.5 EC
- *Topology and Geometry* (WISB341): 7.5 EC

Note: Please keep the following in mind in selecting a Mathematics B.Sc. course from the above list. Courses from this list or ones that are equivalent thereto, which are listed on the student’s Bachelor’s degree cannot be used to obtain credit toward their Master’s degree. Students are therefore required to seek approval.
from the programme coordinator before following these courses. The official language of education in the Mathematics Bachelor programme is Dutch, but typically these courses are taught in English.

Note: Other Master's level courses, within or outside the UU, that contribute towards the aim of the programme, can be approved by the Board of Examiners upon request of the student. In their decision, the board will take into account the advice of the programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

**Deficiency courses**

The Theoretical Physics programme does not offer students the opportunity to take deficiency courses.

**Research part**

Before starting the research project, a meeting with the programme coordinator is mandatory to check the (planned) study programme. Students can only start with the research part after approval by the programme director or the programme coordinator. Students who have not obtained strictly more than 50 EC cannot start their project.

The research is split as follows:

- Thesis project part 1 (NS-TP551M, 15.0 EC)
- Thesis project part 2 (NS-TP553M, 35.0 EC)

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

**Cum laude**

The minimum grade for the course Thesis project part 2 (NS-TP553M) a student needs to obtain a cum laude degree qualification is 9.0. Please note that additional requirements (as listed in the main text of the EER) need to be met to obtain this qualification.
Scientific integrity and labour market perspectives

Both aspects are discussed during the master introduction days. In addition, students attend two additional mandatory sessions on scientific integrity in their first and second year. Information about labour market perspectives is now formally a part of the Theoretical Physics Colloquium (NS-TP505M). It is also given attention in several courses, during discussions between the student and programme coordinator, and during research projects and internships.

Profiles

Instead of the regular programme described above, the student may choose to replace 30 EC of the regular programme with one of the following profiles:

- Applied Data Science
- Complex Systems
- Educational
- Science-based Entrepreneurship
- Communication

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

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

- Mandatory courses: 25.0 EC
- Primary electives: 30.0 EC
- Research part: 35.0 EC
- Total: 90.0 EC

Note: Within the Theoretical Physics Master's programme it is permitted to combine the research part of the profiles Complex Systems and Applied Data Science (15.0 EC) with the research part (35.0 EC) in the table above, but the two
research parts will be separately assessed. The total research project is thus broken down in a first part NS-TP551M (15.0 EC) and a second part, comprised of NS-TP554M (20.0 EC) and GSNS-CSRP (15.0 EC). The student may elect to complete a regular thesis of 50.0 EC and the project / course requirements for the profile separate from the thesis. In this case, the student will need to complete the remaining 15.0 EC of courses/project as part of their secondary electives, beyond the 120.0 EC requirement for completing the programme.

The Board of Examiners will grant approval of a profile as part of the examination programme of the student if the student successfully finished the profile.

**Transitional Provisions**

The Theoretical Physics programme has seen substantial changes per September 2023. This includes the creation of new courses, reduction of course length for some existing courses, and a reweighting of the mandatory, primary-elective, and secondary-elective components to the programme. Below we provide a set of transitional provisions for students who entered the program before September 2023. In case of omission or clear disadvantage to the student, the exam committee has the ability to make rulings on an individual level. These provisions end September 2028. Note that there are two older transitions (Dilemmas and Mathematics requirement for double-degree students) at the end of this section that have their own end date.

The mandatory components of the program have been reduced from 29.5 EC to 25.0 EC. Students who started prior to September 2023 are required to complete 29.5 EC of mandatory courses, including the original *Quantum Field Theory* (NS-TP401M; 10.0 EC), *Statistical Field Theory* (NS-TP402M; 10.0 EC), and *Student Seminar in Theoretical Physics* (NS-TP504M; 7.5 EC). If the students have not been able to complete these courses, a repair assignment of 2.5 EC each, will be offered by the lecturers of *Quantum Field Theory* (NS-TP403M; 7.5 EC) and *Statistical Field Theory* (NS-TP404M; 7.5 EC), respectively, such that students may complete the original versions. A student who has not completed the original version of the *Student Seminar in Theoretical Physics* (NS-TP504M; 7.5 EC) may instead complete the *Student Seminar: Open Science for Theoretical Physics* (NS-TP506M; 3.75 EC) or *Open Science for Physicists* (NS-PH500M; 3.75 EC), and they must follow the *Student
Theoretical Physics

Seminar: Topics in Theoretical Physics (NS-TP507M; 3.75 EC). This is subject to the additional boundary conditions on the courses as described above. Lastly, students are required to complete the course Theoretical Physics Colloquium (NS-TP505M; 1.0 EC) under the original requirements of attending 18 Nico van Kampen Colloquia, 3 Alumni Talks, and 1 Career Event. Students may instead elect to follow the new Theoretical Physics Colloquium (NS-TP505M; 1.5 EC), in which case they gain 0.5 EC of credit toward their secondary electives.

The primary electives have been increased from 22.5 EC to 30.0 EC. A student who entered the program before September 2023 is required to obtain 22.5 EC from the above list of primary elective courses. A student who has already completed the courses:

- Field Theory in Condensed Matter (NS-TP457M): 7.5 EC
- Field Theory in Particle Physics (NS-TP529M): 7.5 EC
- Soft Condensed Matter Theory (NS-TP453M): 7.5 EC

can list these toward completing their primary-elective requirement. They may in addition use courses from the new list of primary electives toward completing this goal, with the following notable exceptions:

- Having completed Soft Condensed Matter Theory (NS-TP453M; 7.5 EC) or Soft Condensed Matter Experiment (NS-EX424M, 7.5 EC) precludes a student from taking any of the following: Fundamentals of Soft Matter (NS-TP449M; 3.75 EC), Experimental Soft Matter (NS-EX432M; 3.75 EC), and Theory of Soft and Active Matter (NS-TP458M; 3.75 EC) for credit.

- Having completed Field Theory in Condensed Matter (NS-TP457M; 7.5 EC) precludes a student from taking Field Theory in Condensed Matter I (NS-TP460M; 3.75 EC) and Field Theory in Condensed Matter II (NS-TP461M; 3.75 EC) for credit.

