

Programme descriptions

Annex to the Education and Examination Regulations (EER)

2022-2023

Graduate School of Natural Sciences

17-06-2022

Contents

Applied Data Science	3
Artificial Intelligence	9
Chemical Sciences	20
Nanomaterials Science	20
Computer Science	32
Computing Science	32
Game and Media Technology	43
History and Philosophy of Science	53
Information Science	63
Business Informatics	63
Human Computer Interaction	75
Mathematical Sciences.....	86
Physics.....	98
Climate Physics	99
Experimental Physics	105
Theoretical Physics	115
Profiles	124
Applied Data Science Profile.....	124
Communication Profile	129
Complex Systems Profile	131
Educational Profile.....	136
Science-based Entrepreneurship Profile	142
Honours programme Q-Biology	151

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 four focus domains (health science, geoscience, social and behavioural science and media studies) 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) 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 offered e.g. during 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 specified in individual application forms.

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

- *Spatial data analysis and simulation modelling* (INFOMSDASM)
- *Spatial Statistics and Machine Learning* (INFOMSSML)
- *Dynamics and causality in the social and behavioural sciences* (INFOMDCSBS)
- *Human Network Analysis* (INFOMHNA)
- *Critical Data Mining of Media Culture* (INFOMCDMMC)
- *Personalisation for (Public) Media* (INFOMPPM)

- *Epidemiology and Big Data* (INFOMEBD)
- *Using data from routine care, registries, health devices and public repositories* (INFOMUDR)

* Some elective courses might have a quota. Students should be aware that since there are no formal tracks, they cannot be guaranteed a place in a certain course.

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

Research part

- *Thesis Applied Data Science* (INFOMTADS): 14 EC

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 is normally performed within the applied data science focus area, and can also be done in a research-and-development department of a company or institution in the network of the focus area. Projects are provided by the programme and students will be assigned a project through a matching procedure. At least three out of four electives need to be completed successfully before the student can start with the research part. 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.

Cum Laude

To obtain a cum laude degree qualification, it is necessary to have a minimum grade of 7.0 on each course, a minimum average course grade of 8.0, and a minimum grade of 8.5 for the research part (*Thesis Applied Data Science*, INFOMTADS). Please note that additional requirements need to be met to obtain this qualification (see EER main document).

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
- 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)
- *Databases* (INFODB)
- *Datastructuren* (INFODS)
- *Inleiding tot de Cognitiewetenschap* (201800004)

- *Experimentele methoden en statistiek* (KI3V14002)
- *"Formele en Natuurlijke Talen"* (KI2V21001)
- *Computationale Linguïstiek* (KI2V13007)
- *Logische Complexiteit* (KI3V12013)
- *Introduction to Machine Learning* (KI2V20001)
- *Machine Learning* (KI3V15001)
- *Computationeel denken* (INFOB1CODE)

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;
 - 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)
- *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* (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: *Reasoning about Meaning in Linguistic Communication*

(TLRMV19103), *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* (INFOMA1): 14 EC
- *Artificial intelligence MSc thesis Part II* (INFOMA2): 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 (INFOMA12) 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
- 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

- 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 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.

- 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

- 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.

Research group	Course (7.5 EC)
Condensed Matter and Interfaces	<i>Solids and Surfaces</i> (SK-MSOLS) or <i>Photon Physics</i> (NS-EX418M)
Inorganic Chemistry and Catalysis	<i>Advanced Catalysis</i> (SK-MCAT)
Materials Chemistry and Catalysis	<i>Advanced Catalysis</i> (SK-MCAT)
Organic Chemistry and Catalysis	<i>Organometallic Chemistry and Homogeneous Catalysis</i> (SK-MOCHC)
Physical and Colloid Chemistry	<i>Colloid Science</i> (SK-MCS)

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

- *Advanced Microscopy* (NS-EX423M)
- *Colloid Science* (SK-MCS)
- *Experimental Quantum Physics* (NS-EX401M)

Chemical Sciences

- *Organometallic Chemistry and Homogeneous Catalysis* (SK-MOCHC)
- *Advanced Organic Synthesis* (SK-MOSS)
- *Photon Physics* (NS-EX418M)
- *Modelling and Simulation* (NS-TP432M)
- *Soft Condensed Matter Theory* (NS-TP453M)
- *Photovoltaic Solar Energy Physics* (GEO4-2513)
- *Solids & Surfaces* (SK-MSOLS)
- *Synthesis of Heterogeneous Catalysts and Energy Materials* (SK-MSCEM)
- *Nonequilibrium Systems and Transport Phenomena* (SK-MNSTP)
- *Atomistic Simulations and Machine Learning for Materials Chemistry* (SK-MASML)
- *Quantum Matter* (SK-MQUMA)
- *Toy Models* (BETA-MTOYM)

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

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)
 - *Kwantummaterie* (NS-371B)

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:

- *Fysische chemie 2* (SK-BFYCH): 7.5 EC
- *Anorganische en Vaste Stof Chemie (Inorganic Chemistry and Solid State Chemistry)* (SK-BANVA13): 7.5 EC
- *Advanced Organic Chemistry* (SK-BORC3): 7.5 EC
- *Organometallic Chemistry* (SK-B3OMC): 7.5 EC

- *Toegepaste Density Functional Theory (Applied Density Functional Theory)*
(SK-BTDFT): 7.5 EC
- *Advanced Super Structures Scattering and Microscopy*
(SK-BASSM): 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 including those belonging to the physics department (i.e. the Soft Condensed Matter and Biophysics and the Nanophotonics group) or, with the permission of the programme director, in a closely related research lab, provided that a staff member of the Debye Institute is willing to act as the primary responsible supervisor and first examiner. The student may start with their research project before the completion of the mandatory courses and the primary elective courses with the permission of the programme director. Research group-specific requirements including the choice of certain primary elective courses, or other activities, are noted on the Research Project Application Form before the start of the project.

