FACULTY OF ENGINEERING
AND ARCHITECTURE

EDUCATION QUALITY AUDIT

Self-Evaluation Report

15 November 2021

PART B

Accreditation of Flemish Engineering Programmes by the Commission des Titres d'Ingénieur

GHENT
UNIVERSITY

Ghent University
Faculty of Engineering and Architecture

Education Quality Audit
Self-Evaluation Report – November 2021

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Accreditation of Flemish Engineering Programmes by the *Commission des Titres d’Ingénieur*

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Table of contents

Introduction

In this part of the SER, the individual bachelor and master programmes are described. The structure of each description is kept identical:

- programme objectives;
- programme specific competences;
- structure of the programme;
- evolution of the programme;
- follow-up of CTI-recommendations
- advanced or subsequent studies (only in bachelor programme descriptions);
- admission (only in master programme descriptions);
- programme's context (only in master programme descriptions);
- SWOC-analysis.

As the bachelor programmes have a directly corresponding master programme, the SWOC-analysis of the bachelor programme is included in that of the master.

For each programme, by way of additional input, a programme specific annex is included in a separate part (see SER, Part B Annexes). Each annex supplies more information on the following items:

- reference to the online programme catalogue (curriculum content and course descriptions);
- link to table with a detailed mapping between the individual (compulsory) courses and the competences of the programme;
- link to previous visitation and accreditation reports;
- number of enrolled students;
- number of graduated students;
- teaching and evaluation methods;
- number of students continuing to PhD studies (only for master programmes);
- list of recent master theses (only for master programmes).

Detailed description of the bachelor's programmes

1.1 Bachelor of Science in Engineering: Architecture

Programme objectives

The Bachelor of Science in Architecture is the first part of a five year programme that aims to develop the ability of students to position themselves as designers with regard to the wide range of fields of knowledge (social, historical, technical, artistic, …) that constitute the field of architecture. In this view, 'architecture' is not approached as the expertise of a particular profession, but as a cultural field that touches upon many facets of society. With its approach, the programme aims to form students who are familiar with, and have a critical understanding of a wide range of heterogeneous forms of knowledge and competences, and are thus uniquely qualified to enable and direct the dialogue between the increasingly specialized actors who govern the design and development of our environment.

The bachelor pursues its goals by (i) introducing students to all aspects of the broad and complex field of architecture, and to foster a critical awareness of the broad scope of the field (ii) familiarizing students with architectural design as a particular form of analysis, knowledge production and action, (iii) developing a critical attitude in students towards the current state of the built environment and the actors, mechanisms and processes that shape it.

In order to do so, the programme offers (i) a training in architectural design on different levels of scale (from the building detail to the tall building), and an introduction to urban design, (ii) an education in the constructional and technical aspects of building, (iii) a thorough introduction in the history and theory of architecture that nourishes an awareness of the cultural and social significance of architecture and urban development, (iv) a training in a variety of graphic and digital techniques that allow students to develop, explain and present architectural projects, (v) a basic training in the methods of academic research and writing.

The programme thus intends to provide students with a broad perspective on a range of fields of knowledge and research pertaining to architecture. At the same time, and especially through the format of studio teaching, the students acquire the basic competences for teamwork, for effective communication, and for critical evaluation.

Programme specific competences

As explained in Section 3.2 (SER, Part A), the objectives are formalised as a list of competences and associated learning outcomes that are specific to the architecture programme. Some of these competences coincide with the generic bachelor competences of the other BSc programmes listed in SER, Part A (indicated in italic in subsequent list).

Field of competences B1: Competences in one/more scientific discipline(s)

- *B1.1 Have a clear understanding of the basic sciences and basic engineering sciences, and have the ability to apply them in a creative and purposeful way in the chosen specific engineering discipline.*
- B1.2 Understand the basic principles of the behaviour of materials, the design of building structures, the construction of the building envelope and the application of technical installations in buildings.
- B1.3 Understand the basic principles of architectural and urban design with regard to spatial analysis, architectural typology, programme definition, figuration and design methodology.
- B1.4 Understand the methodology of the science of architecture, the history of architecture and urbanism, based on a framework of important cases and literature.
- B1.5 Understand the social relevance and impact of architecture, urban development and construction.
- B1.6 Employ the basic sciences and techniques in a creative and purposeful way (statistics, ICT, CAD).

Field of competences B2: Scientific competences

- *B2.1 Research and process technical and scientific information in a purposeful way.*
- *B2.2 Employ standard models, methods and techniques in assignments.*
- *B2.3 Schematize and model phenomena, processes, and systems.*
- B2.4 Propose solutions for simple constructional problems based on scientific methods and insights acquired during the studies.
- B2.5 Organise simple design processes, apply the acquired knowledge to the design process and explain and justify the decisions made in the design process.

Field of competences B3: Intellectual competences

B3.1 *Think in a conceptual, analytical, system-oriented, problem-solving and synthesizing way at different levels of abstraction.*

B3.2 Accept the complexity and uncertainty of architectural and urban design and make solid and qualitative design decisions given the contradictory nature of specifications and boundary conditions.

Field of competences B4: Competences in cooperation and communication

B4.1 *Master scientific and discipline-specific technical terminology (also in English).*

B4.2 *Carry out concrete assignments systematically.*

B4.3 *Work as part of a team.*

B4.4 *Report results verbally, in writing, and graphically.*

Field of competences B5: Societal competences

B5.1 Pay attention to social aspects of own design proposals.

B5.2 Be aware of the life cycle and environmental impact of the built environment.

B5.3 Be aware of aspects of safety and accessibility of the built environment.

Structure of the programme

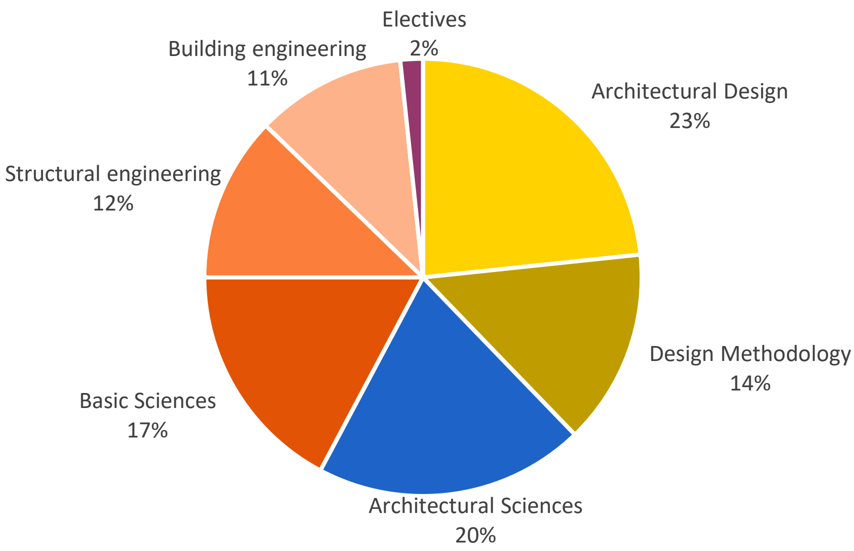
The BSc in Engineering: Architecture is clearly distinct from other Bachelors in Engineering. The introduction to basic sciences is somewhat condensed to make room for a curriculum that addresses the cultural, social and historical aspects of architecture. The programme is conceived as a broad education in all facets of architecture, with architectural design at its centre. This broad scope is retained throughout the six bachelor terms.

The broad introduction in the bachelor allows students to develop their own profile in the master (see the respective programme description). The broad scope also reflects the vision that inspired the current five-year programme many years ago: a university degree in architecture should develop an academic outlook on all aspects of architecture, ranging from the technical over design to the cultural. It should prepare students to enter the professional field of architecture and design, but not confine its mission to training architects. This choice is becoming all the more relevant as we witness a broadening of the roles that architects and architectural engineers play in today's society and the growing differentiation in practices in the field, that are currently at the heart of the debate on the profession.

The programme offers a rich teaching environment. Several courses are taught in traditional formats (lecture courses and exercises), yet those courses pertaining to architectural design and related disciplines incorporate other teaching formats aiming to encourage exchange amongst students and between students and teachers (see also below). In the context of COVID-19, important efforts have been made to develop online teaching modules. While the overall tendency is to go back to on campus teaching for most courses from the academic year 2021-2022 onwards, in some cases the online model has proven to offer opportunities for a more efficient way of teaching. The first Bachelor course of Digital Design 1 is a case in point where the production of online tutorials now allows for a mixed on/off campus teaching approach. Online teaching has also allowed to expand the Internationalisation@Home dimension of the programme, by bringing in lecturers from abroad into the classroom.

Students are introduced to the field of architecture at large through guest lectures and field trips, typically associated with the design studios. A key element of this environment is the '*Jokerweek*', a yearly one-week workshop where all classes are suspended and all students and staff members engage with one particular theme/assignment, supported by a roster of special guests and events. Students play a crucial role in the success of this week. The 2021 edition of the *Jokerweek* also was a first experiment with student-led education, in which students took responsibility for (co-)creating and (co-)defining the theme addressed. Such form of student-led education will be further developed in the future.

Courses are mainly taught by staff members of the Department of Architecture and Urban Planning. Some basic engineering courses are shared with the programme in Civil Engineering, and some courses in Architectural History and Theory are offered to students in the Humanities as well. The overlap between the Department of Architecture and Urban Planning and the teaching programme guarantees that the programme reflects the broad outlook on architecture of the department, supported by the shared vision of a cohesive group of lecturers and researchers, and informed by the research developed at the department, also at the bachelor level.



Programme structure Bachelor of Science in Engineering: Architecture

The bachelor's programme consists of 180 credits:

- 17% basic sciences (mathematics, physics, statistics, philosophy)
- 12% structural engineering (statics, structures, structural design, materials)
- 11% building engineering (building physics, building envelope, comfort systems)
- 14% design methodology (digital design, design theory, presentation, media, urban analysis)
- 23% architectural design
- 20% architectural sciences (architectural history and theory, history of urban planning)
- 2% electives course (one course)

Globally, the programme consists of 17% basic sciences, 23% engineering and technical courses related to architectural design that are partially shared with the Civil Engineering programme, 38% architectural design and related methodological courses and 20% of architectural sciences. The elective course allows students either to slightly orient their programme towards the technical sciences or the humanities, or to incorporate topics such as project management and business administration.

The programme is built around the sequence of the three design studios, Architectural Design 1, 2 and 3, the central pillar of the programme. These courses can only be taken in sequence, as the curriculum for the studios is conceived as a three-year cycle. In the studios, students explore architectural design in a close and individualized dialogue with staff members. The architecture programme is the only programme at Ghent University assigning such a central role to this particular type of learning environment.

In the first three terms, students are introduced to basic topics in sciences and humanities. This introduction serves to nourish the two other pillars around which the curriculum is built, architectural sciences on the one hand, and building engineering sciences on the other hand. The central pillar of architectural design is further supported by courses that develop specific design competences. The chart below shows that these three pillars are present throughout the six terms of the bachelor's programme (allowing for some shifts in emphasis, mainly caused by the concentration of the basic sciences in the first three terms; please note that the size of the fields in the chart is not proportional to study load of the courses).

While retaining a broad and critical outlook on architecture throughout the bachelor's programme, the programme progressively tackles increasingly complex problems. Architectural Design starts in the first year with exploring a broad range of topics across a variety of scales, from the small to the urban, via a series of shorter projects, to embrace the complexity of hybrid programmes and the larger environment of buildings in the second year, to focus in depth on the building and its technical details in the third year. The aim of the sequence is to approach architectural design as an integral process concerning all aspects of building and the built environment. This progression is reflected in the theory courses: the city and urban development are introduced in the 2nd Bachelor year, and thorough courses on particular technical aspects of the building occur in terms five and six. Similarly, courses on methods of design and representation evolve from courses aimed at specific drawing skills and techniques, to design studios on their own right, which further nourish the work in the architectural design studio. The aim is to confront the students over the six terms of the bachelor's programme with a full range of architectural problems and questions and provide them with the necessary basic skills to tackle them.

Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Actual Aspects of Architecture	History of Architecture 1	Architectural Theory 1	History of Architecture 2		Architectural Theory 2
Calculus	Geometry		History of Urban Planning	Building Physics	
Physics 1	Introduction to Philosophy and the History of Thinking	Mathematical Analysis		Statistics and Data Handling	Art and Architecture
Design Theory 1	Design Theory 1	Physics 2		Introduction to Urban Analysis and Design	Methods of Urban Analysis and Design
Perception and Presentation Media 1	Perception and Presentation Media 1	Design Theory 2	Materials science	Perception and Presentation Media 2	Concrete Technology
Statics of structure	Digital design 1	Digital design 2	Structural Load-Bearing Systems in Architectural design		Residential Comfort Systems
Introduction to structural design	Introduction to structural design	Introduction to the strength of materials	Construction of Buildings	Constructional aspects of the building envelope	Constructional aspects of the building envelope
Architectural Design 1	Architectural Design 1	Architectural Design 2	Architectural Design 2	Architectural Design 3	Architectural Design 3

Compulsory courses in the Bachelor of Science in Engineering: Architecture

Evolution of the programme

Over the last couple of years, and since the last visit by CTI in 2016, the overall structure of the programme has remained largely the same, and has only undergone some minor changes. This continuity is in compliance with the positive comments received on the programme in the previous CTI reports. We have, however, been permanently monitoring and fine-tuning the program, in close dialogue with students, in order to respond to comments on the heavy study load. Measures were taken to address this, by downsizing practical assignments and enhancing the communication on the total package of work.

At the end of the academic year, a meeting is organized with the staff responsible for the design studios and design related courses at Bachelor level to discuss assignments for the next year. The outcome of this conversation is the so-called *Bachelorkrant*, a document that provides for each of the three Bachelor years an overview of, on the one hand, all design studio related assignments and the practical work for design related courses. It contains detailed descriptions for each assignment and a calendar with deadlines. Compiling of this document provides the staff of the Bachelor programme with a good overview of the work required in other courses, so that a finetuning of assignments, calendar and workload can be done before the academic year starts. Students receive this *Bachelorkrant* at the beginning of the academic year. It not only gives them a clear insight of where they are positioned within the overall Bachelorprogramme (all students receive indeed information on all 3 Bachelor years), but it also serves as an excellent tool to plan their work.
From the academic year 2021-2022 onwards, the design studios at Bachelor level will be led by a staff member coming from practice and a staff member involved in theory courses. This will allow to build more profound connections between practice and theory, and create relevant interactions within the programme. As such the integration of the different fields of knowledge and expertise in the architectural design studio will be enhanced. Finally, in the academic year 2021-2022, some more finetuning will be done to the curriculum as a result of the recruitment of new staff members in the field of theory and history of architecture and in architectural design, who will replace the significant number of professors taking leave from September 2021 onwards. A deliberate choice was made to hire someone with expertise in Early Modern architectural history, to maintain expertise in a field that has always been one of the spearheads of the department and was crucial in building the Bachelor programme. This was complemented with the recruitment of a staff member in the field of material-cultural history of architectural practice, in order to create stronger connections between the field of architectural history and theory and that of construction techniques. This will also help in safeguarding the equilibrium between the various pillars of the programme (and, as such, is also a response to a previous remark of CTI that “la tendance

chez les étudiants de UGent est d'être advantage architects-ingénieurs qu'ingénieurs-architectes"). We believe that with the newly recruited staff, we will also be better equipped to position the Bachelor programme in a more explicit manner vis-à-vis current shifts in architectural practice, which occur also as a result of societal challenges with which the profession is confronted. In the academic year 2020-2021 we explicitly engaged with such evolution of the profession by devoting the *Jokerweek* to the theme of 'Shifting Positions', a topic that was greatly appreciated by the students. From the academic year 2021-2022 onwards, we plan to already draw attention on this diversity of practices from the very first Bachelor year onwards, by reorienting the course of Current Aspects of Architecture accordingly.

In terms of internationalisation, an effort has been made to bring Bachelor students into contact with researchers from abroad, via guest lectures in particular courses, and by organizing an Excursions@Home lectures series, open to all students and staff, and which consisted of informal talks by invited (foreign) guests who took us on a virtual trip to a site/building they wished to share with us. While this series was started up as an alternative to the study trips made in the context of Bachelor trips, we will continue this formula in post-COVID-19 times in order to broaden the horizon of all students. From the academic year 2021-2022 onwards, we are re-introducing in each Bachelor year the offer of a non-compulsory trip abroad linked to the specific design studio. While most opportunities to include an international mobility in one's curriculum only become available for students at master level, we actively promote taking up an international internship already at the end of the Bachelor trajectory through among others participation in IAESTE or BEST internships and workshops programmes.

Advanced or subsequent studies

Students of the BSc in Engineering: Architecture intend to obtain a five-year degree in the same domain, and typically proceed to the Master of Science in Engineering: Architecture.

A SWOT-analysis of both Bachelor and Master of Science in Engineering: Architecture is included in Section 2.1.

1.2 Bachelor of Science in Engineering – Main Subject Biomedical Engineering

Following up on a recommendation of the CTI visitation report in 2016, the BSc in Engineering: Biomedical Engineering programme (BSc BME) was formally introduced in 2019-2020 in concordance with a curriculum redesign of the master programme. Specific considerations included:

- the basis of life sciences and broadening engineering subjects such as biomaterials, bio-electronics and biomechanics, should be included in the BSc BME;
- projects in the 2nd and 3rd bachelor get a biomedical engineering focus;
- data analysis techniques and modern statistical methods should be included in the curriculum of the biomedical engineer, preferably via practically oriented courses with hands-on use of python.
- where possible, make maximal use of existing courses from the existing bachelor programs in engineering science;
- it is logistically impossible to organize a joint UGent-VUB BSc BME. The bachelor programme is organized separately (in parallel) at UGent and VUB, yet ensuring that students acquire similar competences and skills so that they can enrol in the joint UGent-VUB MSc in Biomedical Engineering.

Programme objectives

The goal of the Bachelor of Science in Engineering is to offer the students (i) a broad education in the basic sciences such as mathematics, physics and chemistry, (ii) a polyvalent technical-scientific education in the basic engineering disciplines, such as informatics, probability, statistics, systems, signals, materials and (iii) a profound domain-specific education in the basic disciplines of the main subject, complemented by (iv) a general social education. On top of that, the students acquire the basic competences for scientific research, for teamwork, for effective communication, and for reasoning at different levels, including about their own functioning. They act in an ethical way, are positively critical towards others, and are open for feedback

Specific for the BSC in BME, it is our objective to train graduates

- with a broad and multidisciplinary scientific education in mathematics, physics, chemistry, biomedical and life sciences;
- with a versatile technical-scientific knowledge and skills in basic engineering disciplines such as (flow) mechanics, material technology, electrical engineering, system and signal analysis, data processing, probability theory and statistics;
- who apply the taught engineering skills within the multidisciplinary domain of the biomedical engineering sciences (biomechanics, biomaterials, bioelectronics);
- with a broad social and human-oriented perspective.

Graduates are expected to

- have acquired basic competences of multidisciplinary scientific research;
- be able to work together in a group;
- being able to communicate in an efficient manner;
- be able to reason at different levels, including about their own functioning;
- have a constructively critical mindset, open to feedback.

Programme specific competences

Competences include generic competences applicable to all engineering disciplines as well as competences specific for biomedical engineering (*in italic*).

As explained in Section 3.2 (SER, Part A), the bachelor's programme objectives are formalised as a list of competences and associated learning outcomes. Most competences are common to all BSc in Engineering programmes; on top of those, the BSc in BME programme has defined a set of programme specific competences to encompass knowledge and understanding of medical physics and basic life sciences and biomedical engineering and to create awareness of ethical and safety aspects specific for the biomedical practice:

Field of competences B1: Competences in one/more scientific discipline(s)

- Knowledge and understanding of the basic concepts and principles from anatomy, (cell) biology, molecular biology, chemistry, physiology, biomechanics, medical and health sciences.

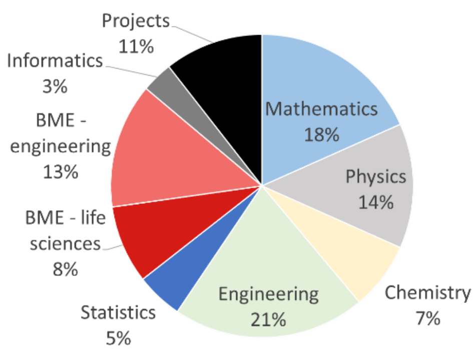
- Knowledge and understanding of the physical principles (electromagnetism, ionizing and non-ionizing radiation) that form the basis of medical imaging and therapy.
- Knowledge and understanding of the standard methods for quantitative measuring structure and function of biological systems at molecular, organ and system level.
- Knowledge and understanding of the composition and physicochemical properties of materials, in particular polymers for biomedical applications.
- Have insight into the basic principles of structural and fluid mechanics and transport physics and apply this to biomechanical and physiological processes and problems.
- Analyse, design (based on well-defined technical specifications) and develop simple electrical circuits for measuring physiological signals.
- Apply mathematical models and numerical techniques for solving biomedical engineering problems.

Field of competences B5: Societal competences

- Be aware of the ethical and safety aspects of the biomedical practice.

Structure of the programme

The structure of the BSc in BME programme (3 years, 180 credits) is schematized below (pie chart and table with curriculum structure).



Pie-chart schematizing the structure of the BSc in Biomedical Engineering

Bachelor 1		Bachelor 2		Bachelor 3	
semester 1	**semester 2**	**semester 3**	**semester 4**	**semester 5**	**semester 6**
Basic Mathematics	Mathematical Analysis 2	Mathematical Analysis III: Applications of Analysis and Vector Analysis	Introduction to Numerical Mathematics	Analysis of Systems and Signals	Modelling and Control of Dynamic Systems
Mathematical Analysis 1	Geometry and Linear Algebra	Electrical Circuits and Networks	Statistical Data Processing	Mechanics of Materials	Medical Physics [E]
Discrete Mathematics 1	Chemical Thermodynamics	Physics 2	Organic Chemistry	Electromagnetism I	Electronic Systems and Instrumentation for Biomedical Engineers
Physics 1	Probability and Statistics	Transport Phenomena	Statistical Physics and Molecular Structure	Quantitative Cell and Tissue Analysis [E]	Biomedical Polymers and Processing
Chemistry: the Structure of Matter	Materials Technology	From Genome to Organism [E]	Sustainable Business Operations	Biomechanics [E]	Medical Signal Processing and Statistics [E]
Informatics	Informatics	Engineering Project	Modelling of Physiological Systems [E]		Cross-course Project
Modelling, Making, Measuring	Sustainability, Entrepreneurship and Ethics		Engineering Project		

Programme structure of the BSc in Biomedical Engineering

The courses, specific for the BSc in BME, start from the 3rd semester. Basic knowledge of biology, anatomy and physiology is covered in *From Genome to Organism*, *Modeling of Physiological Systems* and *Quantitative analysis of cells and tissues*. Specific deepening in organic chemistry is provided in the 4th semester; in-depth knowledge of physics is acquired in the 3rd year in *Electromagnetism*, a domain that forms the basis of many applications and techniques in medical technology, and *Medical Physics*. The course *Statistical Physics and Molecular Structure* in the 4th semester links physics and chemistry, as it were, and deepens the understanding of the fundamentals of matter. In the 3rd bachelor, broad engineering skills are systematically applied within the biomedical engineering discipline, with the courses *Biomechanics*, *Biomedical polymers and Processing*, *Electronic Systems and Instrumentation for Biomedical Engineers* and *Medical Signal Processing and Statistics*.

The subsequent master's program has a distinct international dimension, which we also want to make concrete within the bachelor's program. Some of the BME-specific courses (indicated by [E] in the table above), for a total of 30 credits, are taught in English.

Evolution of the programme

The bachelor programme took an onset in 2019-2020. To also allow students already enrolled in the 2nd bachelor of one of the traditional bachelor programmes (but with the intention to switch to the MSc in BME) to still switch to the BSc in BME, we immediately implemented the 2nd and 3rd year and worked out transition tracks for these students. That was possible because of the very large overlap that exists between all bachelor programs in engineering up to the 3rd semester.

We have run the programme for 2 years. In 2019-2020, a total of 60 students was registered in the BSc in BME with 36 students starting in the 2nd bachelor and 24 students via a transition track in the 3rd bachelor. In 2020-2021, we had a total of 102 students registered in the BSc in BME programme, with 51 students newly registered in the 2nd bachelor. The programme has taken a relatively fluent start and the number of students starting in the BSc in BME has doubled in 2 years.

There are no immediate plans for further finetuning the programme in the next few years. Obviously, we will permanently monitor the programme and update if necessary.

Advanced or subsequent studies

The BSc in BME prepares the students for the follow-up MSc in BME (UGent-VUB interuniversity programme), but the generic and broad nature of the BME programme should allow students to start an MSc in BME in most European universities. Students may still switch to other engineering master programmes, for which they may or may not have to take up a preparatory programme.