- Having completed Field Theory in Particle Physics (NS-TP529M; 7.5 EC) precludes a student from taking Field Theory in Particle Physics I (NS-TP533M; 3.75 EC) and Field Theory in Particle Physics II (NS-TP535M; 3.75 EC) for credit.

The secondary electives have been decreased from 18.0 EC with a Mathematics requirement of 6.0 EC to 15.0 EC without a requirement on completing a suitable Mathematics course. Students who entered the program prior to September 2023
Theoretical Physics

are required to complete a Mathematics course from the list above (this has been extended with respect to the original EER annex) of at least 6.0 EC. They must additionally complete a minimum of 12.0 EC of secondary electives, also adhering to the above requirements.

Students who were enrolled in a profile prior to September 2023, adhere to the original rules. Meaning that if the student fails to successfully complete the profile, the admissible curriculum conditions for the student revert to the regular (120.0 EC) programme structure as outlined in the provisions here. Successful completion of a profile implies that the student completes as per the provisions:

• Mandatory courses: 29.5 EC
• Primary electives: 22.5 EC
• Secondary electives: 3.0 EC
• Research part: 35.0 EC
• Total: 90.0 EC

They do not have to fulfil the mathematics requirement. The combination rules for the research part to the profile and the Master’s thesis are as above.

The course code for the second part of *Dilemmas of the scientist* has been changed per September 2021. For students who started before this date, FI-MHPSDIL2 can be replaced by FI-MHPSDIL. This provision ends September 2025.

Students who entered a double-degree programme before September 2022 are allowed to complement their programme with a Mathematics course meeting the aforementioned requirements, instead of taking an additional theoretical physics elective. This provision ends September 2025.
Profile Applied Data Science

Profiles

Applied Data Science Profile

Description

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

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

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

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

Students can apply for the profile throughout the year; there are no deadlines for registration.

There are masters for which the overlap in content between the master and the ADS profile is too large. This implies that students from these masters cannot follow the profile.

Learning outcomes

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

- Understands the basic methods and techniques in data science
- Is able to apply this knowledge and analyse large datasets in a specific domain

Contents

For the GSNS, the ADS profile comprises two mandatory multidisciplinary courses (15 EC), complemented with either a selection of two elective courses (15 EC) from the elective courses table listed below, OR a multidisciplinary research project (15 EC, INFOMADSRP).

Two mandatory courses (15 EC)

- *Data analytics 1: Supervise learning and visualization* (INFOMDA1): 7,5 EC (Period 1)
- *Data analytics 2: Battling the curse of dimensionality* (INFOMDA2): 7,5 EC (Period 2)
Profile Applied Data Science

Both courses are coordinated by the dept. Methods & Statistics of the Faculty of Social and Behavioural Sciences, that also coordinates the Focus area Applied Data Science (https://www.uu.nl/en/research/applied-data-science).

Complementary course(s) (15 EC)

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

Focus should be on interdisciplinary aspects and at least two supervisors from different departments/faculties should be involved. The student is responsible for the involvement of two eligible supervisors. The project is to be approved by the ADS profile coordinator, based on a 1-page research proposal outlining the research trigger, main question and approach.

The topic should not correspond to the topic of the master thesis.

Two elective courses (15 EC)

The ADS profile can be completed by complementing the mandatory courses with two additional courses from the suggested elective courses list below. Please refer to the Applied Data Science profile web page for up-to-date information, and consult your own master programme coordinator for approval nevertheless.

Note that you can select courses from any of the participating master's programmes in the list below, as long as your own master's programme coordinator also agrees with the inclusion of the selected ADS profile courses as eligible electives within your own master's curriculum (i.e. you need permission from both the ADS profile coordinator and your master's programme coordinator).

This list is not exhaustive; for elective course suggestions, email the ADS profile coordinator for approval. Finally, note that the ADS Profile web page contains the latest version of this electives list.
<table>
<thead>
<tr>
<th>Master's programme</th>
<th>Elective course</th>
<th>Osiris code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial Intelligence</td>
<td><em>Multi-agent learning</em></td>
<td>INFOMAA</td>
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<tr>
<td></td>
<td><em>Cognitive Modeling</em></td>
<td>INFOMCM</td>
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<td></td>
<td><em>Logic and Language</em></td>
<td>TLMV13020</td>
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<td></td>
<td><em>Logic and Computation</em></td>
<td>WBMV13005</td>
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<tr>
<td></td>
<td><em>Natural Language Processing</em></td>
<td>INFOMNLP</td>
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<tr>
<td>Business Informatics</td>
<td><em>Process Mining</em></td>
<td>INFOPROM</td>
</tr>
<tr>
<td>Climate Physics</td>
<td><em>Earth System Modelling</em></td>
<td>NS-MO503M</td>
</tr>
<tr>
<td>Computing Science</td>
<td><em>Data mining</em></td>
<td>INFOMDM</td>
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<tr>
<td></td>
<td><em>Data Intensive System</em></td>
<td>INFOMDIS</td>
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<tr>
<td></td>
<td><em>Computational Thinking</em></td>
<td>INFOMCTH</td>
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<tr>
<td></td>
<td><em>Epidemiology and big data</em></td>
<td>INFOMEBD</td>
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<tr>
<td></td>
<td><em>Using data from routine care</em></td>
<td>INFOMUDR</td>
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<tr>
<td>Game and Media Technology</td>
<td><em>Multimedia Retrieval</em></td>
<td>INFOMR</td>
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<td>Mathematical Sciences</td>
<td><em>Parallel Algorithms</em></td>
<td>WISL603</td>
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<td><em>Causality</em></td>
<td>WISL313</td>
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<td></td>
<td><em>Machine Learning Theory</em></td>
<td>WISL712</td>
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<td></td>
<td><em>Time Series</em></td>
<td>WISL704</td>
</tr>
<tr>
<td>Methodology and Statistics for the</td>
<td><em>Computational inference with R</em></td>
<td>2013000004</td>
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<tr>
<td>Behavioural, Biomedical and Social</td>
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<tr>
<td>Sciences</td>
<td></td>
<td></td>
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<tr>
<td>Utrecht School of Economics</td>
<td><em>Algorithms in Finance</em></td>
<td>ECMAF</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.