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:

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

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

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

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 (37.5 EC: 1 + 14 + 22.5)

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 (22.5 EC)

Experiment Design (NS-EX423M) 7.5 EC

Soft Condensed Matter Experiment (NS-EX424M) 7.5 EC one further course

from the mandatory course choice list 7.5 EC

Primary Electives (45 EC: 22.5 + 22.5)

Nanomaterials (15 EC)

three courses from the list of primary electives of the Nanomaterials programme

Experimental Physics (22.5 EC)

three courses from the list or primary electives of the Experimental Physics programme

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 (60 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-EX554M (45 EC)

Computer Science

Computing Science

Admission to the degree in Computer Science

Applicants should possess:

- solid basic knowledge of computer science and logic;
- the ability to 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 ('profielingsruimte') 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
- a HBO-bachelor in the 'HBO-opleiding Informatica'
- a 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.

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

A bachelor's degree from a 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
- Algorithmic data analysis

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 COSC* (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)
 - *Domain specific languages* (INFOMDSL)
 - *Probabilistic Reasoning* (INFOPROB)
 - *Program semantics and verification* (INFOMPSV)
- Algorithm design and analysis, courses:
 - *Geometric algorithms* (INFOGA)
 - *Algorithms and networks* (INFOAN)
 - *Scheduling and time-tabling* (INFOSTT)
 - *Network science* (INFOMNWSC)
 - *Optimization for sustainability* (INFOMOFS)
- Operations research, courses:
 - *Optimization for sustainability* (INFOMOFS)
 - *Scheduling and time-tabling* (INFOSTT)

- *Algorithms and networks* (INFOAN)
- *Data mining* (INFOMDM)
-
- Algorithmic data analysis, courses:
 - *Data mining* (INFOMDM)
 - *Multimedia retrieval* (INFOMR)
 - *Pattern recognition* (INFOMPR)
 -
 - *Data intensive systems* (INFOMDIS)
 - *Data Visualization* (INFOMDV)
 - *Knowledge and data engineering* (INFOKDE)
 -

Secondary electives

Secondary electives can be chosen from the list below:

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

- With the study path Operations research: Continuous optimization (Mastermath), Queueing theory (Mastermath), Parallel algorithms (Mastermath).

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 director 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)
- *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)
- *Algoritmiëk* (INFOAL)
- *Software testing en verificatie* (INFOB3STV)

- *Data-analyse en retrieval* (INFOB3DAR)

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 Algorithmic Data Analysis chair, or the Algorithmic Systems chair. 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:

- 1 *Thesis project Part I* (INFOMCOSC1): 15 EC
- 2 *Thesis project Part II* (INFOMCOSC2): 25 EC
- 3 *The Computing Science colloquium* (INFOMCCS4): 4 EC

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.

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 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 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 COSC* (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* (INFOM) 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.

Game and Media Technology

Admission to the degree in Computer Science

Applicants should possess

- Solid basic knowledge of computer science and logic;
- The ability to 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 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 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, $O(\cdot)$ -notation, balanced binary search trees, etc.;
- knowledge of mathematics, notably calculus, logic, linear algebra, probability and statistics;
- knowledge of basic computer-graphics techniques;
- have a good level of English understanding, speaking and writing.

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

- BSc programmes with a major in computer science;
- BSc with a major in science and a minor (or comparable) in computer science;
- An HBO BSc programme in HIO or technical computer science. In this case, an average grade of at least 7/10 for the core courses is required next to the already mentioned skills and knowledge.

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.

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.
 - 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

Computer Science

- *Multimodal Interaction* (INFOMMMI): 7.5 EC
- *Mobile Interaction* (INFOMMOB): 7.5 EC
- *Motion and Manipulation* (INFOMOMA): 7.5 EC
- *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
- *Algoritmiëk (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.

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

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, 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

- 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 -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.

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**

- K1. Has a basic knowledge and understanding of the main issues in history and philosophy of the sciences and the humanities.
 - K2. Has detailed knowledge of one of the areas of history and/or philosophy of the sciences and the humanities.
 - K3. Is able to contribute to scientific research in one of these areas using an appropriate methodology.
 - K4. Has demonstrated to be able to compare and assess the applicability and relevance of various ways of knowing;
 - K5. Is aware of important recent developments in one of these areas and understands the relevance of these developments for their scientific discipline.
 - K6. Understands the possible social relevance of these developments.
 - K7. 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.
 - K8. Understands the potential dilemmas related to scientific 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 current issues in science and academia, 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 relate this to their own work.

- A5. Is able to carry out a research plan according to the rules of good practice and ethics.

- **Making judgements**

- M1. Is able to participate critically and constructively in scientific debates.
- 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. Has the skills to conceive papers for international peer-reviewed journals. Is able to present their work orally 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.

- **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. Is able to write, with the help of a senior researcher, a grant proposal.
- L3. Is qualified to compete for a position for which an academic training in one of the areas of history and/or philosophy of the sciences and the humanities is required or useful.
- L4. Has the qualifications to enrol in a PhD programme in the field of history and philosophy of science and is qualified to acquire a position as a professional in the field of history and philosophy of science, or e.g. science publishing, science communication, public policy, science management, or science museums.

- L5. 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.

Mandatory Courses

- *History of Knowledge 1* (GKRMV22006): 7,5 EC
- *History of Knowledge 2* (FI-MHPCHK2): 7,5 EC
- *Philosophy of Science* (FI-MHPSPS): 7,5 EC
- *Research Seminar*, consisting of: (FI-MHPSSR): 6,5 EC

- reading group (history of science, philosophy of science, philosophy of physics)
- colloquium attendance (a minimum of 20)
- *Introducing Natural Sciences* (GSNS-INTRO): 0,5 EC
- *Dilemmas of the scientist* (FI-MHPSDL1 + FI-MHPSDL2): 0,5 EC

Primary Electives

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

Title	EC	code
20th century German Philosophy	5	FRRMV16015
Art History I: Knowledge, Technologies, and Material Culture	5 or 10	GKRMV16051
Digital Ethics	5	FRRMV16017
Ethics and Technology	5	FRRMV22002
Foundations of Quantum Mechanics	5	FI-MHPSQM
History and Philosophy of Objectivity	5	FRRMV16014
History of Magic	7,5	FI-MHPSMAG
History of Medicine	7,5	BMB507812
History and Philosophy of the Modern Life Sciences	7.5	FI-MHPSHLS
History of the Early Modern Book	5	GKRMV17007
HPS Summer School	2	
Investigative Journalism	5 or 7,5	FI-MHPSIJ
Law as an Academic Discipline	7,5	RGMURWOM08
Logic and Computation	7,5	WBMV13005
Making Climatic and Environmental Knowledge	7,5	FI-MHPSMCE
Pharmaceutical Humanities	7,5	FA-MA214
Philosophy of Artificial Intelligence	7,5	WBMV05003
Philosophy of Space and Time 1	5	FI-MHPSST
Philosophy of Space and Time 2	5	FI-MHPSST2
Philosophy of Space and Time	7,5	FI-MHPSST