A SWOC-analysis of both the Bachelor of Science in Engineering – main subject Biomedical Engineering and the Master of Science in Biomedical Engineering is included in Section 2.2.

1.3 Bachelor of Science in Engineering – Main Subject Chemical Engineering and Materials Science

Programme objectives

The domain-specific objectives of the programme are

i) To develop and enhance students' general knowledge of chemistry and materials science.

ii) To acquire the due insights and skills pertaining to the analysis, the modelling and dimensioning of chemical processes.

iii) To acquire the due insights and skills pertaining to the analysis and modelling of the structure-property relationships of materials.

And are translated into the following more specific attainment targets:

i) To have an advanced knowledge and understanding of chemical processes and materials in a general sense, ranging from the fundamental principles up to the application, including chemical manufacturing and materials production processes.

ii) To have the due insights and skills pertaining to the system-based modelling and the dimensioning of feedback systems.

iii) To have an advanced knowledge and understanding of the structures and behaviours of thermal and mass transfer systems.

iv) To have the due insights and skills pertaining to the use of mathematical modelling techniques for chemical processes and the properties of materials.

Foremost, the diploma Bachelor of Science in Engineering – main subject: Chemical Engineering and Materials Science qualifies for further master studies in Belgium and abroad. In addition, its utilitarian aspect enables its holder to apply for jobs in, for example, the chemical, metal producing and processing industry and in the polymer and textile industry.

Programme specific competences

As explained in Section 3.2 (SER, Part A), many competences are shared with the other Bachelor of Science in Engineering programmes and are not repeated here. Below are the programme specific competences in 5 relevant fields. A particular mention goes to complementary programme specific competences 1.3-1.5 and 5.3-5.4, illustrating that the Chemical Engineering and Material Science bachelor's programme covers a broad range of key issues, including sustainability and following a multidisciplinary approach. Additionally, the competences 1.6-1.9, 2.5-2.7, 3.6-3.7 and 4.5 account for features and corresponding competences more frequently encountered in chemical engineering and material sciences compared to other engineering sciences.

Competence field 1: Competences in one/more scientific discipline(s)

3. Apply acquired knowledge of chemistry and materials in a creative way.
4. Make use of mathematical modelling techniques for chemical/technological and material-related applications in a creative way.
5. Have an understanding of transport phenomena and be aware of their importance in chemical technology and materials science.
6. Be familiar with modelling of systems with feedback.
7. Including working methods and the complexity of process techniques characteristic for chemical technology and materials science in own decision making.
8. Be aware of the continuous evolution of materials (catalytic agents, polymers, fibres, metal alloys, composite materials, ceramics,…).
9. Be aware of the necessity of multidisciplinary in the process of establishing and applying requirements that meet quality- and environmental aspects and standard procedures in chemical and material-related industries.

Competence field 2: Scientific competences

5. Apply essential concepts of chemical technology and materials science to case studies.
6. Apply essential concepts of chemical technology and materials science to the design of experiments and projects.
7. To be able to build on past research and design competences while understanding the limits of knowledge and methods.

Competence field 3: Intellectual competences

6. Be able to analyse problems in the area of chemical technology and materials science.
7. Be able to critically analyse the own approach for problem solving.

Competence field 4: Competences in cooperation and communication

5. To be able to apply an integrated project approach as part of a team.

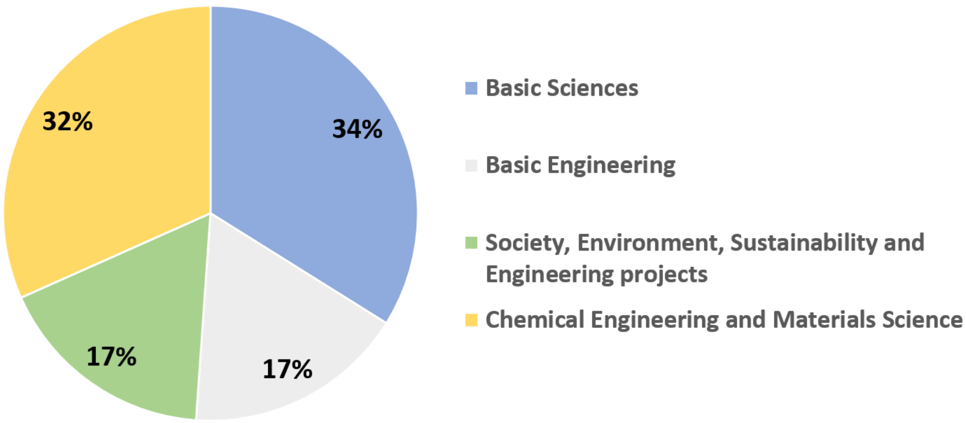
Competence field 5: Societal competences

3. Be aware of safety and environmental issues in chemical engineering and materials science.
4. Be aware of public and economic importance of the chemical and materials industry.

Structure of the programme

The study programme (180 credits) comprises ca. three terms of general science and engineering education, followed by another three terms of engineering education in the programme specific fields of chemical engineering and material science. Sustainability is a common denominator in both specific fields around which the programme has been constructed. Further, more chemical engineering oriented courses focus on reactors, kinetics and thermodynamics, while the material science oriented ones focus on material production, use, recycling, structure and properties. The latter are typically applied to metals and polymers (and derivatives such as fibres) in line with the subsequent master programme. Most courses are taught by staff members of the Faculty of Engineering and Architecture, which guarantees a clear engineering focus. Additionally, a selection of courses situated in the transition between basic sciences and basic engineering on the one hand and the programme specific courses on the other hand are taught by colleagues belonging to the Faculty of Sciences, given their relevant expertise while simultaneously guaranteeing some cross-fertilization. Practical sessions are organized to directly illustrate the concepts of the lectures to the students. Questions and answer and feedback sessions are organized at regular times to facilitate further improvement of the course content and to optimally prepare the students for their examination.

The courses can be classified into four main categories, as shown in the pie chart below. A detailed breakdown of the programme, color-coded identical to the pie-chart, over the four terms is provided in the table below. Students take five or six courses per term, which means that *ca.* one full day per week can be spent per course. This provides lecturers with sufficient time to thoroughly discuss the topics of the course and the students get ample time to gain a profound understanding of the different course topics.



Pie chart illustrating the six main categories of courses in the programme and their relative share.

As explained in Section 3.2 (SER, Part A), all bachelor programmes have been constructed around a project line with one engineering project per year. This project line is also integrated in the sustainability line to provide a hands on approach regarding sustainable engineering. In term 1, the Study Programme Committee Chemical Engineering and Materials Science contribute to 'Modelling, Making and Measuring' with topics related to chemical engineering and material science. The project line continues in term 4 with the 'Engineering Project', in which the students integrate the knowledge and skills acquired in for instance the courses Materials Technology, Probability and Statistics, and Organic Chemistry. At the end of the bachelor's programme, the students integrate the knowledge and skills of the complete bachelor's programme in a more substantial project carried out in groups of four to five students in 'Cross-Course Project'. The students can indicate their preference in topics with respect to more chemical engineering or more material science oriented topics. A high diversity in topics is ensured and allows the student to optimally determine his or her preference with respect to a possible consecutive MSc in Chemical Engineering or MSc in Sustainable Materials Engineering.

Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Informatics (year-course)	Geometry and Linear Algebra	Mathematical Analysis III	Introduction to Numerical Mathematics	Analysis of Systems and Signals	Modelling and Control of Dynamic Systems
Mathematical Analysis I	Chemical Thermodynamics	Physics II	Organic Chemistry	Process Engineering	Microstructure of Materials
Basis Mathematics	Mathematical Analysis II	Transport Phenomena	Chemical Thermodynamics II	Heat Engineering and Mass Transport	Advanced Fibres and Derived Materials
Chemistry: the Structure of Matter	Probability and Statistics	Mechanics of Materials	Statistical Physics and Molecular Structure	Introduction to Reactor Science and Kinetics	Environmental Technology and Climate Challenges
Discrete Mathematics I	Materials Technology	Sustainable Business Operations	Analytical Techniques	Polymers	**Cross-Course Project**
Physics I	**Sustainability, Entrepeneurship and Ethics**	Sustainable Use of Materials: Metals	Sustainable Use of Materials: Plastics and Derived Materials		
Modelling, Making and Measuring			**Engineering Project**		

The courses are colour-coded according to the four categories. Engineering projects are highlighted in bold.

Evolution of the programme/follow-up of CTI-recommendations

Since the last CTI visit, there have been two substantial evolutions in the bachelor programme: one pertaining to the general engineering courses shared between the different main subjects, see Section 6.3 (SER, part A) and one pertaining to the programme-specific courses in chemical engineering and materials science. As both programme revisions had to occur in a synchronised manner, the change in programme-specific courses will only take effect in academic year 2021-2022. Indeed, the change of the general engineering programme was delayed till 2020-2021. As the general programme revision is applicable to all main subjects, this section will focus on the programme specific evolutions.

First of all, it is important to mention that since the last CTI visitation, the programme committees of ‘Chemical Engineering’ and ‘Sustainable Materials Engineering’ have joined forces to provide a more effective workflow and ensure a more profound synergy between both programmes. In addition, a core work group, comprising both professorial staff, young researchers (PhD) covering both chemical engineering and materials science – typically alumni from the programme, and administrative support, has been installed. Thanks to this new structure, challenges relating to student information campaigns (to attract more students), evaluation of student and lecturer feedback, optimization of (external) student admission and support for both master programmes are tackled in a more efficient manner, which in turn results in a positive evolution of the programme. The merger of the program committees coincided with the merger at the departmental level of all research groups relating to chemical engineering and materials science within the faculty into the Department of Materials, Textiles and Chemical Engineering (MaTCh). This merger has increased the visibility of all research groups within the department, both nationally as well as internationally.

Secondly, as was also remarked by the previous CTI visitation as a working point, the learning line considering sustainability for chemical and material engineers has been expanded considerably. Three new courses have been introduced resulting in a total of 12 credits dedicated to programme-specific sustainable engineering courses. In addition, for the project education line, sustainability has become more integrated as well (a good example is the project course ‘Sustainability, Entrepreneurship and Ethics’). Furthermore, different concepts of sustainability are more pronounced in other courses as lecturers are encouraged to include learning outcomes pertaining to sustainability in their course (where possible).

Thirdly, the revision of the bachelor programme also enabled the rationalisation of several courses that treated similar topics. This resulted in a more efficient programme and gave the possibility to introduce additional credits for new courses related to sustainability while retaining all the required learning outcomes for transition to the master programmes.

Considering the previous SWOC analysis, several of the foreseen strategies were successful. Thanks to the more efficient programme committee structure, the evaluation of the programme considering all the stakeholders (students, lecturers in both bachelor and master programmes, industry) is more effective. The programme content has been updated to include more sustainable engineering related topics and the courses have been rationalized to have better synergy in line with the two master programmes.

Advanced or subsequent studies

The holders of a Bachelor of Science in Engineering – main subject: Chemical Engineering and Materials Science degree have several options to continue their education. The most frequently chosen programmes are (i) Master of Science in Chemical Engineering, and (ii) Master of Science in Sustainable Material Engineering. Some students select a master's programme recruiting from a wider panel of bachelor's programmes, e.g. Master of Science in Industrial Engineering and Operations Research or Master of Science in Biomedical Engineering, although the latter is now having a specialization at the bachelor level.

The programme's context

The chemical and material sector is one of the most important industries in Belgium. The programme prepares students such that they are immediately employable in the chemistry (Shell, TotalEnergies, BASF, …), metal (e.g. Umicore, ArcelorMittal, …) , plastics (e.g. Solvay, Amcor, …) and textile (e.g. Sioen, Beaulieu, …) sector, This gives students a broad job market consisting out of large international enterprises as well as SME's. The strong link with industry is, among other things, practically established via frequent company visits, courses taught by (senior) experts from world-leading companies, master theses in collaboration with industry, and actively encouraging and helping students to take up an internship during the summer months in a relevant company.

The student eco-system is ensured by a strong representation of the student organization MaChT. They not only connect students (bachelor to master) with each other, but also with professors, scientific collaborators (master thesis coaches) and industry. Many extracurricular activities are organised, such as company visits, trips, and parties. The annual job fair attracts many companies and the majority of the students finds an internship or permanent position at one of the attending companies.

International mobility is encouraged and typically performed under the form of an international internship or an Erasmus exchange. As the bachelor programme is taught in Dutch, the focus on internationalization is set in the master programme, either in the first or second year. For any of the master programmes a wide variety of universities, institutes and/or schools is available throughout Europe and even beyond. Part of these are based on established scientific connections, however, specific education oriented collaborations have also been established, e.g., with CPE in Villeurbanne/Lyon.