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15 This course is recommended as an elective course for GSLS students, but cannot be elected by GSNS students.
Transitional arrangement for Applied Data Science

With effect from 2021-2022 the content of the Applied Data Science profile has been changed in such a way that a transitional arrangement has been introduced. Students who have started the profile up to and including the academic year 2020-2021 and have not yet completed it, will be given up to and including the academic year 2021-2022 to complete the profile as it was designed in the EER of 2020-2021. They may also choose, in consultation with the profile coordinator, to complete the profile in the new form, whereby they may or may not maintain the components already followed. Ultimately, the profile coordinator decides, subject to the approval of the Board of Examiners, whether the components taken together suffice, whereby the student must in any case have obtained 30 EC. As of the academic year 2024-2025, this transitional arrangement will expire and every student who wishes to complete the ADS profile must meet the requirements as determined in the Exam regulation (EER) of that year.
Communication Profile

Description and aims
The Master’s profile Communication offers students the opportunity to focus on science communication and informal science education within the context of their own natural science research Master for a semester.

The aim of the Communication Profile is for students to develop

- a solid knowledge base on science communication, its theory and practice,
- skills to apply that knowledge into communication and informal education products that will meet their aims,
- affinity for complex socio-scientific issues that are worthwhile topics to give attention to, and
- practical and reflective communication and informal education skills.

Admission requirements

- The student belongs to one of the GSNS master programmes
- Students should have completed a minimum of 30 EC out of their own GSNS master programme
- The C profile starts twice a year, in September and February. By default, the profile will be completed in a single semester of full time study.
- Deadline for registration is 1 May for a start in September and 15 October for a start in February. If possible, please register as early as possible as it takes a lot of time to arrange good internships. Late applications will only be considered if there are still places left (max. 16 students per semester) but placement cannot be guaranteed.
Profile Communication

- Early registration is especially important for international students who do not speak and understand Dutch, as suitable EN-language internships are hard to find in the Netherlands. In addition you already need to have a good command of the English language and good communication skills before starting the C profile.

Learning outcomes

Upon completion of the Master’s profile the student can

- give a general overview of the field of science communication and its knowledge base,
- work in a project-based way and carry out relevant analyses for several product development tasks,
- in a research based way, develop education / communication products, based on a science communication / education knowledge base including relevant theories
- properly communicate in various ways with a variety of target audiences about complex socio-scientific issues,
- on the basis of pre-set learning aims, reflect on his / her own learning process and professional development.

Programme

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

Mandatory courses (25 EC):

- Internship Product Development (FI-MSECIPD): 20 EC
- Communicating Science with the Public (FI-MSECCSP): 5 EC

One elective course (5 EC):

- Issues and Theories in SEC (sem1) (FI-MSECITS): 5 EC
- Professional Skills and Identity (period 2) (FI-MSECPSI): 5 EC
- Designing for Science Education in formal and informal settings (sem2) (FI-MSECDSE): 5 EC
- Science and Society (period 4) (FI-MSECISIS): 5 EC
Complex Systems Profile

Description and aims

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

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

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

Learning outcomes

Upon completion of the Master's profile the student

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

Programme

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

- Two electives (7.5 EC each) from the following courses (one of these electives need to be from 1-3 below, which are termed as core courses for Complex Systems):

1. Introduction to Complex Systems (WISM484)
2. Advanced Topics in Climate Physics16 (NS-MO411)
3. Computational Aspects of Machine Learning17 (NS-EX426M)
4. Mathematical Biology18 (WISL411)

5. A Complex Systems labelled course listed under a master programme that is different from the one to which the student is admitted (see list below). **Note on this list:** some programmes may require one of their own primary elective courses, labelled as Complex Systems course to be taken; the student cannot count them as primary electives as well as Complex Systems master profile courses. More information can be found in the specific programme description section of the Education and Examination Regulations.

- A Research Project on a Complex Systems topic (15 EC, Osiris code GSNS-CSRP), for which focus should be on interdisciplinary aspects and at least two supervisors from two different departments/faculties must be involved.

The topic should not correspond to the topic of the master thesis, however if the master research project deals with a complex system subject – currently available only for Theoretical Physics, Experimental Physics and Climate Physics Master programmes at Utrecht University – it is permitted to combine the research project of the master’s profile Complex Systems (15 EC) with the master thesis project. In case the master research project deals with a complex system subject, the complex systems aspects must be separately assessed and a supervisor from a different department or faculty other than the department related to the student’s master programme needs to be involved in assessing the complex system aspects of the research project.

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16 In the academic year 2022-23, the course topic is machine learning to climate research. CLPH students cannot claim it as their primary elective as well as a Complex Systems master profile course.

17 EXPH and THPH students cannot claim it as their primary elective as well as a Complex Systems master profile course.

18 Registration via elo.mastermath.nl. Mathematics students cannot claim it as their primary elective as well as a Complex Systems master profile course.
Profile Complex Systems