Philosophy of the Social Sciences	5 or 7,5	201600160
Professional Skills and Identity	5	FI-MSECPSI
Research Seminar History of Mathematics	7,5	WISM481
Science and the Dilemmas of Modernity	7,5	FI-MHPSDM
Science and the Public	7,5	FI-MHPSSP
Science in Society	5	FI-MSECSIS
The Quantum World	5	FI-MHPSQW
The Quantum World	7,5	FI-MHPSTQW
Topics in Early Modern Philosophy	5	FRRMV16010
Topics in Epistemology and Philosophy of Science	5	FRRMV16011
Topics in German Idealism	5	FRRMV17006
Topics in Metaphysics	5	FRRMV16008
Topics in Moral Psychology	5	FRRMV16013
Topics in Philosophy of Language and Logic	5	FRRMV17003
Topics in Philosophy of Mind	5	FRRMV17007
Tutorial HPS	5 or 7,5	FI-MHPSTUT, FI-MHPSTU2
Tutorial Philosophy	5	FRRMV17009, FRRMV17010

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 *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.

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.

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

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

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

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.

Information Science

Business Informatics

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.

Additionally, a very good level of English proficiency is expected, at least equal to C1 Advanced Cambridge English or equivalent IELTS or TOEFL standards.

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.

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 30 EC Pre-Master's programme 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 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 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 and Information Technology;
- Artificial Intelligence (AI);
- 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 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):

- *Applications of Machine Learning* (INFOB3APML)
- *Architecture of Digital Ecosystems* (INFOB2ADE)
- *Computationeel Denken* (INFOB1CODE)
- *Data Analytics* (INFOB2DA)
- *Datamodelleren* (INFOB1DM)
- *Informatieuitwisseling* (INFOB1IUW)
- *Information Security* (INFOB3INSE)
- *Knowledge-Intensive Process Analysis* (INFOB3KMPA)
- *Math and Statistics for Information and Computing Sciences*(INFOB3MSIC)
- *Mens, Maatschappij en ICT* (INFOB1IMM)
- *Ontwerpen van Interactieve Systemen* (INFOB1OIS)
- *Organisaties en ICT* (INFOB1OICT)
- *Procesmodelleren* (INFOB1PROM)
- *Product Software* (INFOB3PS)

- *Programmeren in Python* (BETA-B1PYT)
- *Responsible Data Science* (INFOB3RDS)
- *Strategisch Management van Organisaties en ICT* (INFOB3SMI)
- *Systeemontwikkelingsmethoden* (INFOB2SOM)
- *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 course¹: 0-7.5 EC
- Secondary electives: 0-22.5 EC
- Research: 43 EC
- Total: at least 120 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).

Mandatory courses

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

Primary electives

- *Responsible ICT* (INFOMRICT)
- *Technologies for Learning* (INFOMTFL)
- *Software Ecosystems* (INFOMSSE)
- *Digital Transformation and Architecture* (INFOMDTA)
- *Software Architecture* (INFOMSWA)
- *Natural Language Generation* (INFOMNLG)
- *Science-Based Entrepreneurship* (INFOMSBE)
- *Requirements Engineering* (INFOMRE)
- *Process Mining* (INFOMPROM)
- *Data Intensive Systems* (INFOMDIS)
- *Knowledge and Data Engineering* (INFOMKDE)
- *Visualization* (INFOMVIS)
- *Adaptive Interactive Systems* (INFOMAIS)

- *ICT Start-ups* (INFOMICTS)

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:

- *Thesis Project Part 1* (INFOMMBI1): 15 EC
- *Thesis Project Part 2* (INFOMMBI2): 25 EC
- *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.

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 courses such as: *Digital Transformation and Architecture, Method Engineering, and Software Architecture*;
- 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, staff uses plagiarism detection tools.

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 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.

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.

- 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.

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 modeling, and evaluation and development methods;
- programming; and
- research methods and statistics.

Additionally, a very good level of English proficiency is expected, at least equal to C1 Advanced Cambridge English or equivalent IELTS or TOEFL standards.

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.

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 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 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)

Complementary to the general Information Science knowledge and skills, applicants should 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, including Industrial Design Engineering;
- Psychology; and
- Biomedical Sciences.

Students with a Dutch HBO bachelor and equivalent degrees in Computer Science and Engineering disciplines (e.g., electrical engineering) will also be considered.

Students with a Dutch HBO bachelor and appreciated equivalent degrees in subjects such as psychology, communication, management, and design will normally *not* meet the admission criteria.

Pre-Master's

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 30 EC Pre-Master's programme 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.*

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

L1. has the skills to evaluate their own learning and development process, and to motivate and correct themselves during their studies where necessary;

L2. has developed their own effective, performance-oriented methodology to enable them to perform independently in the field of Interaction 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;

L5. 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

Mandatory courses	32.0	EC
Primary electives	22.5	EC
Secondary electives	22.5	EC
Research part	43.0	EC
Total	120.0	EC

Notes:

- In case a deficiency course needs to be completed, this replaces 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* (INFOMLHVL7.5 EC)

Period 2

- Requirements Engineering (INFOMRE 7.5 EC)
- Cognitive Modeling (INFOMCM 7.5 EC)
- Visualization (INFOMVIS 7.5EC)
- Pattern Recognition (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)

Period 4

- Mobile Interaction (INFOMMOB7.5 EC)
- Serious Gaming (INFOMSEGA 7.5 EC)

- Human-Centered Machine Learning* (INFOMHCML 7.5 EC)
- Natural Language Processing (INFOMNLP 7.5 EC)

* One of the courses Machine Learning for Human Vision and Language (INFOMLHVL) and Human-Centered Machine Learning (INFOMHCML) can be chosen; not both.