Alumni activities are organized at various levels, i.e., that of Ghent University, that of the Faculty of Engineering and Architecture (AIG), that of the programme committee in collaboration with the student organization as well as that of the Flemish engineering association ie-net and more specific the working group (bio)chemical technology. Particularly the latter started the organization of a bi-yearly lecture series eFFECT within which a good selection of UGent alumni is represented, now working in a wide variety of companies (Umicore, Worley, EuroChem, etc.)

SWOC-analysis

Strengths

- An excellent relation between theory and practice via a well-elaborated project line.
- Teaching methods dedicated to the content of the courses, ranging from classical lectures to exercise sessions and individual projects to group projects with a strong design component.
- Strong focus on sustainability and its relation to societal issues with regards to chemical engineering and materials science, in line with the increasing demand from students for this content in their evaluations.
- Broad programme that covers content ranging from raw materials, chemical processes to convert these materials, and applications based on these materials, allowing students to become familiar with the overall

process chain in the chemical and material sector and deepen their knowledge further in the master programme depending on their interest.

Weaknesses

- General perception by the wide public and, more particularly among potential students, of the programme and related industry as being non-sustainable, i.e., responsible for climate change. This could reduce the student influx.
- Distribution between general and programme specific courses leads to complexity of the programme.

Opportunities

- The numerous relations of the lecturers with industry and interest groups allow to bring the students in contact with society's most relevant topics, e.g., through internships, company visits and guest seminars.
- Chemical engineering and materials science are crucial for a sustainable society, making it easier to gain traction about the importance of the programme in the broader public, taking care that no wrong perception develops.

Challenges

- The variation in and (in specific years) total number of student numbers in the bachelor programme whom choose chemical engineering and materials science as their main subject.
- Guaranteeing the continuity of the practically oriented courses taught by lecturers with main activities in the industry.

Strategies for improvement

- Informing the students in time and comprehensively about (i) the choice of a specific master's programme while in the final year of the bachelor's programme (ii) possible foreign experiences (iii) the master's dissertation possibilities and internships.
- Evaluate and reform the master's programmes in line with the changes of the bachelor programme on sustainability and integration of chemical engineering and materials science.
- Enthusing students in the first year of the bachelor's programme about chemical engineering and materials science to increase the number of students. This will be done by informing the students, e.g. by turning a potentially negative perception into a positive one thanks to the essential role played by chemical engineering and materials science in a sustainable society.

1.4 Bachelor of Science in Engineering – Main Subject Civil Engineering

Programme objectives

The goal of the Bachelor of Science in Engineering is to offer the students (i) a broad education in the basic sciences such as mathematics, physics and chemistry, (ii) a polyvalent technical-scientific education in the basic engineering disciplines, such as informatics, probability, statistics, systems, signals, materials and (iii) a profound domain-specific education in the basic disciplines of the main subject, complemented by (iv) a general social education. On top of that, the students acquire the basic competences for scientific research, for teamwork, for effective communication, and for reasoning at different levels, including about their own functioning. They act in an ethical way, are positively critical towards others, and are open for feedback

The goal of the domain-specific education in Civil Engineering is to offer the students (i) a broad education resulting in a basic knowledge and understanding of the properties of the materials used in civil engineering constructions, (ii) a practical education so they have due command of the analysis and computation techniques of civil engineering constructions in the wider sense of the term, (iii) an advanced education giving knowledge and understanding of the behaviour of hydraulic systems pertinent to civil engineering and (iv) a profound domain-specific education resulting in due insight and skills pertaining to the use of computers in the design process of civil engineering constructions. On top of that, the students acquire insights and skills pertaining to the analysis and the dimensioning of various civil engineering constructions and a due knowledge of the materials used for these purposes.

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the bachelor's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GB1-GB5). All competences are shared with the other main subjects within the Bachelor of Science in Engineering programme. The exceptions are the domain-specific competences B1.3-B1.8, showing that the main subject Civil Engineering aims to be a very broad education, covering all civil engineering fields (materials, calculation methods, practical applications, etc.). The bachelor also includes specific scientific competences B2.5-B2.6 focusing the students on integrated design and practical application of the programme specific disciplines. In addition, competence B5.3 aims for awareness of environmental and mobility aspects of civil engineering, while competence B6.1 improves the acquaintance with the civil engineering field.

Field of competences B1: Competences in one/more scientific discipline(s)

B1.3 Be familiar with important terms, basic principles, theories, models, boundaries, methods, processes and applications of civil engineering and have the ability to apply this knowledge in a creative way.

B1.4 Be familiar with standard calculation methods and apply them in standard architectural and civil engineering construction problems. Be able to critically analyse these methods.

B1.5 Be able to interpret basic features and basic characteristics of (building-) materials and their use in simple civil engineering constructions.

B1.6 Be able to identify and understand transport phenomena in liquids, especially the flow of water, and to apply them to standard design problems.

B1.7 Be able to apply basic knowledge of soil characteristics to basic foundation problems.

B1.8 Be familiar with constructional and physical aspects of buildings and basic principles of the construction of roads and bridges.

Field of competences B2: Scientific competences

B2.5 Employ basic civil engineering knowledge in an integrated way to case studies in the field of the construction of buildings.

B2.6 Use an integral approach to the design and examination of building activities of others thereby constructively handling limitations of knowledge and applied methods.

Field of competences B5: Societal competences

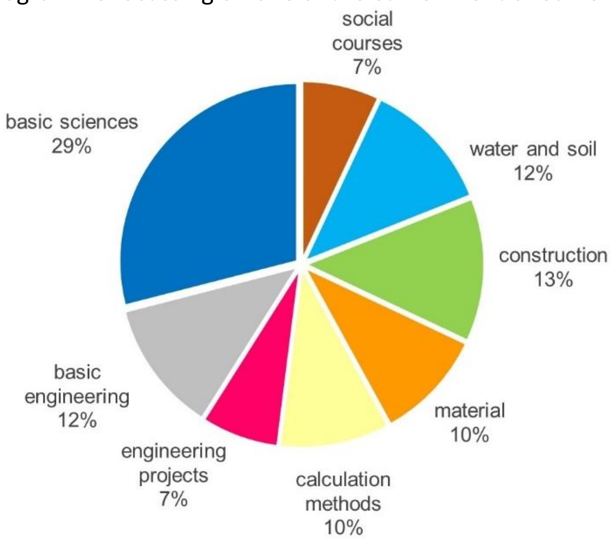
B5.3 Be familiar with aspects of environment and mobility in the field of civil engineering.

Field of competences B6: Profession-specific competences

B6.1 Be able to identify all kinds of professional situations and fields of activity of a civil engineer.

Structure of the programme

The study programme consists of more than one year of general science and engineering education, followed by about two years of civil engineering education. The latter one is composed of a combination of courses focussing on calculation methods, civil engineering specific materials, construction methods, soil mechanics and hydraulics, as well as some specific subjects. This makes the main subject Civil Engineering an all-round civil engineering programme, instead of a programme focussing on one of the earlier mentioned fields.



Programme structure Bachelor of Science in Engineering – main subject Civil Engineering

The bachelor's programme consists of 180 credits:

- 29% basic sciences (mathematics, chemistry, physics)
- 15% basic engineering courses (informatics, statistics, signals, mechanics, computer aided design)
- 10% calculation methods (structural analysis, metal structures)
- 10% materials (general, mechanics of materials, concrete)
- 13% construction specific courses (roads, bridges, buildings, building physics, topography)
- 12% water & soil oriented courses (transport phenomena, hydraulics, soil mechanics, geotechnical structures)
- 7% social education (sustainability, entrepreneurship and ethics, business administration, principles of law and construction law, elective course)
- 7% engineering projects, one engineering project per year

Roughly 50% of the programme consists of actual civil engineering courses. The remaining 50% consists of a broad engineering education: basic sciences, basic engineering and projects. This 50/50 division is the result of a careful weighing of the breadth and depth of the programme.

The table underneath shows how the different courses are scheduled in the six terms of the bachelor's programme. The average size of a course is 4.4 credits. Students take on average seven courses per term in each year. This gives lecturers enough time to thoroughly discuss the topics of the course, and the students get ample time to gain a deep understanding of the different course topics.
The Study Programme Committee (SPC) of Civil Engineering is convinced that Civil Engineering students should have a very broad education, in line with the opinion of its industrial advisory board. Instead of focusing on one specific field, students should acquire knowledge in all subfields of civil engineering. Typical real-world civil engineering problems are after all a combination of issues from related (sub)fields that need a multidisciplinary approach. Hence, the SPC decided to not only include general calculation and material oriented courses in the bachelor's programme, but also construction specific courses focusing on diverse fields such as roads, bridges, hydraulics and soil mechanics. The first three terms are shared with other main subjects in the Bachelor of Science in Engineering and focus on the common broad engineering education. Students choose for the main subject Civil Engineering when entering term 3.

All main subjects of the bachelor's programme contain a project line with one engineering project per year. The first project is shared by all main subjects and is associated to the Modelling, Making and Measuring course. The project line continues in term 4 with the Engineering Project, in which the civil engineering students integrate

the knowledge and skills acquired in Structural Analysis I, Construction of Buildings, Concrete Technology, Mechanics of Materials and Transport Phenomena. At the end of the bachelor's programme, the students integrate the knowledge and skills of the complete bachelor's programme in a more substantial Cross-Course Project, carried out in groups. During the Cross-Course project, the students familiarize with the design of the concept of a bearing structure, including its foundation, and with concepts such as load transfer, stability of buildings, engineering and architectural design, building materials and structural elements, project work.
The three projects are an important element in the soft skills education of the bachelor's programme.

Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Basic mathematics	Mathematical Analysis II	Mathematical Analysis III	Chemistry: Selected Topics	Concrete Structures: Reinforced Concrete	Metal Structures
Mathematical Analysis I	Geometry and Linear Algebra	Physics II	Concrete Technology	Structural Analysis II	Introduction to Bridge Engineering
Discrete Mathematics I	Chemical Thermodynamics	Mechanics of Materials	Statistical Data Processing	Building Physics	Topography
Physics I	Materials Technology	Analysis of Systems and Signals	Mechanical Engineering	Geometric Aspects of Roads	Structural Analysis of Geotechnical Structures
Chemistry: The Structure of Matter	Probability and Statistics	Transport Phenomena	Structural Analysis I	Soil Mechanics	Hydraulics
Informatics	Informatics	Sustainable Business Operations	Computer Aided Design	Principles of Law and Construction Law	Elective Course
Modelling, Making and Measuring	Sustainability, Entrepreneurship and Ethics		Construction of Buildings		Cross-Course Project
			Engineering Project		

Courses in the Bachelor of Science in Engineering – main subject Civil Engineering

Evolution of the programme

In 2020, the common part of the bachelor has been revised to account for the change in initial competences of students entering the programme; a stronger focus on ethical and sustainable issues as suggested by UGent and also by CTI; strengthening the project line. The new course on Sustainability, Entrepreneurship, and Ethics not only introduces these important concepts to the people that will shape our future society, but also introduces new engaging teaching methods. In addition, informatics is smeared out over the first year which allows a less steep learning curve and interaction between adopting programming skills and course content where they can be applied. This programme change strengthened the learning pathways sustainability, entrepreneurship and ethics.

To enable the programme changes, while maintaining the aim to train broadly educated civil engineers, the elective course in term 4 was eliminated, but the one in term 6 was retained. Next, the following changes have been implemented in the sequel of the project line. Sustainability and entrepreneurship have been emphasized more in the Engineering Project (term 4), where now each group of students is owner of a concrete manufacturing company and needs to design an environmentally friendly and price-competitive concrete mixture for a civil engineering project (e.g. a quay wall, an urban swimming pool,…). Moreover, a visit to a cement manufacturing company is now included, where students get in touch with the innovations of the industry in view of sustainability. In the Cross-Course Project (term 6), the civil engineering students need to deal with the structural and civil engineering aspects of a construction designed by students in the architecture programme, which requires an interaction between the students of both programmes. In addition, it concerns no longer bachelor's but master's students in architecture, with whom the architectural design needs to be discussed and possibly improved. Moreover, the importance of sustainability thinking and nearly zero energy buildings has been increased in the Cross-Course Project. Finally, a guest lecturer from industry now presents an overview of alternative building team formats and entrepreneurship.

Follow-up of CTI-recommendations

CTI has made recommendations in 2016 for the Bachelor of Science in Engineering as a whole, but not for the main subject Civil Engineering in particular. Besides the positive appreciation of the organization of the bachelor's programme(s), the cohesion of the staff and the changes in the programme(s), the following recommendations were made.