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

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

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>Artificial Intelligence</td>
<td>Evolutionary Computing</td>
<td>INFOEA</td>
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<tr>
<td>Climate Physics</td>
<td>Waves in Geophysical Fluids</td>
<td>NS-MO447M</td>
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<tr>
<td>Computing Science</td>
<td>Network Science</td>
<td>INFOMNWSC</td>
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<td>Data Science</td>
<td>Data Mining</td>
<td>INFOMDM</td>
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<td>Pattern Recognition and Deep Learning</td>
<td>INFOMPR</td>
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<td>Energy Science</td>
<td>Energy Systems Modelling</td>
<td>GEO4-2515</td>
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<td>Experimental Physics</td>
<td>Modelling and Simulation</td>
<td>NS-TP432M</td>
</tr>
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<td></td>
<td>Fundamentals of Biophysics AND Advanced Methods in Biophysics†</td>
<td>NS-TP464M AND NS-EX433M</td>
</tr>
<tr>
<td>Game and Media Technology</td>
<td>Pattern Recognition and Deep Learning</td>
<td>INFOMPR</td>
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<td></td>
<td>Crowd Simulation</td>
<td>INFOMCWS</td>
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<tr>
<td>Mathematical Sciences</td>
<td>Inverse Problems in Imaging*</td>
<td>WISL435</td>
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<td>Introduction to Numerical Bifurcation Analysis of ODEs and Maps*</td>
<td>WISL606</td>
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<tr>
<td>Nanomaterials Science</td>
<td>Toy Models</td>
<td>SK-MTOYM</td>
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<td></td>
<td>Modelling and Simulation</td>
<td>NS-TP432M</td>
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<td>Sustainable Development</td>
<td>Systems Thinking, Scenarios and Indicators</td>
<td>GEO4-2331</td>
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<td></td>
<td>Environmental Systems Analysis</td>
<td>GEO4-2303</td>
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<tr>
<td></td>
<td>Integrated Assessment of Climate Change</td>
<td>GEO4-2340</td>
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<tr>
<td>Theoretical Physics</td>
<td>Modelling and Simulation</td>
<td>NS-TP432M</td>
</tr>
<tr>
<td></td>
<td>Fundamentals of Biophysics AND Advanced Methods in Biophysics†</td>
<td>NS-TP464M AND NS-TP465M</td>
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<td>Multidisciplinary Economics</td>
<td>Algorithms in Finance</td>
<td>ECMAF</td>
</tr>
<tr>
<td></td>
<td>The Triumph of the City</td>
<td>ECRMTCE</td>
</tr>
</tbody>
</table>

† These two courses can only be taken in combination with each other since individually they are 3.75 EC courses
* Registration via elo.mastermath.nl

Entry requirements

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

**Participating Master’s programmes**

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

**Legacy issues**

The following courses were labelled as Complex Systems courses in the past academic years (noted in parenthesis).

<table>
<thead>
<tr>
<th>Master’s programme</th>
<th>Course</th>
<th>Osiris code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Artificial Intelligence</strong></td>
<td>Seminar Social Simulation (2018-19)</td>
<td>INFOMSOCS</td>
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<tr>
<td><strong>Core courses</strong></td>
<td>Algorithms in Finance (2018-19, 2019-20)</td>
<td>WISM410</td>
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<tr>
<td></td>
<td>Complex Networks (2020-21)</td>
<td>WISL115</td>
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<tr>
<td></td>
<td>Seminar Applications of Mathematics in Radiation Research (2018-19, 2019-20)</td>
<td>WISM409</td>
</tr>
<tr>
<td></td>
<td>Understanding Complexity: Economy and the Planet (2018-19, 2019-20)</td>
<td>NS-MO450M</td>
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<tr>
<td></td>
<td>Mathematical Neuroscience</td>
<td>WISL413</td>
</tr>
<tr>
<td></td>
<td>Data Mining (2020-21, 2021-22, 2022-23)</td>
<td>INFOMDM</td>
</tr>
<tr>
<td></td>
<td>Pattern Recognition (2020-21, 2021-22, 2022-23)</td>
<td>INFOMPR</td>
</tr>
<tr>
<td><strong>Experimental Physics</strong></td>
<td>Biophysics</td>
<td>NS-EX430M</td>
</tr>
<tr>
<td><strong>Game and Media Technology</strong></td>
<td>Games and Agents (2017-18)</td>
<td>INFOMGMAG</td>
</tr>
<tr>
<td><strong>Mathematical Sciences</strong></td>
<td>Interacting particle systems: Theory and applications (2018-19)</td>
<td>WISL431</td>
</tr>
<tr>
<td></td>
<td>Introduction to Numerical Bifurcation Analysis of ODEs and Maps (2019-20, 2021-22)</td>
<td>WISL606</td>
</tr>
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<td></td>
<td>Inverse Problems in Imaging (2020-21)</td>
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<tr>
<td>Profile Complex Systems</td>
<td>Laboratory class for scientific computing (2018-19)</td>
<td>WISL430</td>
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<td></td>
<td>Mathematical Biology (2017-18, 2019-20, 2021-22)</td>
<td>WISM454</td>
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<td>Mathematical Neuroscience (2020-21)</td>
<td>WISL411</td>
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<td>Nonlinear Waves (2017-18)</td>
<td>WISL413</td>
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<td></td>
<td>Numerical bifurcation analysis of large-scale systems (2018-19, 2020-21, 2021-22)</td>
<td>WISL409</td>
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<td>WISL425</td>
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</table>

| Multidisciplinary Economics | Advanced behavioural and experimental finance (2018-19) | ECRMABEF |
| Sustainable Development | Sustainability Modelling and Indicators (2018-19, 2019-20) | GEO4-2331 |
Da Vinci Programme

Description

The Da Vinci Program offers students an immersive learning experience with the aim of educating a new generation of changemakers, connectors, and innovators. In collaboration with private and public partners, interdisciplinary student teams will attack sustainability-related challenges. During the program students from Eindhoven University of Technology, Wageningen University & Research and Utrecht University work a couple of days a week in interdisciplinary teams on their challenge at the partner's site.

Sustainable development and the strive to make our economies circular are grand challenges the world faces. These can only be solved via an interwoven collaboration of society, science, and technology. Academic education should be at the forefront of training the new generation of connectors, who are skilled in collaborating outside their comfort zone and in creating viable and practical solutions with different stakeholders. This manner of working requires strong disciplinary and transdisciplinary knowledge and skills. The Da Vinci Program focusses on this transdisciplinary knowledge and skills, and attitude required for sustainability problem-solving. Future professionals will be encouraged to challenge the status quo, to change what doesn't work in the transition towards a sustainable world. They will be stimulated to develop strong connector skills so they can build bridges between scientific disciplines and between organizations outside the academic world. And they will be inspired to become innovators that can develop the solutions of the future.

The Da Vinci Program consists of 20 weeks of full-time challenge-based education in which students will work in innovation hubs at public and private partners outside university. Students will work at the partners workspace, like an internship, but in an interdisciplinary student team, dedicated to the challenge. Five or six societal partners will facilitate a team and provide real-life challenge, such as AkzoNobel, Province of Utrecht, Energy Transition Campus Amsterdam and UMC Utrecht. In several iterations and by applying design thinking
methodology, the teams will move from a challenge briefing to feasible, viable, desirable, and sustainable solutions. Students spend two third of their time on this challenge. The teams are guided by a supervisor at the partner organization and by a mentor from university to professionally master tackling real sustainability-related problems. The remaining time they co-work with fellow students in the Da Vinci community and build a personal development portfolio. The Da Vinci community is an important platform for knowledge exchange, peer learning, and personal growth. Students have workshops together and operate in squads with fellow students from other teams to co-create the Da Vinci Program.