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:

- Elementary Math for Information and Computing Science (INFOEMICS 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)
- Datastructuren (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 (INFOHCI 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.

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.

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

Transitional provision for students who enrolled in the programme before September 2016

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.

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.

Mathematical Sciences

Admission to the degree in Mathematical Sciences

Applicants should possess:

- A solid basic knowledge of mathematics at the bachelor level, including single-variable and multi-variable real analysis, linear algebra (theory and applications) and probability. Moreover we require advanced knowledge of at least four of the following ten subjects: differential equations and dynamical systems, complex analysis, probability theory and statistics, numerical analysis, geometry and topology, algebra and number theory, discrete mathematics, optimisation, logic, and functional analysis.
- 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.

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

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

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 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 specialisations:

- 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,
- 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 specialisation Applied Mathematics, Complex Systems and Scientific Computing 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*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

² not open for students who have followed WISM556 in 2015-2016

programme coordinator. Note that for courses outside the UU further conditions apply; see art. 3.7 of the main EER text.

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:

- *Research project: Proposal* (WISM105): 15 EC
- *Research project: Thesis* (WISM109): 30 EC

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 of the main programme: Specialisation Applied Mathematics, Complex Systems and Scientific Computing

Students following the specialisation *Applied Mathematics, Complex Systems and Scientific Computing* have the freedom to choose up to 30 EC of as 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 this specialisation 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
- Communication

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
- *Research project: Thesis* (WISM108): 20 EC

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

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

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 -MHPSDIL2 can be replaced by FI-MHPSDIL.
- 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 the Utrecht University (UU).

The courses that are part of the national Mastermath programme, as listed on <https://elo.mastermath.nl>, form the core part of the master's programme

Mathematical Sciences. Examination takes place according to general rules of Mastermath, to be found at <https://elo.mastermath.nl>.

Mastermath courses 2022-2023

Fall 2022

WISL525	Advanced Algebraic Geometry: Abelian Varieties	8 EC
WISL509	Algebraic Geometry 1	8 EC
WISL305	Algebraic Number Theory	8 EC
WISL508	Algebraic Topology 1	8 EC
WISL333	Algorithms Beyond the Worst Case	6 EC
WISL329	Analytic Number Theory	8 EC
WISL702	Asymptotic Statistics	8 EC
WISL336	Category Theory	8 EC
WISL526	Commutative Algebra	8 EC
WISL103	Continuous Optimization	6 EC
WISL503	Differential Geometry	8 EC
WISL101	Discrete Optimization	6 EC
WISL404	Dynamical Systems	8 EC
WISL708	Ergodic Theory	8 EC
WISL716	Forensic Probability and Statistics	8 EC
WISL401	Functional Analysis	8 EC
WISL519	Lie Groups	8 EC
WISL701	Measure Theoretic Probability	8 EC
WISL304	Modern Cryptography	8 EC
WISL601	Numerical Linear Algebra	8 EC
WISL533	p-adic Numbers	8 EC
WISL603	Parallel Algorithms	8 EC
WISL402	Partial Differential Equations	8 EC
WISL316	Set Theory	8 EC
WISL108	Stochastic Gradient Techniques in Optimization and Learning	6 EC
WISL201	Systems and Control	6 EC
WISL704	Time Series	8 EC

Spring 2023

WISL105	Advanced Linear Programming	6 EC
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WISL539	Algebraic Geometry 2	8 EC
WISL540	Algebraic Methods in Combinatorics	8 EC
WISL541	Algebraic Topology 2	8 EC
WISL607	Calculus of Variations	8 EC
WISL313	Causality	8 EC
WISL306	Coding Theory	8 EC
WISL303	Elliptic Curves	8 EC
WISL429	Group Theory and Dynamical Systems	8 EC
WISL810	History and Philosophy of Mathematics	8 EC
WISL435	Inverse Problems in Imaging	6 EC
WISL609	Lie Algebras	8 EC
WISL712	Machine Learning Theory	8 EC
WISL413	Mathematical Neuroscience	8 EC
WISL432	Mathematical Theory for Tomography	8 EC
WISL717	Nonparametric Statistics	6 EC
WISL425	Numerical Bifurcation Analysis of Large-Scale Systems	8 EC
WISL602	Numerical Methods for Time-Dependent PDEs	8 EC
WISL517	Operator Algebras	8 EC
WISL117	Quantum Computing	8 EC
WISL119	Quantum Information Theory	8 EC
WISL109	Queueing Theory	6 EC
WISL514	Riemann Surfaces	8 EC
WISL107	Scheduling	6 EC
WISL534	Selected Areas in Cryptology	8 EC
WISL502	Stochastic Loewner Evolution	8 EC
WISL703	Stochastic Processes	8 EC
WISL504	Survival Analysis	8 EC
WISL516	Symplectic Geometry	8 EC
WISL328	Topos Theory	8 EC

Local courses 2022-2023

Fall 2022

WISM446	Algebraic Curves	7.5 EC
WISM484	Introduction to Complex Systems	7.5 EC
WISM454	Laboratory Class Scientific Computing	7.5 EC
WISM558	Topology of Geometric Structures	7.5 EC
WISM436	Seminar Mathematical Epidemiology	7.5 EC

Spring 2023

WISM467	Computational Finance	7.5 EC
WISM565	Seminar Algebraic Topology	7.5 EC
WISM442	Seminar Differential Geometry	7.5 EC
WISM569	Seminar Interacting Random Systems	7.5 EC
WISM550	Seminar Logic	7.5 EC
WISM485	Seminar Machine Learning	7.5 EC
WISM568	Seminar Number Theory	7.5 EC

Physics

Admission to the degree Physics

Applicants should possess:

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

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.

Climate 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 concerning Pre-Master's programmes.