Firstly, CTI found the strategic vision not very clear and probably related to the bachelor being viewed as the first step for the master. As explained above in the Structure of the programme, the SPC of Civil Engineering aims at training broadly educated civil engineers, by means of learning pathways that indeed continue throughout the bachelor and master programmes. However, the programme is such that the students should already have a sufficiently wide knowledge at the end of the bachelor to enable the integration thereof in the Cross-Course project. The master programme then further deepens and widens their knowledge along the defined pathways. This vision did not change since 2016, despite the evolution in the programme.

Secondly, CTI found the ways of improvement not clear and recommended a mixed approach between a bottom-up and a top-down approach to be more efficient. As explained above, both the part common to all main subjects in the bachelor's programme and the specific part related to the main subject Civil Engineering have evolved since 2016. It is hard to distinguish, and probably not meaningful, which evolutions have been initiated more top-down and which ones more bottom-up, since the evolutions concern increased attention to important societal challenges, valued by all stakeholders.

Advanced or subsequent studies

The holders of a Bachelor of Science in Engineering – main subject Civil Engineering degree have several options to continue their education. The most frequently chosen programmes are:

- Master of Science in Civil Engineering
- Master of Science in Biomedical Engineering
- Master of Science in Industrial Engineering and Operations Research
- Master of Science in Physical Land Resources (Soil Science)

A large majority of students chooses the Master of Science in Civil Engineering (more than 95%).

The programme's context

The programme context of both the Bachelor of Science in Engineering – main subject Civil Engineering and the Master of Science in Civil Engineering is included in Section 2.5.

SWOC-analysis

A SWOC-analysis of both the Bachelor of Science in Engineering – main subject Civil Engineering and the Master of Science in Civil Engineering is included in Section 2.5.

1.5 Bachelor of Science in Engineering – Main Subject Computer Science Engineering

Programme objectives

The goal of the Bachelor of Science in Engineering is to offer the students (i) a broad education in the basic sciences such as mathematics, physics and chemistry, (ii) a polyvalent technical-scientific education in the basic engineering disciplines, such as informatics, probability, statistics, systems, signals, materials and (iii) a profound domain-specific education in the basic disciplines of the main subject, complemented by (iv) a general social education. On top of that, the students acquire the basic competences for scientific research, for teamwork, for effective communication, and for reasoning at different levels, including about their own functioning. They act in an ethical way, are positively critical towards others, and are open for feedback.
The objectives of the domain-specific education are listed below.

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the bachelor's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GB1-GB5).
All competences are shared with the other Bachelor of Science in Engineering programmes. The sole exceptions are the programme specific competences B1.3-B1.6, showing that the programme of Computer Science Engineering encompasses the complete compute stack (from physical layer to application) and focuses on designing such systems. These programme-specific competences have also been benchmarked against the ACM/IEEE Curriculum guidelines for Undergraduate Degree Programmes in Computer Science.

Field of competences B1: Competences in one/more scientific discipline(s)

B1.3 Know the common physical realisation forms of information processing systems.
B1.4 Have a command of several data models, programming models and programming languages.
B1.5 Have a sound grasp of the important current applications and application areas of informatics.
B1.6 Be familiar with models of system aspects and design methodologies of information processing systems.

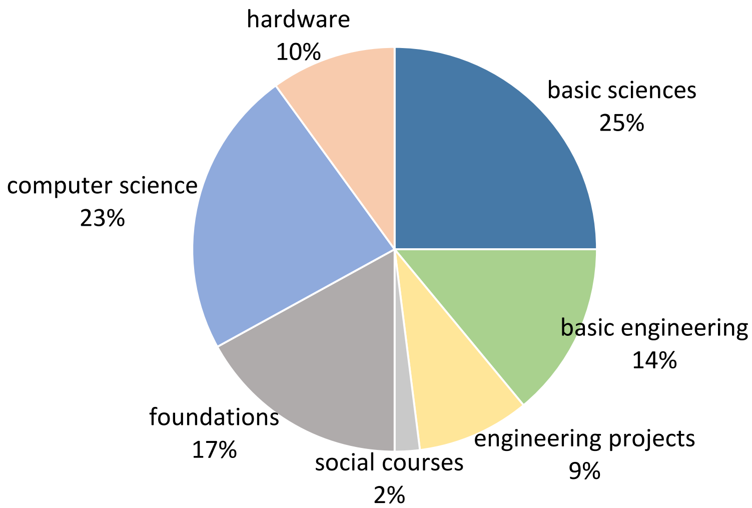
Structure of the programme

The study programme roughly consists of a first year of general science and engineering education, followed by two years of computer science engineering education. The latter one is a mix of electrical engineering and computer science, meaning that it covers the complete compute stack, ranging from the physical layer to the (internet-based) application layer. This makes computer science engineering broader than electrical engineering (mostly focused on the physical layer and hardware design), and computer science (focused on higher-level abstractions and software design).
Although several of the core computer science engineering courses are shared with the Bachelor of Science in Computer Science of the Faculty of Sciences, they are all taught by staff from the Faculty of Engineering and Architecture, which guarantees a clear engineering focus in all those courses.

The bachelor's programme consists of 180 credits:

- 25% basic sciences (mathematics, chemistry, physics)
- 14% basic engineering courses (materials, signals, statistics, mechanics, communication theory)
- 17% foundations of computer science (discrete math, algorithms, automata, formal modelling)
- 10% hardware courses (circuit, architecture, digital design)
- 2% social education (sustainable business operations)
- 9% engineering projects, one engineering project per year (and two in the first year)
- 23% core computer science topics.

Overall, 50% of the programme consists of computer science engineering courses (leftmost 50% of the pie chart). The rightmost 50% covers a broad engineering education: science, basic engineering and projects. This 50/50 division is the result of a careful weighing of the breadth and depth of the programme.



Programme structure Bachelor of Science in Computer Science Engineering

The next chart shows how the different courses are scheduled in the six terms of the bachelor's programme. The average size of a course is 5.5 credits. Students take six courses per term in the first two years, and five during the terms of the last year, which means that one full day per week can be spent per course. This gives lecturers enough time to thoroughly discuss the topics of the course, and the students get ample time to gain a deep understanding of the different course topics.

Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Informatics		Sustainable Business Operations	Computer Programming	Communication Networks	Software Engineering
Mathematical Analysis I	Mathematical Analysis II	Physics II	Algorithms and Data Structures	Operating Systems	Multimedia Techniques
Basic Mathematics	Geometry and Linear Algebra	Mathematical Analysis III	Applied Probability	Databases	Formal Systems Modelling for Software
Physics I	Chemical Thermodynamics	Mechanics of Materials	Discrete Mathematics II	Communication Theory	Automata Theory
Chemistry: the Structure of Matter	Probability and Statistics	Analysis of Systems and Signals	Engineering Project	Digital Electronics	Cross-Course Project
Discrete Mathematics I	Materials Technology	Electrical Circuits and Networks	Computer Architecture		
Modelling, Making and Measuring	Sustainability, Entrepreneurship and Ethics				

Courses in the Bachelor of Science in Computer Science Engineering

The Study Programme Committee (SPC) Computer Science Engineering strongly believes that there is more value in acquiring deep knowledge of the basics of (computer science) engineering, than in having superficial knowledge on many topics, some of which being ephemeral. Hence, the SPC decided to limit the bachelor's programme to the essential core topics, and cover these very well. One of the consequences is that there is very little overlap between courses, and that there are few course dependencies - most courses only require basic programming skills as initial competence, and the students acquire these very early on in their curriculum.
The first three terms are shared with other engineering bachelors and focus on the common broad engineering education. The common programme contains two teaser courses (Informatics and Discrete Mathematics I) for the computer science engineering. Students choose for computer science engineering when entering term 3.
As explained in Section 3.2 (SER, Part A), all bachelor's programmes contain a project line. In term 1, the SPC Computer Science Engineering organises and offers a number of Engineering Projects in computing for the

MMM-project (Modelling, Making and Measuring). In the second term the project line focuses on aspects of sustainability, entrepreneurship, and ethics, typically continuing the project started in the first term. The project line continues in term 4 with Engineering Project, in which the students integrate the knowledge and skills acquired in Computer Architecture, Computer Programming (C, C++) and Algorithms and Data Structures, and program a physical device (micro controller, robot, …). At the end of the bachelor's programme, the students integrate the knowledge and skills of the complete bachelor's programme in a more substantial project carried out in groups of four. In some cases, the team also includes students of other engineering bachelor's programmes (like electrical engineering). The four projects are important elements of soft skills education of the bachelor's programme.

Evolution of the programme

Yearly, the lecturers are provided an opportunity to update the specification of their course. The updated specifications are discussed and approved by the study programme committee.

The current study programme was composed in 2001 when the bachelor-master structure was introduced. It has since then been adapted several times. The most important change was the introduction of the engineering projects in 2008. Other changes were the introduction of the course on Algorithms and Data Structures and Discrete Mathematics II, and the move of the formal modelling course from the master's programme to the bachelor's programme to strengthen the foundational courses in the bachelor's programme.
In 2010, the bachelor's programme started focussing on stimulating student-entrepreneurship by offering an elective introductory course on entrepreneurship in term 3 (selected by about 50% of the students), and by stimulating the students to create a self-defined product or service in the cross-course project. The rationale behind it is that students should learn how to innovate, and be confronted with market requirements as early as possible in their curriculum. The elective course about entrepreneurship has now (2020-2021) been replaced by the integration of entrepreneurship in the Sustainability, Entrepreneurship and Ethics course in term 2, which is taken by all students. The students are also encouraged to take on student jobs in local IT companies, to participate in contests, or to undertake internships in IT-companies. Several mailing lists advertise such jobs to the different student groups.
In 2020 the first three semesters of the bachelor programme were thoroughly revised, and the Bachelor of Science in Computer Science Engineering became a main subject of the more general Bachelor of Science in Engineering. The common part of the bachelor has been revised to account for the change in initial competences of students entering the programme; a stronger focus on ethical and sustainable issues as suggested by UGent and also by CTI; strengthening the project line. The new course on Sustainability, Entrepreneurship, and Ethics not only introduces these important concepts to the people that will shape our future society, but also introduces new engaging teaching methods. In addition, informatics is smeared out over the first year which allows a less steep learning curve and interaction between adopting programming skills and course content where they can be applied. This programme change strengthens the learning pathways sustainability, entrepreneurship and ethics.

In 2022 we plan a revision of the remaining semesters in combination with a revision of the subsequent master programme. One of the goals is to include in the bachelor programme more aspects of data processing and artificial intelligence, which are now mainly dealt with in the master. Another objective is to increase the attention to the societal impact of computer science, highlighting aspects of ethics and sustainability, which have also received a more important weight in the first bachelor programme.

Advanced or subsequent studies

The holders of a Bachelor of Science in Computer Science Engineering degree have several options to continue their education. The most frequently chosen programmes are:

- Master of Science in Computer Science Engineering (chosen by more than 90% of the students)
- Master of Science in Industrial Engineering and Operations Research
- Master of Science in Bioinformatics – main subject Engineering
- Master of Science in Computer Science

A SWOC-analysis of both the Bachelor and Master of Science in Computer Science Engineering, and a discussion of follow-up of CTI-recommendations is included in Section 2.6.

1.6 Bachelor of Science in Engineering – Main Subject Electrical Engineering

Programme objectives

The goal of the Bachelor of Science in Engineering is to offer the students (i) a broad education in the basic sciences such as mathematics, physics and chemistry, (ii) a polyvalent technical-scientific education in the basic engineering disciplines, such as informatics, probability, statistics, systems, signals, materials and (iii) a profound domain-specific education in the basic disciplines of the main subject, complemented by (iv) a general social education. On top of that, the students acquire the basic competences for scientific research, for teamwork, for effective communication, and for reasoning at different levels, including about their own functioning. They act in an ethical way, are positively critical towards others, and are open to feedback.
The objectives of the domain-specific education in Electrical Engineering are (i) to develop and enhance students' general knowledge of signal processing and telecommunications systems, (ii) to acquire the due insights and skills pertaining to the analysis, the modelling and sizing of electrical circuits and systems and (iii) to understand the properties of semi-conductor materials and their use in electrical engineering.

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the bachelor's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GB1-GB5).
All competences are shared with the other Bachelor of Science in Engineering programmes. The sole exceptions are the programme specific competences B1.3-B1.7, showing that the programme of electrical engineering encompasses the analysis, design and realisation of elementary circuits, signal and data processing algorithms and systems containing hardware and software components. It also makes the students familiar with physical models for electric and thermal properties of materials and with the role of electromagnetic waves, targeting both electronic and opto-electronic systems.