Admission requirements

We accept a maximum of 30 students. In case the number of applicants exceeds the maximum, a selection will be done by the coordinators of the program, based on three aspects: 1. We aim to create interdisciplinary student teams, which means ideally an equal representation of alpha, beta, and gamma sciences. Some challenges require certain disciplines and for some challenges particular disciplines are more desirable than others. 2. Students must submit a video with their motivation when they register for the program. 3. Students that have registered and submitted a sufficient quality motivation video will be invited for an interview and will be asked to perform an assignment. Based on the criteria of composing the best interdisciplinary teams, the quality of the motivation, the interview and the assignment, the coordinators retain the right to reject students.

More information on registration, criteria & selection procedure is available on this webpage.

Learning outcomes

In the Da Vinci Master Program we have the ambition to educate future changemakers that are connectors and innovators. To prepare master students for that role in society, we focus on personal development. To achieve the required learning outcomes students will be immersed in a learning experience of doing – experiencing – becoming. These outcomes are distinguished from learning objectives which are defined on the level knowledge, skills, and attitude described below.
Participants of the program will **BECOME:**

1. collaborators that are aware of their relationship to the real world,
2. confident changemakers that know how to act in uncertainty and complexity,
3. ECO-centric instead of EGO-centric leaders,
4. creative innovators that are aware of their talents and expertise,
5. pro-active connectors in a transdisciplinary working environment

### Learning Objectives

<table>
<thead>
<tr>
<th>Shows understanding and critical thinking of theory and practices of:</th>
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<tbody>
<tr>
<td>• innovation for sustainable development,</td>
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<tr>
<td>• systems thinking and design thinking</td>
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<tr>
<td>• co-design and stakeholder management</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Applies methods and tools of systems thinking and design thinking on real-life challenge to develop sustainable, desirable, feasible and viable solutions</th>
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<tbody>
<tr>
<td>Applies methods of co-design and stakeholder management within a network of public and private stakeholders outside university</td>
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<tr>
<td>Designs sustainable solutions in an iterative process by repeatedly doing research, select and synthesize different types of data, generate innovative ideas, build prototypes, setting up and conduct experiments and critically evaluate your own designs</td>
</tr>
<tr>
<td>Communicates, collaborates, and facilitates effectively in a transdisciplinary environment</td>
</tr>
<tr>
<td>Shows personal leadership skills, such as empathy, decisiveness, critical reflection, integrity, creativity, resilience and adaptivity</td>
</tr>
<tr>
<td>Awareness and understanding of the complexity of sustainability challenges</td>
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<tr>
<td>Estimates the value of:</td>
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<tr>
<td>• an iterative process in complex problem solving</td>
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<tr>
<td>• diversity and working in transdisciplinary teams for sustainability development</td>
</tr>
<tr>
<td>• co-design with stakeholders in sustainability challenges</td>
</tr>
<tr>
<td>• the design thinker's mindset and an integrative approach to complex problem solving</td>
</tr>
<tr>
<td>Approaches challenges as a reflective practitioner</td>
</tr>
<tr>
<td>Shows creative confidence in an uncertain and complex environment</td>
</tr>
<tr>
<td>Shows initiative in establishing connections and collaboration in a transdisciplinary team and in a diverse network of stakeholders</td>
</tr>
<tr>
<td>Shows empathy, curiosity, decisiveness, critical reflection, integrity, creativity, resilience and adaptivity</td>
</tr>
</tbody>
</table>
Course name:       Da Vinci (SK-MDAVI) 30 EC.

The entire program consists of the team challenge, workshops, jams, fieldtrips, squad activities and a personal development portfolio. The team challenge is 2/3 (560 hrs, including workshops and mentor sessions) and the remaining parts ± 1/3 (280 hrs, including the jams, field trips, squad activities and end game) of the study load.

Program

The program is divided into three parts according to the iterations in the team challenge as shown in the visual below. In every iteration the teams undertake the whole design thinking cycle from gathering data to experimenting. At the end of the iteration the teams present their results to a panel of experts. The teams will be guided in their performance by mentors from academic staff and by supervisors of the partner. Every iteration is anticipated by a Jam in which the community comes together for a whole week. The first Jam has the goal of boosting the community and kickstarting a specific way of working. During the first iteration there will be weekly workshops on systems thinking, design thinking and interdisciplinary co-working. During the second and third iteration other activities such as field trips will be organized. There is room for students to co-create and organize parts of the program. For that purpose, students are organized in squads. The Da Vinci Program finishes with an ‘End Game’ as a large showcase of the results from the team challenges and squad activities.
Competencies & Assessment

The assessment at Da Vinci is competency-based. At the end of the program students show proof of competence on nine competencies: Immersion, Sensemaking, Alignment, Emergence, Imagining, Learning in Action, Critical thinking, Communication, and Collaboration. These competencies will be assessed in two ways. First, the total assessment of the team challenge (2/3 of the final grade) consists of three assessments: a presentation and progress report, at the end of every iteration. The first two assessments are formative. Students receive constructive feedback from a panel of experts. The third assessment is summative. Not only the final presentation and progress report is being assessed here, but the entire process and progress of the team during the year. Second, the students work on a personal development portfolio (PDP) in which they show individual proof of competence (1/3 of the final grade). This individual assessment will be done by incremental grading. The student is entitled to make use of three formal assessments in which they can show their proof of competence on specific learning objectives. It is up to the student to decide when to be assessed by the examiner. Active participating in the jams, workshops, team meetings, field trips and squads is a conditional requirement to qualify for the individual assessment. The deliverables of the team challenge and the individual development will be assessed by a panel of experts from academic staff. The mentor and supervisor provide the panel with advice. Both the team challenge and the PDP must be graded sufficient (5.5 or above) to pass.