Learning outcomes

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

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

- c) can read and understand the professional literature in the field of at least one of the five research themes of the programme, and is able to relate this to 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 climate physics; to formulate a research question, and to design a basic strategy to solve this problem;
 - f) is able to carry out this research plan under supervision of a 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;
 - g) 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**
 - h) is able to participate critically and constructively in the scientific debate in the research group;
 - i) is able to indicate the relevance of graduate's research for the advancement of physics;
 - j) is able to critically reflect on the graduate's own results, as well as on published scientific literature in the field of climate dynamics.
 - **Communication skills**
 - k) 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 orally and in writing;
 - l) is able to professionally act in a (possibly multi-disciplinary and international) research team.
 - **Learning skills**
 - m) has the skills to reflect upon the graduate's 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;
 - n) is able to apply knowledge and insight in a way that demonstrates a professional approach to the graduate's work or profession;
 - o) has the qualifications to enrol in a PhD programme in Climate Physics; is qualified to acquire a position as a professional in a (semi) public or commercial organization;

- p) 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
- *Making, Analysing and Interpreting Observations*³ (NS-MO502M): 7.5 EC
- *Earth System Modelling* (NS-MO503M): 7.5 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 courses⁴:

- *Ice and Climate* (NS-MO427M): 7.5 EC
- *Current Themes in Climate Change* (NS-MO434M): 7.5 EC
- *Advanced Topics in Climate Dynamics*⁵ (NS-MO436M): 7.5 EC

³ Students participating in the (coordinated) exchange with the master programmes "Integrated Climate System Studies" (ICSS) or "Ocean and Climate Physics" (OCP) at the Universität Hamburg are allowed to replace, after approval of the programme director or programme coordinator, NS-MO502M by a course followed during this exchange within the programmes listed above, that includes a clear observational component.

⁴ Students may also list the following discontinued courses as primary elective: "Remote Sensing" (NS-MO424M), "Ocean Waves" (NS-MO428M), "Boundary Layers, Transport and Mixing" (NS-MO412M) and the NS-MO411M.

⁵ NS-MO411M and NS-MO436M will count either as core course of the profile Complex Systems or as primary elective, but not as both.

- *Marine Masters Summer Course* (NS-MO446M): 3.75 EC
- *Waves in Geophysical Fluids* (NS-MO447M): 7.5 EC
- *Turbulence in Fluids*⁶ (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.

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.

⁶ Selection of this course requires permission of the programme director or programme coordinator.

The research part is split as follows⁷:

- Thesis project part 1 (NS-MO551M): 14 EC
- Thesis project part 2 (NS-MO552M): 30 EC

Research is done under the supervision of a staff member of the Institute for Marine and Atmospheric Research (IMAU). If the research is initiated and executed in the Faculty of Geoscience, a staff member of the Faculty of Geoscience may serve as project supervisor, while the second examiner is a staff member of IMAU. The exam committee of the physics department will designate the supervisor at the Faculty of Geoscience as examiner of the thesis after approval of the research application.

In case of a reduced research project as part of a profile, a second examiner remains mandatory.

Research can be done in the following directions:

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

⁷ Incoming exchange students are allowed to do a smaller research project of 15 EC (Thesis project part 2NS-MO553M), if their exchange period at Utrecht University is one semester or less.

- 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: 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.

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

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.
- Students enrolled in September 2020 or earlier may use "Simulation of Ocean, Atmosphere and Climate" (NS-MO501M) as replacement for "Earth System Modelling" (NS-MO503M), and only for those students exempt ^a applies. It is not allowed to choose both NS-MO501M and NS-MO503M.

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 experimental 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;

- 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: 8.5 EC
- Primary electives: 37.5 EC
- Secondary electives or Internship: 15 EC
- Research part: 59 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 three 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
- *Experiment Design* (NS-EX422M): 7.5 EC

Primary electives

- Students can choose from the following list of primary elective courses; for research in either of the three specialisations (P: Particle Physics, A: Atomic and Molecular Physics, SB: Soft Condensed Matter & Biophysics) it is strongly recommended to choose 22.5 EC of courses with the appropriate label.

- Utrecht Courses
 - *Particle Physics I* (NS-EX416M, 7.5 EC): P
 - *Photon Physics* (NS-EX418M, 7.5 EC): A
 - *Soft Condensed Matter Experiment*⁸ (NS-EX424M, 7.5 EC): SB
 - *Advanced Microscopy* (NS-EX423M, 7.5 EC): A/SB
 - *Modelling and Simulation* (NS-TP432M, 7.5 EC): P/A/SB
 - *Soft Condensed Matter Theory* (NS-TP453M, 7.5 EC): SB
 - *Biophysics Experiment* (NS-EX430M, 7.5 EC): SB
 - *Quantum Optics* (NS-EX428M, 7.5 EC): A
 - *Particle Physics II* (NS-EX429M, 7.5 EC): P
 - *Gravitational Waves Theory & Observations* (NS-EX427M, 7.5 EC): P
 - *QCD in Extreme Conditions* (NS-EX431M, 7.5 EC): P
 - *Cosmology* (NS-TP430M, 7.5 EC): P
 - *General Relativity* (NS-TP428M, 7.5 EC): P

⁸ Due to overlap in content, students can only choose one of the two options NS-EX424M or NS-TP453M, *Soft Condensed Matter Experiment / Theory*.

- *Computational Aspects of Machine Learning* (NS-EX426M, 7.5 EC): P/A/SB
 - *Quantum Field Theory* (NS-TP401M, 10 EC): P/A
 - *Statistical Field Theory* (NS-TP402M, 10 EC): P/A/SB
 - *Field Theory in Particle Physics* (NS-TP529M, 7.5 EC): P
 - *Advanced Spectroscopy* (SK-MSPEC, 7.5 EC): SB
 - *Colloid Science* (SK-MCS, 7.5 EC): SB
 - *Atomistic Simulations for Materials Science* (SK-MASMS, 7.5 EC): SB
 - *Toy Models* (SK-MTOYM, 7.5 EC): SB
 - *Quantum Materials* (SK-MQUUMA, 7.5 EC): SB
 - *Advanced Topics in Physics I or
Advanced Topics in Physics II* (NS-EX557M, 1.5 EC⁹)
(NS-EX556M, 3 EC): P/A/SB
- External NIKHEF Master Courses:
 - *Beyond the standard model* (NS-EX425M, 6 EC): P
 - *Flavour Physics and CP violation* (NS-EX415M, 3 EC): P
 - *Programming C++* (NS-EX413M, 3 EC): P/A/SB
 - *Astroparticle Physics* (NS-EX407M, 6 EC): PP
 - *Statistical Data Analysis* (NS-EX414M, 6 EC): P /A /SB
 - *CERN Summer Student Programme* (NS-EX406M, 6 EC): P

⁹ 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.