Field of competences B1: Competences in one/more scientific discipline(s)

B1.3 Analyse, design (based on well-defined technical specifications) and realise elementary circuits by means of the most common analogue and digital (opto-) electronic components.

B1.4 Know and creatively apply physical models for the description of electric and thermal properties of materials and (opto-) electronic components, and for the design of elementary systems (based on well-defined technical specifications).

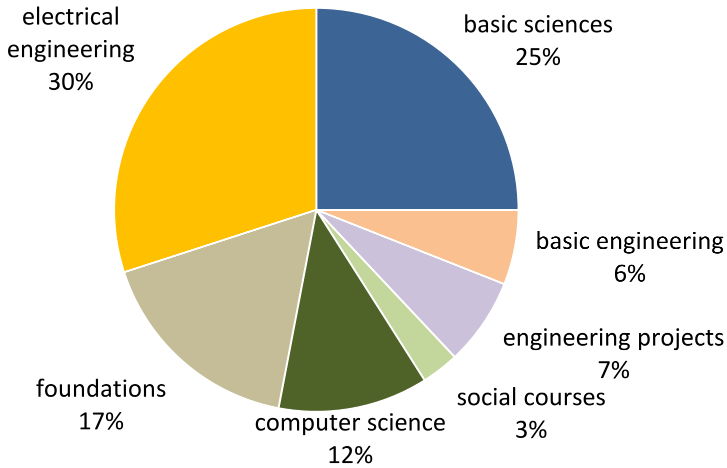
B1.5 Analyse, design (based on detailed technical specifications) and realise simple algorithms for signal and data processing in information and communication systems.

B1.6 Be familiar with the role of electromagnetic waves in (opto-) electronic systems and account for these wave phenomena when designing elementary systems.

B1.7 Perform measurements on elementary systems that incorporate a hardware and/or software component, and draw conclusions about the system performance given the measurement outcomes.

Structure of the programme

The study programme roughly consists of a first year of general science and engineering education, followed by two years of electrical engineering education. The latter one prepares the students for the two main subjects or options within the Master of Science in Electrical Engineering ('Electronic Circuits and Systems' and 'Communication and Information Technology') and for the Master of Science in Photonics Engineering. As electrical systems often combine hardware and embedded software components, our programme also has some overlap with the Computer Science Engineering programme for the more software-related background. Due to this, at the Bachelor level, our electrical engineering programme is broader than most other electrical engineering programmes (typically focused on the physical layer and hardware design). In the master's programme more emphasis is put on electrical engineering topics.



Programme structure Bachelor of Science in Electrical Engineering

The bachelor's programme consists of 180 credits:

- 25% basic sciences (mathematics, chemistry, physics)
- 6% basic engineering courses (statistics, mechanics)
- 17% foundations of electrical engineering (systems and signals, materials, communication theory)
- 30% core electrical engineering topics
- 12% computer science courses (discrete math, informatics, programming, computer architecture)
- 3% social education (business administration, elective course)
- 7% engineering projects, one engineering project per year

Globally, 47% of the programme consists of electrical engineering courses (leftmost part of the pie chart) and 12% of the programme consists of computer science courses, consistent with the emphasis on a broad education covering both hardware and software aspects related to electrical engineering disciplines. The rightmost 41% consists of a broad engineering education: science, basic engineering and projects. This 47+12/41 division is the result of a careful weighing of the breadth and depth of the programme.

The next chart shows how the different courses are scheduled in the six terms of the bachelor's programme. The average size of a course is 5.3 credits. Students take around six courses per term in the first two years, and five during the terms of the last year, which means that one full day per week can be spent per course. This gives lecturers enough time to thoroughly discuss the topics of the course, and the students get ample time to gain a deep understanding of the different course topics. Hence, for the bachelor's programme, the SPC explicitly chose to focus on the essential core topics. One of the consequences is that there is very little overlap between courses, and that there are few course dependencies. The first three terms are shared with other engineering bachelors and focus on the common broad engineering education. Students choose for electrical engineering when entering term 3.

As explained in Section 3.2 (SER, Part A), all bachelor's programmes contain a project line with one engineering project per year. In term 1, the SPC Electrical Engineering contributes several topics related to electrical engineering to the first course in this line (*Modelling, Making and Measuring*). The project line continues in term 4 with *Engineering Project*, in which the students integrate the knowledge and skills acquired in Electrical Circuits and Networks as well as some of the foundational courses. At the end of the bachelor's programme, the students integrate the knowledge and skills of the complete bachelor's programme in a more substantial project carried out in groups of four. For this *Cross-Course Project* we cooperate with the Computer Science Engineering to encourage students of Electrical Engineering to work in teams together with Computer Science Engineering students so that they can tackle more complete hardware and software projects. In some cases, team members propose their own project subjects, which can be linked to their own business ideas or research interests. The three project courses are an important element in the soft skills education of the bachelor's programme.

Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Basic Mathematics	Geometry and Linear Algebra	Mathematical Analysis III	Modelling and Control of Dynamic Systems	Communication Theory	Signal Processing
Mathematical Analysis I	Mathematical Analysis II	Physics II	Materials in Electronics	Applied Electromagnetism	Photonics
Chemistry: the Structure of Matter	Chemical Thermodynamics	Mechanics of Materials	Applied Probability	Digital Electronics	Fluid Dynamics and Heat Transfer in Electronics
Physics I	Probability and Statistics	Analysis of Systems and Signals	Computer Programming	Analog Electronics	Design of Analog Circuits and Building Blocks
Discrete Mathematics I	Materials Technology: Basic Concepts and Project	Electrical Circuits and Networks	Computer Architecture	Communication Networks	
Informatics Part 1	Informatics Part 2				
Modelling, Making and Measuring	Sustainability, Entrepreneurship and Ethics	Sustainable Business Operation	Engineering Project		Cross-Course Project

Courses in the Bachelor of Science in Electrical Engineering

Evolution of the programme

Yearly, the lecturers get the opportunity to update the specification of their course. The updated specifications are discussed and approved by the SPC.

The current study programme was composed in 2001 when the bachelor-master structure was introduced. It has since then been adapted several times. An important change was the introduction of the engineering projects in 2008. Another change was in 2017 when the course *Design of Analog Circuits and Building Blocks* was moved from the 1st semester of the 1st master year to the last semester of the Bachelor. The motive for this change was to have a better matching on the successive Master programme which was going through a more substantial programme change at the same moment.

The last change was in 2020. Then the common part of the bachelor has been revised to account for the change in initial competences of students entering the programme; a stronger focus on ethical and sustainable issues as suggested by UGent and also by CTI; strengthening the project line. The new course on Sustainability, Entrepreneurship, and Ethics not only introduces these important concepts to the people that will shape our future society, but also introduces new engaging teaching methods. In addition, informatics is smeared out over the first year which allows a less steep learning curve and interaction between adopting programming skills and course content where they can be applied. This programme change strengthened the learning pathways sustainability, entrepreneurship and ethics.

Since 2010, the bachelor's programme has had a focus on stimulating student-entrepreneurship by offering an elective introductory course on entrepreneurship in term 3 and by stimulating the students to create a self-defined product or service in the Cross-Course Project. The rationale behind it is that students should learn how to innovate, and be confronted with market requirements as soon as possible in their curriculum. The students are also encouraged to take on student jobs in local electronics companies, to participate in contests (such as the robot competition organised by IEEE student branch), or to do internships in an industrial environment focusing on electronic system hardware and/or software.

Follow-up of CTI recommendations and SWOC analysis

The discussion of the follow-up of the recommendations from the previous CTI-audit is combined for both the Bachelor and Master of Science in Electrical Engineering and is included in Section 2.7.

Advanced or subsequent studies

The holders of a Bachelor of Science in Electrical Engineering degree have several options to continue their education. The majority of the students continue with the Master of Science in Electrical Engineering but every year several students also continue with one of the following programmes:

- Master of Science in Photonics Engineering
- Master of Science in Industrial Engineering and Operations Research
- Master of Science in Bio-informatics

1.7 Bachelor of Science in Engineering – Main Subject Electromechanical engineering

Programme objectives

The goal of the Bachelor of Science in Engineering is to offer the students (i) a broad education in the basic sciences such as mathematics, physics and chemistry, (ii) a polyvalent technical-scientific education in the basic engineering disciplines, such as informatics, probability, statistics, systems, signals, mechanics, transport phenomena, electromagnetism and (iii) a profound domain-specific education in the basic disciplines of the main subject, complemented by (iv) education on a sustainable society. On top of that, the students acquire the basic competences for scientific research, teamwork, effective communication and for reasoning at different levels, including their own functioning. They act in an ethical way, are positively critical towards the others and are open for feedback.

In the Main subject Electromechanical Engineering the profound domain specific knowledge has several objectives: to develop and enhance students' general knowledge of thermodynamics and energy conversion systems, to acquire the due insights and skills pertaining to the analysis, the modelling and sizing of machinery and mechanical constructions. To acquire the due insights and skills pertaining to the analysis and modelling of the properties of materials.

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the bachelor's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GB1-GB5).
All competences are shared with the other Bachelor of Science in Engineering programmes. In all but one (GB4) fields of competences specific competences have been added. This is due to the broad approach expected of an electromechanical engineer. The programme of the Bachelor of Science in Electromechanical Engineering focuses on the understanding of electro-mechanical systems and wants to provide the students with the fundamental understanding needed to analyse, design and size these systems. To achieve this, the basic aspects of all the engineering sciences needed for this are treated: thermal and fluid engineering, structural mechanics and machine design, system dynamics and control engineering, power engineering and electrical engineering.

Field of competences B1: Competences in one/more scientific discipline(s)

- B1.3. Be familiar with fluid dynamics, heat transfer, thermodynamics and combustion and apply this knowledge creatively.
- B1.4. Be familiar with system dynamics and control engineering and apply this knowledge creatively in the design of control loops.
- B1.5. Be familiar with the conversion, transmission, distribution and application of electrical power and apply this knowledge creatively.
- B1.6. Be familiar with the mechanics of materials and structures, be able to size components of machines and mechanical constructions and apply this knowledge creatively on today's problems.
- B1.7. Identify and apply the relations and analogies between the different disciplines of electromechanical engineering.
- B1.8. Apply mathematical models and computational techniques to mechanical and electrotechnical applications.

Field of competences 2: Scientific competences

- B2.5 Apply the acquired knowledge and essential concepts of electromechanical engineering to (multidisciplinary) projects, case studies and experiments.
- B2.6 Design in a targeted way, by using the acquired knowledge and bearing in mind the technological limitations.

Field of competences 3: Intellectual competences

- B3.6 Analyse problems in the field of electromechanical engineering.
- B3.7 Critically evaluate own solutions to problems in the field of electromechanical engineering.

Field of competences 5: Societal competences

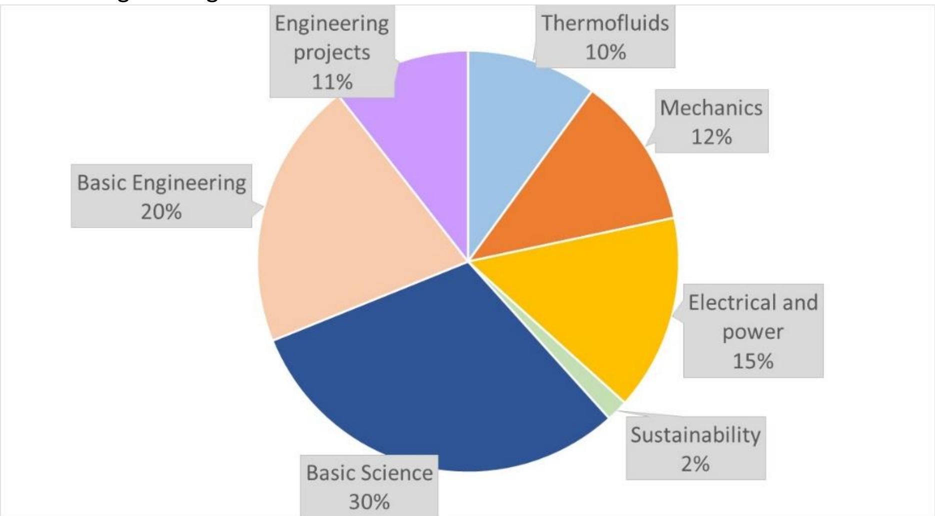
B 5.3 Be aware of aspects of safety in industrial environments.

B 5.4 Be aware of the social and economic importance of the mechanical and electrotechnical industry.

B 5.5 Be aware of sustainability in an industrial context.