Participating master’s programmes

- Nanomaterials Science
- History & Philosophy of Science
- Game & MediaTechnology
- Computing Science
Educational Profile

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

The aim of the educational profile is to:

• convey specialised knowledge, skills and insight in the field of education for one of the school subjects computer sciences, physics, chemistry or mathematics, as well as more in-depth and comprehensive knowledge of the domain involved;

• prepare for professional practice as a second or first degree teacher in one of the above-mentioned school subjects;

• prepare for professional practice in the field of (informal) 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.

The Educational Profiles (limited second degree teacher qualification; EP2 and first degree teacher qualification; EP1) are offered by the Graduate School of Teaching.
Educational profile for students without a prior educational qualification (EP2)

Admission

- Admission to this profile is open to students who have accomplished at least 30 EC of their Master’s programme.
- 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 skills that are founded upon the level that is typically associated with Bachelor’s level.
- The student has the learning skills, and the social and communicative skills that are needed to develop as a teacher in secondary education.

If you are eligible for admission, the placement committee decides which students are admitted based on their motivation, study progress, the number of applications per school subject, relevant experience and (a prognosis of) available internships.

Learning outcomes

Graduates generally have:

- Knowledge of the corresponding school subject at various levels of secondary education, with a focus on VMBO-TL and lower secondary education HAVO and VWO.
- Knowledge, skills and experience in the field of communication, pedagogy and educational sciences in order to be able to contribute in a scientifically sound way to defining, analysing and solving challenges in the field of formal education.
- Knowledge, skills and experience to be able to practice and improve teaching as an adaptive expert, i.e., someone who systematically analyses and improves his own functioning critically.
Profile Educational

In addition, graduates have – in four operational fields – the following competences:

- (subject-specific) didactic knowledge to develop, implement and evaluate education, which they use in a research-based way in educational practice.
- Pedagogical knowledge to develop, implement and evaluate education and guidance of adolescents with attention to qualification, socialisation and personal development.
- Competence to apply knowledge, insights into education and interpersonal skills in broader contexts and with various target groups (pupils, colleagues, parents/guardians, experts/non-experts, inside/outside of school) to be discussed and further developed.
- Knowledge, skills and experience to critically analyse personal functioning and education in a broader sense, to formulate judgements, and to act on the basis of these judgements, taking into account social and ethical responsibilities that are part and parcel of the profession.

Graduates have skills that enable them to continue to develop and, to this end, to embark on follow-up studies or careers of a largely self-directed or autonomous nature.

Contents

The programme consists of the following parts:

- Teaching practice 1a Professional in Praktijk 1a (10 EC, GSTPIP1A)
- Teaching practice 1b Professional in Praktijk 1b (10 EC, GSTPIP1B)
- Teaching methodology 1 Pedagogiek (5 EC, GSTPED1)
- Subject teaching methodology 1 Vakdidactiek 1 - [Subject] (5 EC, GSTVAKD1IN /GSTVAKD1NK /GSTVAKD1SK /GSTVAKD1WK /GSTVAKD1BI)

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)
Profile Educational

second degree teacher qualification for lower secondary education (vmbo-t and the lower grades in havo and vwo) as described in the Law on professions in education (“Wet op de beroepen in het onderwijs” – Wet BIO, 2006), and the competences derived from it as described in the nationally agreed upon competency profile for academic teacher education.

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

Educational Profile after a previously obtained (limited) second degree teaching qualification (EP1)

Admission

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

If you are eligible for admission, the placement committee decides which students are admitted based on their motivation, study progress, the number of applications per school subject, relevant experience and (a prognosis of) available internships.

Learning outcomes

Graduates generally have:

- Knowledge of the corresponding school subject at various levels of secondary education, with a focus on upper secondary education (HAVO/VWO), which surpasses or broadens the bachelor level;
Profile Educational

- Knowledge, skills and experience in the field of (scientific) communication, pedagogy and educational sciences in order to be able to contribute in a scientifically sound way to defining, analysing and solving challenges in the field of formal education.

- Knowledge, skills and experience to be able to practice and improve teaching as an adaptive expert, i.e., someone who systematically analyses and improves his own functioning critically.

Graduates have skills that enable them to continue to develop and, to this end, to embark on follow-up studies or careers of a largely self-directed or autonomous nature.

In addition, graduates have – in four operational fields – the following competences:

- (subject-specific) didactic knowledge to develop, implement and evaluate education, which they use in a research-based way in educational practice, so that they contribute to the creation of new knowledge about the development of school subjects and education.

- Pedagogical knowledge to develop, implement and evaluate education and guidance of adolescents with attention to qualification, socialisation and personal development both at the level of the individual pupil as well as at the group level, and to contribute from there to the development of education within and outside one’s own school context.

- Competence to apply knowledge, insights into education and interpersonal skills in new or unfamiliar circumstances, broader contexts and with various target groups (pupils, colleagues, parents/guardians, experts/non-experts, inside/outside of school) in order to integrate new knowledge and to deal with complex subject matter and processes.

- Knowledge, skills and experience to critically analyse personal functioning and education in a broader sense, to formulate judgements, to make them explicit and to act on the basis of these judgements, taking into account social and ethical responsibilities that are part and parcel of the profession.
Contents

The programme consists of the following parts:

- *Teaching practice 2 Professional in Praktijk 2* (10 EC, GSTPPIP2)
- *Teaching methodology 2 Pedagogiek 2* (2.5 EC, GSTPED2)
- Subject teaching methodology 2 Vakdidactiek 2 – [Subject] (7.5 EC, GSTVAKD2IN/GSTVAKD2NK/GSTVAKD2SK/GSTVAKD2WK/GSTVAKD2BI)
- Mandatory pedagogical elective (5 EC, choose from GSTPKC01 – GSTPKC07)
- Mandatory general elective (5 EC, choose from GSTOKC01 – GSTOKC10)

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.