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 and Life Sciences;
- the course *Photovoltaic Solar Energy Physics and Technology* (GEO4-2513),
- an internship of 15 EC (NS-EX515M) outside Utrecht University; there is also the possibility to add 15 EC of primary electives for a 30 EC internship (NS-EX516M), as described in the section on 'Primary Electives'.

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 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-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 including those belonging to the chemistry department (Condensed Matter & Interfaces, Physical & Colloid Chemistry) or, with the permission of the programme director or programme coordinator, 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 only 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 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: 8.5 EC
- Primary electives: 37.5 EC
- Secondary electives: 0 EC
- Research part: 44 EC
- Total: 90 EC

The research is split into thesis part 1 (NS-EX553M, 14 EC) and thesis part 2 (NS-EX555M, 30 EC).

Remark: in this master's programme it is permitted to combine the research part of the profiles Complex Systems and Data Science (15 EC) with the research part (44 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-EX553M (14 EC) and a second part, comprised of NS-EX555M (30 EC) and GSNS-CSRP (15 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

Transitional Provision

- 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.

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, 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.

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- **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;
- 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: 29.5 EC
- Primary electives: 22.5 EC
- Secondary electives: 18.0 EC
- Research part: 50.0 EC

- Total: 120.0 EC

Note: For the secondary electives, the student is required to take a minimum of 6 ECs of mathematics courses at the Master's level. Please refer the discussion that follows for additional details and exemptions to this rule.

Mandatory Courses

- *Quantum Field Theory* (NS-TP401M): 10.0 EC
- *Statistical Field Theory* (NS-TP402M): 10.0 EC
- *Dilemmas of the Scientist* (FI-MHPSDL1 + FI-MHPSDL2): 0.5 EC
- *Graduate School's Master Introduction* (GSNS-INTRO): 0.5 EC
- *Student Seminar in Theoretical Physics* (NS-TP504M): 7.5 EC
- *Theoretical Physics Colloquium* (NS-TP505M): 1.0 EC

Primary electives

At least 22.5 EC to choose out of the following list:

- *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
- *Field Theory in Condensed Matter* (NS-TP457M): 7.5 EC
- *Field Theory in Particle Physics* (NS-TP529M): 7.5 EC
- *General Relativity* (NS-TP428M): 7.5 EC
- *Modelling and Simulation* (NS-TP432M): 7.5 EC
- *Soft Condensed Matter Theory* (NS-TP453M): 7.5 EC
- *String Theory* (NS-TP526M): 7.5 EC
- *Kramer's College* (NS-TP451M): 7.5 EC
- *Theory for Technology* (NS-TP531M): 7.5 EC

- *Gravitational Waves* (NS-EX427M): 7.5 EC
- *QCD in Extreme Conditions* (NS-EX431M): 7.5 EC

Note: The following additional conditions hold. Students are only allowed to follow either *Advanced Topics in Theoretical Physics* course once. For *Soft Matter Theory*, overlap in terms of content precludes a student from following *Soft Condensed Matter Experiment* (NS-EX424M, 7.5 EC) as a secondary elective. The *Kramer's College* is taught infrequently. *Theory for Technology* is 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 leader.

Mathematics requirement

At least 6.0 EC of the secondary electives is to be chosen from any master-level course in mathematics, or alternatively one third-year course of the bachelor programme in mathematics from the following list:

- *Differentieerbare variëteiten* (WISB342): 7.5 EC
- *Topologie en meetkunde* (WISB341): 7.5 EC
- *Maat en integratie* (WISB312): 7.5 EC
- *Stochastische processen* (WISB362): 7.5 EC
- *Distributies* (WISB314): 7.5 EC
- *Functionaalanalyse* (WISB315): 7.5 EC
- *Inleiding scientific computing* (WISB356): 7.5 EC
- *Inleiding niet-lineaire dynamische systemen* (WISB333): 7.5 EC

Note: Students taking a profile do not have to fulfill the above mathematics requirement. Students enrolled in a double-degree program are required to follow an additional primary theoretical physics elective instead; also see the Transitional Provisions.

Please keep the following in mind in selecting a mathematics bachelor course from the list above. At most one of these bachelor courses can be selected as part of the master's programme. The official language of education in these

courses is Dutch, but typically these courses are taught in English. Appearance in this list is not a guarantee that the course will be taught in a particular year. Courses from this list, or ones that are equivalent thereto, that are listed on a student's bachelor's degree cannot be used to obtain points toward their master's degree. Students are therefore required to seek approval from the programme coordinator before following courses (or equivalents) from this list.

Secondary electives

18.0 EC to choose out of the following list:

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

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: Within the 18.0 EC, the student is required to take a single mathematics course with the above boundary conditions.

Deficiency courses

The theoretical physics programme does not offer 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 Student Seminar in Theoretical Physics (NS-TP504M). 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: 29.5 EC
- Primary electives: 22.5 EC
- Secondary electives: 3.0 EC
- Research part: 35.0 EC
- Total: 90.0 EC

Note: Students in a profile do not have to fulfil the mathematics requirement. Additionally, 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 EC) with the research part (35 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 EC) and a second part, comprised of NS-TP554M (20 EC) and GSNS-CSRP (15 EC). The student may elect to complete a regular thesis of 50 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 EC of courses/project as part of their secondary electives, beyond the 120 EC requirement for completing the programme.

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.

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.

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

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

have completed a certified introductory MOOC course on basic statistical methods and / or be motivated in programming in R / Python.

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)

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 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.