Structure of the programme

The study programme roughly consists of a first year of general science and engineering education, followed by two years of Electromechanical Engineering education. The latter one is a mix of mechanical and electrical engineering, meaning that the programme covers the multidisciplinary field of electromechanical engineering including thermal and fluid engineering, structural mechanics and machine design, system dynamics and control, power and electrical engineering.



Programme structure Bachelor of Science in Electromechanical Engineering

The bachelor's programme consists of 180 credits:

- 30% basic sciences (Mathematics, Chemistry, Physics).
- 20% basic engineering courses (Materials Technology, Informatics, Probability and Statistics, Statistical Data Analysis, Electrical Circuits and Networks, Electronic Systems and Instrumentation, Analysis of systems and Signals).
- 10% thermo-fluid sciences (Transport Phenomena, Technical Thermodynamics, Heat and Combustion Engineering).
- 12% mechanical engineering (Machine Elements, Mechanics of Materials, Mechanical Production Technology, Mechanics of Structures, Kinematics and Dynamics of Mechanisms)
- 15% electrical and power engineering (Electrical Power Systems, Electromagnetic Energy Conversion, Electrical Drives, Modelling and Control of Dynamic systems).
- 2% Sustainability (Sustainable Business Operations, but also in the several projects).
- 11% engineering projects, one engineering project per year.

The programme consists of 37% mechanical-engineering courses and 63% broad engineering education: science, basic engineering and projects. All students get an in depth education in thermos-fluids, mechanics and electricity in both basic science and basic engineering. The application to machine and system design is started in the mechanical-engineering courses.

The table below shows how the different courses are scheduled in the six terms of the bachelor's programme. The average size of a course is 5.5 credits. Students take seven courses per term in the first two years, and five in the third term and six during the last 3 terms, which means that one full day per week can be spent per course. This gives lecturers enough time to thoroughly discuss the topics of the course, and the students get ample time to gain a deep understanding of the different course topics.

The SPC is of the opinion that students should have a broad basic knowledge of all aspects of electromechanical engineering. As electromechanical engineering covers a very broad range of applications, the focus in the second year is on elaborating the basics of the engineering subjects in this field. Only in the third year, this knowledge is applied in courses that focus more on the different application fields (thermo-fluids/electrical/mechanical). The first three terms are shared with other engineering bachelors and focus on the common broad engineering education. Students choose for electromechanical engineering when entering term 3.

As explained in Section 3.2 (SER, Part A), all bachelor's programmes contain a project line with one engineering project per year. In the first year, the SPC Electromechanical Engineering organises and offers a number of Engineering Projects, related to electromechanical engineering. The project line continues in term 4 with Engineering Project, in which the students are trained in machine design and CAD. At the end of the bachelor's programme, the students integrate the knowledge and skills of the complete bachelor's programme in a more substantial Cross-Course project carried out in groups of four. The three projects are an important element in soft skills education of the bachelor's programme.

Term 1	**Term 2**	**Term 3**	**Term 4**	**Term 5**	**Term 6**
Basis Mathematics	Geometry and Linear Algebra	Transport Phenomena	Electromagnetic Energy Conversion	Heat and Combustion Engineering	Technical Thermodynamics
Mathematical Analysis I	Mathematical Analysis II	Physics II	Dynamics of Rigid Bodies	Electrical Power Systems	Modelling and control of Dynamic systems
Chemistry: the Structure of Matter	Chemical Thermodynamics	Mathematical Analysis III	Introduction to Numerical Mathematics	Sustainable Business Operations	Electrical Drives
Discrete Mathematics I	Probability and Statistics	Electrical Circuits and Networks	Electronic Systems and Instrumentation	Analysis of Systems and Signals	Statistical Data Processing
Physics I	Material Technology	Mechanics of Materials	Machine Elements	Kinematics and Dynamics of Mechanisms	Mechanical Production Technology
Informatics	Informatics		Engineering Project	Mechanics of Structures	Cross-Course Project
Modelling, Making and Measuring	Sustainability, Entrepreneurship and Ethics				

Courses in the Bachelor of Science in Electromechanical Engineering

Evolution of the programme

Yearly, the lecturers get the opportunity to update the specification of their course. The updated specifications are discussed and approved by the SPC.

In 2020 the common part of the bachelor has been revised to account for the change in initial competences of students entering the programme; a stronger focus on ethical and sustainable issues as suggested by UGent and also by CTI; strengthening the project line. The new course on Sustainability, Entrepreneurship, and Ethics not only introduces these important concepts to the people that will shape our future society, but also introduces new engaging teaching methods. In addition, informatics is smeared out over the first year which allows a less steep learning curve and interaction between adopting programming skills and course content where they can be applied. This programme change strengthened the learning pathways sustainability, entrepreneurship and ethics.
This resulted also in adaptations to the program in the second and third year. The Engineering project was given more credits, in order to introduce subjects on safety and sustainability and also to reduce the perceived work load by the students. The Cross-Course project was reworked and topics now focus in the design project on sustainable technology (like wind energy, city farming, solar boiler, …). The Cross-Course project now also contains a student assignment on a Multi-Level Perspective analysis on the topic of their design, which introduces the students to sustainable transition thinking.

Follow-up of CTI-recommendations

The CTI report of 2016 gave following conclusions on the program : An attractive programme that allows the enrolment of 80 students per year, a very strong content and in line with expectations of companies, good quality staff with broad expertise, excellent relationship with research.

During the visit of CTI, the SPC discussed the intention to start working on the introduction of Sustainability in the program, which was a lot appreciated by the CTI.
A very important step for the program was thus the selection in 2017 as a pilot project (out of 2) for the Sustainable Education Program of Ghent University. Ghent University wants to be a leading knowledge institute for a future that is ecologically, socially and economically sustainable within a local and global context. To start up the transition to sustainable education two pilot projects were selected to experiment with how and what sustainability within a master program could be. These pilot studies provided inspiration and insights into the methodology to be used for future roll-out. The pilots were supported by specialists of the Centre for Sustainable Development of Ghent University.
A series of workshops and seminars and 2 training courses resulted in a training-specific vision text about the integration of sustainability, as well as an action plan for its implementation.
The implementation of this vision text lead to the program changes discussed above in the bachelor program. Secondly, in 2020 the process was started to rework the learning trajectories, introducing learning trajectories on basic technical knowledge in the 4 fields of Electromechanical Engineering, as well as Numerical Techniques, Safety and Sustainability. This is now being implemented into the ECTS-fiches of the bachelor courses.

Advanced or subsequent studies

The holders of a Bachelor of Science in Engineering -main subject Electromechanical engineering degree have a lot of options to continue their education.
The most frequently chosen programmes are:

- Master of Science in Electromechanical Engineering (90% of the students)
- Master of Science in Biomedical Engineering (about 5 per year)
- Master of Science in Industrial Engineering and Operations Research (1 or 2 per year)
- Master of Science in Fire Safety Engineering (1 or 2 per year)

SWOC-analysis

A SWOC-analysis of both the Bachelor and Master of Science in Electromechanical Engineering is included in Section 2.8.

1.8 Bachelor of Science in Engineering – Main Subject Engineering Physics

Programme objectives

The goal of the Bachelor of Science in Engineering is to offer the students (i) a broad education in the basic sciences such as mathematics, physics and chemistry, (ii) a polyvalent technical-scientific education in the basic engineering disciplines, such as informatics, probability, statistics, systems, signals, materials and (iii) a profound domain-specific education in the basic disciplines of the main subject, complemented by (iv) a general social education. On top of that, the students acquire the basic competences for scientific research, for teamwork, for effective communication, and for reasoning at different levels, including about their own functioning. They act in an ethical way, are positively critical towards others, and are open for feedback

The Main subject Engineering Physics prepares students to be the innovators that will be shaping our common future. They will be prepared for research and development tasks with foundations in physics both in industry and research labs but also have the skills to set up and lead industrial production departments.

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the bachelor's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GB1-GB5). All competences are shared with the other Bachelor of Science in Engineering programmes. In addition the Bachelor of Science in Engineering – Main subject Engineering Physics includes competences B1.3-1.5, showing the focus of the programme on applying new insights from physics in designing new devices, products and systems. Competences B1.4-B1.5 highlight the two main application areas envisaged by the programme. These programme specific competences have been benchmarked against similar engineering programmes at other European technical universities and were evaluated against the EPS European Specification for Physics Bachelor Studies and Bachelor in Physics programmes at Ghent University, to ensure the engineering specificity of the programme.

Field of competences B1: Competences in one/more scientific discipline(s)

B1.3 Possess the scientific knowledge, insight, and skills to analyse, model analytically and numerically, specify, design, control, and test experimentally, systems that are a direct application of the fundaments of physics.

B1.4 Have a thorough understanding of the basis of quantum mechanics, the composition of matter, the states of matter, semiconductors, and their applications.

B1.5 Have a clear insight in fields (electric, magnetic) and wave phenomena (electromagnetic, acoustic, optic) and the competence to creatively apply it in systems

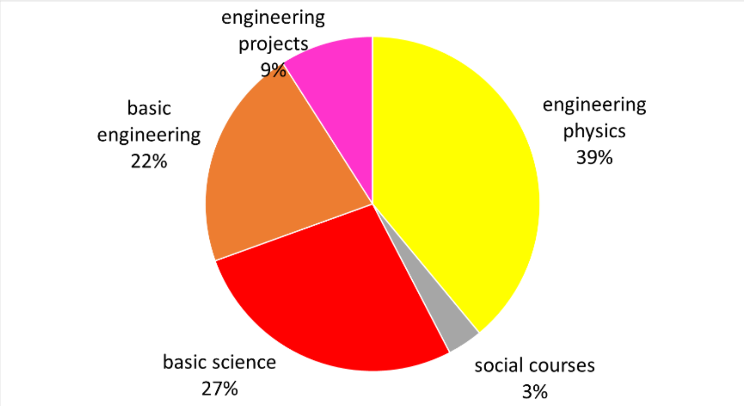
Structure of the programme

The study programme roughly consists of a first year of general science and engineering education, followed by two years of engineering physics education. The engineering physics part of the programme is designed for depth rather than attempting to touch upon the wide variety of application areas. This is consistent with a bachelor's programme that extremely rarely results in alumni that do not continue their education in a master's programme: e.g. Master of Science in Engineering Physics, Master of Science in Photonics. In accordance with this view, specialising courses in several areas are included: thermodynamics and statistical physics; quantum mechanics, solid state physics and semiconductors; fields, electromagnetics, and photonics; mechanics and transport phenomena.

The bachelor's programme consists of 180 credits:

- 27% basic sciences (mathematics, chemistry, physics)
- 21% basic engineering courses (signals, statistics, informatics, electronics)
- 5% social education (business administration, sustainability, entrepreneurship, ethics)
- 9% engineering projects, one engineering project per year
- 38% core engineering physics topics.

The weight of the basic engineering courses and projects together roughly matches the weight of the specific courses in Engineering Physics. This balance assures that a Bachelor of Science in Engineering – Main subject Engineering Physics is a well-trained engineer with the broad engineering skills reflected in the general learning outcomes. In line with the programme objectives, the programme also contains a significant fraction of basic science courses (25%), mainly mathematical and physical in nature. As mathematics and physics are closely related and as the mathematical abstraction is an ideal context to educate logical reasoning and creative scientific thinking, the weight of mathematics is made slightly higher for the Bachelor of Science in Engineering than for other Bachelor of Science programmes.



Programme structure Bachelor of Science in Engineering – Main subject Engineering Physics

The table below shows the courses in detail and how they are scheduled in the six terms of the programme. The size of the courses varies between 3 and 6 credits. Only the two courses of 3 credits that can be considered as standalone are the social courses. It is indeed the firm choice of the programming committee to opt for in depth knowledge on a limited number of topics rather than a superficial knowledge in a wide variety of fields in the bachelor's programme. In the key areas of the specific courses for Engineering Physics, courses are even grouped in pairs precisely for this reason: e.g. theoretical mechanics I and II, quantum mechanics I and II, solid state physics and semiconductors I and II, electromagnetism I and II. With this in depth knowledge, students are well prepared for the master's programmes where they can either choose for further specialisation in one of the application areas or a broadening of competences.