Non-Dutch students

*As the Educational profile is primarily targeted towards teaching in the Dutch school system, the courses and the internships are by default in Dutch. This profile has an entry level of C1 for reading and listening in Dutch. Admission to the Educational Profile is therefore not available for students that are not proficient in the Dutch language.*

Admission is possible if the candidate masters the Dutch language for reading and listening at B2 level. Sufficient passive control of the Dutch language can be demonstrated 1) during an interview or 2) by passing the Reading and Listening components of the State Examination NT2 before the start of the course (minimum score 500 points). If you already have a Dutch second degree in teaching and would like to obtain a first degree in teaching, it is necessary to understand and speak Dutch fluently, to be demonstrated and confirmed in the aforementioned NT2 test. The ultimate decision about admitting a candidate is up to the admissions committee of the Graduate School of Teaching.
Science-based Entrepreneurship profile

Description

Science-based entrepreneurship is a foundational source of innovation and thereby for economic growth. Academic institutions are excellent breeding grounds for start-ups and there is international recognition for the need of education on *science-based entrepreneurship* (SBE) [3]. The High-Tech Campus Eindhoven, the Leiden Bio Science Park, and the Wageningen Campus are excellent examples of successful science-based entrepreneurial ecosystems. Science-based entrepreneurship is described as the ways in which scientific knowledge drives economic activity and underpins societal impact. It encapsulates the study of how scientific innovations can be validated and brought to market.

There are many routes towards entrepreneurship [3]; whether it is finding a science-based product while working at a large company or performing research in an incubator. It is not obvious, however, how students in the Graduate School of Natural Sciences can follow a path in entrepreneurship [1]. The SBE profile has been created with the goal of providing such a path for students in all science programs. Three stages are recognized when it comes to entrepreneurship education: Educate, Stimulate, and Incubate [4] (see also Figure 1). This profile focuses on the first two; it has the goal of educating students about entrepreneurship and stimulates them into considering a position in an entrepreneurial organization. The profile is unique in that it values the domain specific knowledge brought by the students, while stimulating them to bring that knowledge to the market.
Research groups consisting of scholars with postdocs and PhD students usually have difficulty in identifying valorisation possibilities for their research and are not incentivized to do so [1, 2]. Academic ambitions, personal circumstances, lack of opportunity awareness are among the reasons that innovative research gets stuck with good intentions. We therefore propose an active collecting of ideas in the workplace of the faculty with the help of the research directors and research support officers. We envision science student teams picking up innovations from staff members and starting an entrepreneurial journey together. The profile thus serves two purposes: (1) to educate students about the entrepreneurship option and (2) to support researchers in valorising their innovations.

Utrecht University is currently trying to establish more science-based start-ups. Furthermore, the Faculty of Science has explicitly mentioned in the strategic plan 2025 that it wants to “Encourage entrepreneurship and start-ups” and “to stimulate our own staff to be more entrepreneurial." While there have been many initiatives and some good examples (Channable.com, Relay42.com, UCrowds,
Profile Science-based Entrepreneurship

CoreLifeAnalytics, Numworx, etc.) the university is now more concretely setting goals for spinning out more science-based start-ups. This profile encourages students to take existing science-based technologies and try to develop a start-up around it. As such, the profile can contribute to this positively.

Related Literature


Admission to the profile

To apply for the SBE profile, students must first contact the SBE profile coordinator to discuss eligibility, and subsequently register through the online form accessible from the SBE education web pages at https://students.uu.nl/en/science/science-based-entrepreneurship. The SBE profile coordinator then assesses your profile. The coordinator looks for the following:

- Currently admitted to one of the master programs in the GSNS.
- Experience in an innovative science domain, shown by a relevant bachelor and if possible already completed master courses.
- Explicit interest into the topic of entrepreneurship, through a short motivational text in the application form.
Profile Science-based Entrepreneurship

- Experience in executing a research or development project, such as a bachelor project or software project.

It is intended that students from the master programs in the Science Faculty can follow the profile without many administrative hurdles.

**Learning outcomes**

After finishing the profile, a student should:

- Understand the entrepreneurial process.
- Have an overview of methods that can be used to identify and verify science-based market opportunities in a scientific domain.
- Understand and be able to identify innovation steps in the entrepreneurial process, such as idea generation, opportunity recognition, and evaluation.
- Have an understanding of their own entrepreneurial skills and ambitions.
- Have an overview of the research that is done about entrepreneurship.
- Have the ability to integrate knowledge from various scientific domains and the own academic discipline for the development of a new business.
- Have experience in the first steps of valorizing a science-based innovation.

**Contents**

The profile consists of two parts. First, students follow the course of *Science-based Entrepreneurship* (7.5 EC) as a jumping board towards launching a start-up. Secondly, students can follow electives from a selection of entrepreneurship oriented courses within Utrecht University (22.5 EC). It is also possible for students to replace one or two electives with a project, but under very strict conditions.

**Part 1: Science-based Entrepreneurship (7.5 EC)**

In the compulsory course of science-based Entrepreneurship students develop a business plan and a prototype of a science-based innovation, with an ICT component. The main learning goals of the course are to awaken the
Profile Science-based Entrepreneurship

entrepreneur in students, to teach students the role of ICT in entrepreneurship, and to review methods for entrepreneurship research. The course has been successful in bringing forth several companies, such as Channable (100 FTE+) and Relay42 (75 FTE+). Please note that this course was previously known as ICT Entrepreneurship.

Part 2: Approved Electives (22.5 EC)
Approved electives are master courses that have been pre-approved by the profile coordinator. Other courses may be proposed but can only be approved by the profile coordinator. Please note that some combinations are prohibited, as some of the courses have overlap. The student will be informed of this overlap, as it may differ from year to year, after the student applies for the profile.