Master's programme	Elective course	Osiris code
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Artificial Intelligence	<i>Multi-agent learning Cognitive Modeling</i>	INFOMAA
	<i>Experimentation in Psychology Linguistics</i>	INFOMCM
	<i>Logic and Language</i>	INFOMEPL
	<i>Logic and Computation</i>	TLMV13020
	<i>Natural Language Processing</i>	WBMV13005 INFOMNLP
Business Informatics	<i>Process Mining</i>	INFOMPROM
Climate Physics	<i>Earth System Modelling</i>	NS-MO503M
Computing Science	<i>Data mining</i>	INFOMDM
	<i>Pattern set mining</i>	INFOMPMSM
	<i>Big data</i>	INFOMBD
	<i>Data Intensive System</i>	INFOMDIS
	<i>Computational Thinking¹⁰</i>	INFOMCTH
Game and Media Technology	<i>Multimedia Retrieval</i>	INFOMR
Mathematical Sciences	<i>Parallel Algorithms</i>	WISL603
	<i>Statistics for Stochastic Processes Complex</i>	WISL116
	<i>Networks</i>	WISL115
Methodology and Statistics for the Behavioural, Biomedical and Social Sciences	<i>Computational inference with R</i>	201300004
Utrecht School of Economics	<i>Algorithms in Finance</i>	ECMAF

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.

¹⁰ 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.
- 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-MSECSIS): 5 EC

Complex Systems Profile

Description

The Master's profile Complex Systems is an interdisciplinary profile for students who are interested to broaden their knowledge and expertise within the field of Complex Systems. In this research field societal issues, such as a financial 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.

Contents

Programme

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

- Two electives (7.5 EC each) from the following courses (one of these 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 Physics (NS-MO411)¹¹
 3. Computational Aspects of Machine Learning (NS-EX426M)¹²
 4. Mathematical Neuroscience (WISL413)¹³
 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

¹¹ 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.

¹² EXPH and THPH students cannot claim it as their primary elective as well as a Complex Systems master profile course.

¹³ Registration via elo.mastermath.nl. Mathematics students cannot claim it as their primary elective as well as a Complex Systems master profile course.

two supervisors from two different departments/faculties must be involved.

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

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

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

List of courses labelled as a complex systems course

Master's programme	Course	Osiriscode
Artificial Intelligence	Evolutionary Computing	INFOEA
Climate Physics	Waves in Geophysical Fluids	NS-MO447M
Computing Science	Data Mining Pattern Recognition Network Science	INFOMDM INFOMPR INFOMNWSC
Energy Science	Energy Systems Modelling	GEO4-2515
Environmental Science	Climate Systems and Adaptation	GEO4-2327
Experimental Physics	Modelling and Simulation Biophysics	NS-TP432M NS-EX430M
Game and Media Technology	Pattern Recognition Crowd Simulation	INFOMPR INFOMCRWS
Mathematical Sciences	Inverse Problems in Imaging* Numerical Bifurcation Analysis of Large-Scale Systems*	WISL435 WISL425
Nanomaterials Science	Toy Models	SK-MTOYM

	Modelling and Simulation	NS-TP432M
Sustainable Development	Systems Thinking, Scenarios and Indicators Environmental Systems Analysis	GEO4-2331 GEO4-2303
Theoretical Physics	Modelling and Simulation	NS-TP432M
Multidisciplinary Economics	Algorithms in Finance The Triumph of the City	ECMAF ECRMTCE

* 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

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).

Master's programme	Course	Osiris code
Artificial Intelligence	Seminar Social Simulation (2018-19)	INFOMSOCS
Core courses	Applying Mathematics in Finance (2017-18), Algorithms in Finance (2018-19, 2019-20) Complex Networks (2020-21) Seminar Applications of Mathematics in Radiation Research (2017-18, 2018-19, 2019-20) Understanding Complexity: Economy and the Planet (2016-17, 2017-18, 2018-19, 2019- 20)	WISM410 WISL115 WISM409 NS-MO450M
Computing Science	Evolutionary Algorithms (2018-19, 2019-20), Evolutionary Computing	INFOEA
Game and Media Technology	Games and Agents (2017-18)	INFOMGMAG
Mathematical Sciences	Interacting particle systems: Theory and applications (2018-19) Introduction to Numerical Bifurcation Analysis of ODEs and Maps (2017-18, 2019-20, 2021-22) Inverse Problems in Imaging (2020-21) Laboratory class for scientific computing (2018- 19) Mathematical Biology (2017-18, 2019- 20, 2021-22) Mathematical Neuroscience (2020-21) Nonlinear Waves (2017-18) Numerical bifurcation analysis of large-scale systems (2018-19, 2020-21) Seminar mathematical epidemiology (2017-18)	WISL431 WISL606 WISL430 WISM454 WISL411 WISL413 WISL409 WISL425 WISM436
Multidisciplinary Economics	Advanced behavioural and experimental finance (2017-18, 2018-19)	ECRMABEF
Sustainable Development	Sustainability Modelling and Indicators (2018-19, 2019-20)	GEO4-2331

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 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.

Educational profile for students without a prior educational qualification

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.

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

Learning outcomes

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.

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

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.

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

Learning outcomes

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;
- 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* (10 EC, GSTPIP2)
- *Teaching methodology 2* (2.5 EC, GSTPED2)
- Subject teaching methodology 2 – [Subject] (7.5 EC, GSTVAKD2IN/GSTVAKD2NK/GSTVAKD2SK/GSTVAKD2WK/GSTVAKD2BI)

- Mandatory elective (5 EC, choose from GSTPKC01 – GSTPKC07)
- Mandatory 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. Non-native candidates are welcome to follow the educational profile and obtain the Dutch "limited second degree in teaching", provided they have a basic proficiency in Dutch. The programme will try to find an internship in a bilingual or international school. However, placement opportunities in bilingual or international schools are limited.

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.

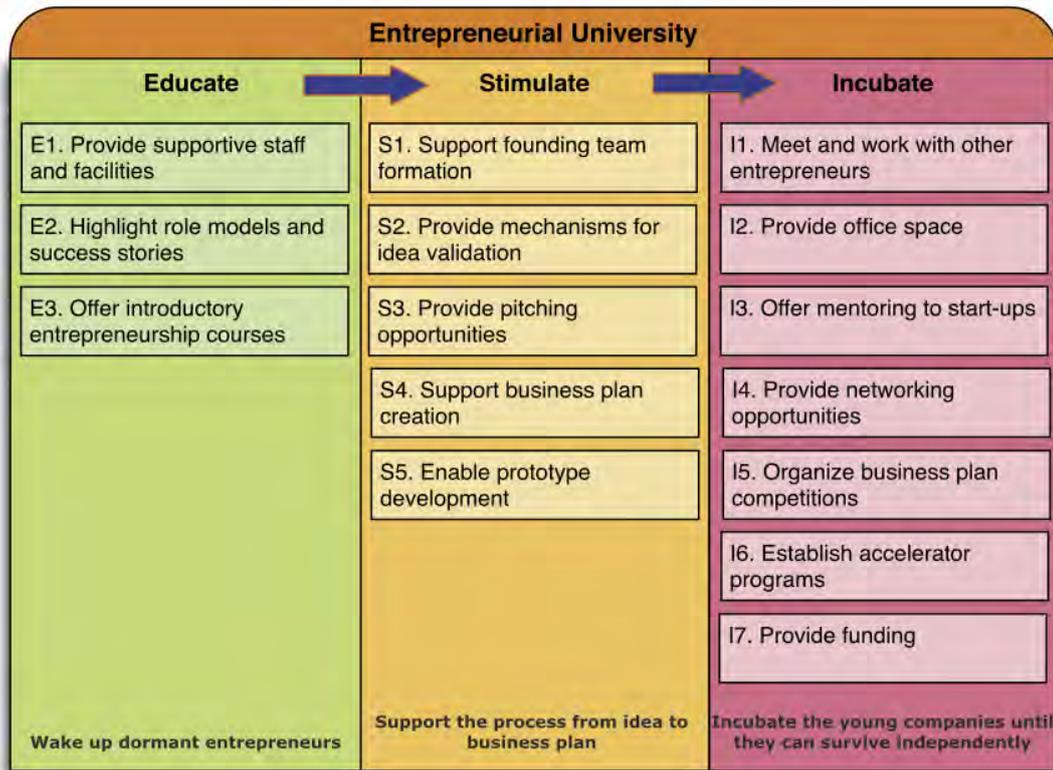


Fig. 1. Three-stage Student Entrepreneurship Encouragement Model (SEEM) to contribute to becoming an entrepreneurial university.

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, 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

1. Nab, J., Bulte, A. M., & Pilot, A. (2013). Fostering the competence of science students in identifying business opportunities: a design research approach. *International Journal of Entrepreneurial Venturing*, 5(1), 28-47.
2. Henrekson, M., & Rosenberg, N. (2001). Designing efficient institutions for science-based entrepreneurship: Lesson from the US and Sweden. *The journal of technology transfer*, 26(3), 207-231.
3. Blankesteyn, M., Bossink, B. & van der Sijde, P. (2020). Science-based entrepreneurship education as a means for university-industry technology transfer *International Entrepreneurship Management Journal*.
4. S. Jansen, T. van de Zande, S. Brinkkemper, E. Stam, V. Varma (2015). How Education, Stimulation, and Incubation Encourage Student Entrepreneurship: Observations from MIT, IIT, and Utrecht University *The International Journal of Management Education*.

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.

- 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 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.

Elective course ¹⁴	Course Origin	Osiris code	Course Size
<i>Human Centered Machine Learning</i>	AINM	INFOMHCML	7.5 EC
<i>Social Computing</i>	AINM	INFOMSOC	7.5 EC
<i>Advanced Graphics</i>	AINM	INFOMAGR	7.5 EC
<i>Multi-agent Systems</i>	AINM	INFOMAS	7.5 EC
<i>Natural Language Processing</i>	AINM	INFOMNLP	7.5 EC
<i>Global Design Challenge</i>	BII	B-MBIGDC	7.5 EC

¹⁴ 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.

<i>Integrative Bio-inspired Design</i>	BII	B-MIBID	7.5 EC
<i>Advanced Topics in Climate Dynamics</i>	CLPH	NS-MO411M	7.5 EC
<i>Data Mining</i>	COSC	INFOMDM	7.5 EC
<i>Pattern Recognition</i>	COSC	INFOMPR	7.5 EC
<i>Big Data</i>	COSC	INFOMBD	7.5 EC
<i>Network Science</i>	COSC	INFOMNWSC	7.5 EC
<i>Experiment Design</i>	EXPH	NS-EX422M	7.5 EC
<i>Modelling and Simulation</i>	EXPH	NS-TP432M	7.5 EC
<i>Mobile Interaction</i>	GMT	INFOMMOB	7.5 EC
<i>AI for Game Technology</i>	GMT	INFOMAIGT	7.5 EC
<i>Innovation Management</i>	IN-SC	GEO4-2268	7.5 EC
<i>ICT Start-ups</i>	MBI	INFOMICTS	7.5 EC
<i>Software Production</i>	MBI	INFOMSPR	7.5 EC
<i>Software Ecosystems</i>	MBI	INFOMSSE	7.5 EC
<i>Responsible ICT</i>	MBI	INFOMRICT	7.5 EC
<i>Process Mining</i>	MBI	INFOMPROM	7.5 EC
<i>Data Intensive Systems</i>	MBI	INFOMDIS	7.5 EC
<i>Digital Transformation and Architecture</i>	MBI	INFOEAR	7.5 EC
<i>Technology Related Venturing</i>	SBI	GEO4-2268	7.5 EC
<i>Innovation Systems and Processes</i>	SBI	GEO4-2257	7.5 EC
<i>Societal Challenges & Innov. Theory</i>	SBI	GEO4-2258	7.5 EC
<i>Business & Sustainability Challenges</i>	SBI	GEO4-2601	7.5 EC
<i>Technologies for Sustainability</i>	SBI	GEO4-2608	7.5 EC

<i>Theory for Technology</i>	THPH	NS-TP531M	7.5 EC
<i>Sustainable Entrepreneurship</i>	USE	ECMSE	7.5 EC
<i>The Economics of Entrepreneurship</i>	USE	ECRMECE	7.5 EC
<i>Entrepreneurial Marketing</i>	USE	USEMEM	7.5 EC
<i>Data-driven Entrepreneurship</i>	USE	USEMDDE	7.5 EC
<i>Frontiers of Entrepreneurship</i>	USE	USEMRP-BDE	7.5 EC
<i>Intrapreneurship</i>	USE	USEMI	7.5 EC

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 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 honours programme (see <http://tbb.bio.uu.nl/qbio/honours.html>) during their Master.

- In the second year of Qbio honours programme, the students will organize a one day symposium on Quantitative Biology and continue to attend monthly journal clubs.
- (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.