<table>
<thead>
<tr>
<th>Elective course</th>
<th>Course Origin</th>
<th>Osiris code</th>
<th>Course Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Centered Machine Learning</td>
<td>AINM</td>
<td>INFOMHCML</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Social Computing</td>
<td>AINM</td>
<td>INFOMSOC</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Advanced Graphics</td>
<td>AINM</td>
<td>INFOMAGR</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Multi-agent Systems</td>
<td>AINM</td>
<td>INFOMAS</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Natural Language Processing</td>
<td>AINM</td>
<td>INFOMNLP</td>
<td>7.5 EC</td>
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<tr>
<td>Global Design Challenge</td>
<td>BII</td>
<td>B-MBIGDC</td>
<td>7.5 EC</td>
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<tr>
<td>Integrative Bio-inspired Design</td>
<td>BII</td>
<td>B-MIBID</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Advanced Topics in Climate Dynamics</td>
<td>CLPH</td>
<td>NS-MO411M</td>
<td>7.5 EC</td>
</tr>
<tr>
<td>Data Mining</td>
<td>COSC</td>
<td>INFOMDM</td>
<td>7.5 EC</td>
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<tr>
<td>Pattern Recognition</td>
<td>COSC</td>
<td>INFOMPR</td>
<td>7.5 EC</td>
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</tbody>
</table>

19 Please note that many of the courses above have their own particular requirements for entering. Participating in the profile does not provide access automatically to each course in this list. The regular entry requirements need to be met.
## Profile Science-based Entrepreneurship

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>EC</th>
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<tbody>
<tr>
<td><strong>Big Data</strong></td>
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<td>INFOMBD</td>
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<td><strong>Network Science</strong></td>
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<td><strong>Experiment Design</strong></td>
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<tr>
<td><strong>Modelling and Simulation</strong></td>
<td>EXPH</td>
<td>NS-TP432M</td>
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<td><strong>Mobile Interaction</strong></td>
<td>GMT</td>
<td>INFOMMOB</td>
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<td><strong>AI for Game Technology</strong></td>
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<td>INFOMAIGT</td>
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<td>IN-SC</td>
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<tr>
<td><strong>ICT Start-ups</strong></td>
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<td><strong>Responsible ICT</strong></td>
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<td>USEMSE</td>
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<tr>
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<td>USE</td>
<td>USEMEM</td>
</tr>
<tr>
<td><strong>Marketing and Society</strong></td>
<td>USE</td>
<td>USEMMS</td>
</tr>
</tbody>
</table>
**Part 2b: Entrepreneurship Project (7.5-15 EC)**

Students can perform an optional project that fulfils the learning goals of the course, where they research an entrepreneurship topic in collaboration with a *willing staff member*, typically around the domain of the staff member. Projects can be done in teams and as an individual.

Projects can be of roughly two types:

1. An academic feasibility or validation study for an innovation product.
2. An academic research project into the role of entrepreneurship in a particular science domain.

The end products of the project can consist of any deliverable that can be judged by the learning goals of the profile. The project is graded based on how well the set of predetermined learning goals have been met by the project. It is required that the project concerns an innovation from a particular science domain.

The project must be embedded in an existing project format within the master programme of the student under an existing project course code. This typically means that if the student performs the project, they cannot perform another project under the same course code. The topic has to be approved by the profile coordinator, and by the programme coordinator of the master programme for which the student is admitted.

The student is responsible for finding a supervising staff member for the SBE aspects of the disciplinary project. This is done on a case-by-case basis depending on the research topic, but commitment from a staff member is required before the research project is allowed to commence. In this way, it is avoided that the projects lead to an excessive project load for teaching staff. To enable project matching, a website will be created for listing the entrepreneurship projects.
Example Profile and Constraints
A typical profile consists of 4 courses, but under strict conditions it is possible to replace one or two of the courses with a research project related to science-based entrepreneurship. An example of the profile, which closely resembles the study path of a recent student, could thus be:

- *Science-based Entrepreneurship* (7.5 EC)
- *Innovation Systems and Processes* (7.5 EC)
- *Theory for Technology* (7.5 EC)
- A capita selecta in the Dept. of Information and Computing Sciences into using artificial intelligence for fall detection in elderly people (7.5 EC)

It is encouraged that students also do part of their thesis on their start-up product or entrepreneurship, but this is not a condition to fulfil the requirements of the Profile.

Goal of the profile
The goal of the profile is to stimulate entrepreneurship in a broader context. To be more precise, we aim to reach two goals:

- Test entrepreneurship gene - After the profile students have had the possibility to discover to what extent they desire to become entrepreneurs. This implies we have made the students aware of their abilities and skills in this domain.

- Increase UU Start-ups - But more importantly, in line with the goals of the university and the faculty, we increase the number of student and staff led start-ups and the number of students that follow programs at UtrechtInc.

Intellectual Property
As students may start new start-ups, the intellectual property (IP) that is developed should follow the correct paths. There are several scenarios. If students develop IP on their own, the IP belongs to them. However, if it is developed with staff, the IP must be divided among the different team members. For advice about this, we recommend contacting the [UU Holdings](#).
Final Notes
Please note that the total number of EC of each master’s programme does NOT increase by completing the master profile SBE.
Honours programme Q-Biology

Description
This honours programme is open to all natural and life 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 (EER) of the Graduate School of Life Sciences.

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

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

Short after the application (less than 2 weeks) the student will be notified whether or not she/he can join the Qbio programme. Yearly there is a maximum of 20 students that can participate in this programme. The students that are selected for Qbio programme will join the monthly journal club meetings. The aim of this journal club is to learn to read interdisciplinary papers and to develop current overview of Quantitative Biology.

Learning outcomes
Discoveries in the biological and biomedical sciences increasingly require combining sophisticated technologies, quantitative measurements, and theoretical approaches such as bioinformatics, mathematical modelling, and
Honours programme Q-Biology

computer simulations. Hence, modern Life Sciences research faces the challenge to integrate different scientific disciplines and foster collaborative projects between biologists, chemists, physicists, computer scientists and mathematicians to make biology a quantitative natural science.

Therefore, the most important learning outcomes of this honours programme is:

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

Contents

The programme has the following components:

- Attending Monthly Journal Club (see http://tbb.bio.uu.nl/qbio/journal_club.html): The students that are selected for Qbio programme will join the monthly journal club meetings. The aim of this journal club is to learn to read interdisciplinary papers and to develop current overview of Quantitative Biology. It is obligatory to attend 12 journal clubs to finish the programme.

- (Optional, but strongly suggested) Perform at least one interdisciplinary research project within the Institute of Bioinformatics and Biocomplexity or any other groups associated with Qbio honors programme (see http://tbb.bio.uu.nl/qbio/honours.html) during their Master.

- In the second year of Qbio honours programme, the students will organize a one day symposium on Quantitave Biology and continue to attend monthly journal clubs.

- (Optional, but strongly suggested) Writing own PhD proposal as final literature thesis. Students are free to choose their own research topic, and
by which group they would prefer to be supervised (7.5 EC). The supervisor may decide to submit your PhD proposal to grant agencies.