Term 1	Term 2	Term 3	Term 4	Term 5	Term 6
Basic mathematics	Mathematical analysis II	Electrical Circuits and Networks	Mathematical Tools in Engineering: Linear Algebra	Analysis of Systems and Signals	Modelling and Control of Dynamic Systems
Physics I	Geometry and Linear Algebra	Physics II	Physics III	Solid-state Physics and Semiconductors I	Solid State Physics and Semiconductors II
Mathematical Analysis I	Chemical Thermodynamics	Transport phenomena	Materials and Fields	Mathematical Tools in Engineering: Complex Analysis	Electromagnetism II
Discrete Mathematics I	Probability and Statistics	Mathematical Analysis III	Quantum Mechanics I	Quantum Mechanics II	Photonics
Chemistry: the Structure of Matter	Materials technology	Theoretical Mechanics I	Engineering Project	Electromagnetism I	Electronic systems and instrumentation
Modelling Making and Measuring	Sustainability, Entrepreneurship and Ethics		Theoretical Mechanics II	Sustainable Business Operations	Cross-Course Project
Informatics					

Courses in the Bachelor of Science in Engineering – Main subject Engineering Physics and their planning per semester

The first two terms are common for the whole engineering bachelor and focus on the broad engineering education and scientific background. Students choose for engineering physics when entering term 3. In the specific Engineering Physics courses, the relationship with the programme specific learning outcomes B1.4 and B1.5 becomes clear: with courses such as quantum mechanics, solid state physics and semiconductors focussing on the former, electromagnetics and photonics on the latter, while the other courses are mainly related to learning outcome B1.3.

The bachelor programme contains an explicit project line: “Modelling, Making, and Measuring” introduces general engineering, cooperation and communication competences at an early stage in the programme. The “Engineering Project” in the fourth term provides hands on training on experimental design, reporting, working in groups on engineering physics topics. Following a project based learning paradigm, the students explore three domains, learning to design and conduct explorative experimental work in a discipline they do not completely master yet. Indeed, corresponding courses will be formally taught during the later terms. At the end of the bachelor’s programme, the students integrate the knowledge and skills of the complete bachelor’s programme in a more substantial cross-course project carried out in groups of four. Open ended, real-world projects in the area of liquid crystals, acoustics, and plasma physics are offered to the students. Students are trained to independently and in small groups handle these projects, which require project management skills, planning, and communication, beyond the level they are used to in other courses. This project work is considered essential in acquiring the general engineering skills outlined above.

The Main subject Engineering Physics contains five learning pathways: quantum mechanics, thermodynamics, solid-state physics, electromagnetism, and sustainability, entrepreneurship and ethics. These pathways are continued in the MSc Engineering Physics.

Evolution of the programme

The original programme was developed in 2001 with the introduction of the bachelor-master structure. It has been thoroughly revised several times since then. The latest changes in the programme occurred in 2018 and 2020.
In 2018 mainly the order of courses was adapted in response to feedback of the students in the programme to make the learning process more efficient. Mathematical Tools in Engineering was split in a part on Linear Algebra and a part on Complex Analysis.
In 2020 the common part of the bachelor has been revised to account for the change in initial competences of students entering the programme; a stronger focus on ethical and sustainable issues as suggested by UGent and also by CTI; strengthening the project line. The new course on Sustainability, Entrepreneurship, and Ethics not only introduces these important concepts to the people that will shape our future society, but also introduces new engaging teaching methods. In addition, informatics is smeared out over the first year which allows a less steep learning curve and interaction between adopting programming skills and course content where they can be applied. This programme change strengthened the learning pathways sustainability, entrepreneurship and ethics..

Follow-up of CTI-recommendations

These programme reforms contribute to remediating a concern of CTI formulated in their 2015 report: increasing the skilled-based approach and making the programme less “a la carte” by more strongly embedding the skilled-based training and by structuring more rigidly the sustainability, entrepreneurship and ethics track. These reforms are however minor compared to the change in the master programme, discussed later.
With regard to the SWOC analysis in the previous SER, most adaptations are discussed in the MSc Engineering Physics part of this report. The clear profiling of Engineering Physics – a concern that was also highlighted by CTI – has improved as a side effect of the introduction of the bachelor in Biomedical Engineering. Prior to this, part of the students in the bachelor Engineering Physics followed this trajectory towards the master in biomedical engineering. Now the connection between our bachelor and master programme is more unique.
The content and teaching methods of each specific course in the programme are continuously adapted to follow evolutions in field knowledge, to mitigate the shortcomings pointed out by the students and to accommodate the changing demands of the recruiting industry. These changes are initiated by the teaching staff and approved by the SPC.

Advanced or subsequent studies

The Bachelor of Science in Engineering (Engineering Physics) optimally prepares students for the Master of Science in Engineering Physics and the (European) Master of Science in Photonics. And these are indeed the main follow-up studies chosen by our students. It is also a preferred path to the European Master of Science in Nuclear Fusion and Engineering Physics, but access to this programme is subject to an admission procedure.

In addition several broader master programmes inside and outside the faculty of Engineering and Architecture allow students with a BSc in Engineering Physics to enter. Finally, students that want to reorient can enter most of the MSc programmes offered by the faculty of Engineering and Architecture after following a preparatory program.

SWOC-analysis

See Section 2.9 Master of Science in Engineering Physics.
Specific strategies for improvement of the bachelor programme will be based on a thorough analysis of the most recent adaptation with regard to sustainability, entrepreneurship and ethics as students on the programme report that they did not come in contact with these aspects in 2020. Students of the Bachelor of Science in Engineering in general report a lack of international experience, yet the programme committee leaves the focus on internationalisation for the master.

Detailed description of the master's programmes

2.1 Master of Science in Engineering: Architecture

Programme objectives

Today it is impossible for a single person to possess the full range of competences necessary for the design and construction of buildings. Architects are also increasingly engaged in other professional activities than designing buildings, ranging from urban and landscape design, over research into the mechanisms shaping the larger territory, to project management, work in the cultural and academic sector, or in government administration. In order to prepare students for this increasingly wide, multifaceted and collaborative professional environment, which has evolved significantly in the last years, triggering new forms of practice in the architectural field, the primary objective of the Master of Science in Architecture is to train academic engineer-architects who possess the necessary intellectual and technical competences to be capable of conversing with all partners involved in the design and construction processes shaping the built environment (principals, developers, policy makers, building contractors, users, …), and of organizing the combined action of these partners around a shared project. At the same time, the SPC believes that students will position themselves more effectively in the professional world inside and outside the architectural profession if, along with the general set of competences, they develop an individual profile tailored to their interests and ambitions. This profile can either be highly specialized, or can retain the broad outlook that characterizes the field of architecture itself. The success of our students in securing positions in a wide range of professional contexts suggests that exactly this broad outlook, coupled with a rich set of competences and a critical attitude, is a unique and highly valued asset.

In order to allow students to shape their own profile, the master currently offers two main subjects. They differ in their focus on different ranges of scale of buildings and the built environment. The main subject **Architectural Design and Building Technology (ADBT)** zooms in from the scale of the building to the building detail. It wants students (i) to acquire a thorough expertise in the aspects of architectural design pertaining to construction, details, construction techniques, as well as the comfort systems of buildings, (ii) to have a due command of the construction techniques that are relevant for the demands of a specific project, (iii) to possess the necessary skills to take up the architectural profession.

The main subject **Urban Design and Architecture (UDA)** zooms out from the building towards its wider context, from the neighbourhood to the territory. It wants students (i) to acquire a thorough expertise in architectural design and urban design, (ii) to be knowledgeable about the construction techniques that are relevant to the demands of a specific project, (iii) to have a command of urban planning and development, nourished by an analysis of the (contemporary) urban condition from the point of view of various disciplines, (iv) to be able to perform independent research within the field of architecture and construction, (v) to possess the necessary skills to take up the profession of architect and/or the professional practice of urban planning (legislation, procedures, …).

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the objectives are formalized as a list of competences and associated learning outcomes that are specific to the architecture programme. Some of these competences coincide with the generic master competences of the other MSc programmes listed in SER, Part A (indicated in italic in subsequent list).

Field of competences MA1: Competences in one/more scientific discipline(s)

M1.1 *Master and apply advanced knowledge in the own engineering discipline and apply this knowledge to complex problems and designs.*

M1.2 Have a profound knowledge and a critical understanding of the application of materials, structures, building components and technical installations in buildings.

M1.3 Have a profound knowledge and a critical understanding of architectural and urban design with regard to spatial analysis, architectural typology, programme definition, figuration, design methodology and representation techniques.

M1.4 Comprehend research methods in the history and theory of architecture and urbanism.

M1.5 Know the procedural, legal and deontological aspects of architecture and urban planning.

M1.6 Have a critical understanding of standard problems and calculation methods in architectural engineering.

M1.7 Have a thorough knowledge and critical understanding of the application areas and methods in the field of urban design, urbanism and spatial planning.

Field of competences MA2: Scientific competences

M2.1 *Analyse complex problems and formulate them into concrete research questions.*
M2.2 Consult the scientific literature as part of the own research.
M2.3 Select and apply the appropriate models, methods and techniques.
M2.4 *Interpret research findings in an objective and critical manner.*
M2.5 Independently develop solutions for complex design problems in a wide range of application areas and scales based on design research.
M2.6 Organise complex design processes and apply acquired knowledge and advanced design tools in an effective and creative way in the different stages of the design.

Field of competences MA3: Intellectual competences

M3.1 *Define one's position on complex situations and defend this point of view.*
M3.2 *Apply knowledge in a creative, purposeful and innovative way to research, conceptual design and production.*
M3.3 Reflect critically and independently on own design proposals, based on the scientific, historical and social knowledge acquired.
M3.4 Make detailed and sound design decisions within the inherent complexity and uncertainty of architectural design, and evaluate these decisions constantly during the design process.
M3.5 Develop a consistent learning path within the courses offered in order to broaden and/or deepen individual fields of interest and expertise.

Field of competences MA4: Competences in cooperation and communication

M4.1 Project management: have the ability to formulate objectives, report efficiently, keep track of targets, progress of the project,...
M4.2 Ability to work as a member of a (design) team in a multi-disciplinary working environment.
M4.3 Present and defend own research and design results to a public in a systematic and clear way.

Field of competences MA5: Societal competences

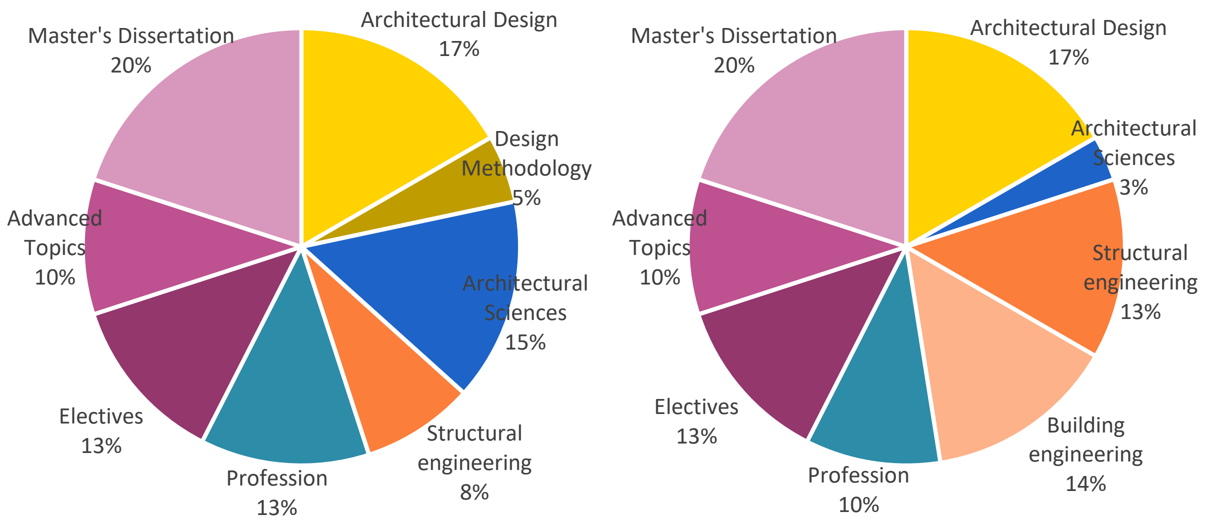
M5.1 Include social aspects of architecture, urbanism and building to the own work.
M5.2 Include the life cycle and environmental impact of the built environment to the own work.
M5.3 Include safety and accessibility in the built environment to the own work.

Structure of the programme

Studio teaching retains its central role at the MSc level. Whereas theory courses in the BSc in Architecture are predominantly taught in traditional formats (lecture courses and exercises), on the master level students are more directly engaged in the ongoing research of the Department of Architecture and Urban Planning, both in the studios and in seminars (Advanced Topics). This teaching environment strongly favours the development of competences related to analytical, critical and synthetic thinking, as well as to teamwork. Most of all, this environment is crucial to foster the key competence that the programme wishes to impart to its students, a designer's attitude towards the different fields of knowledge pertaining to architectural, urban and constructional design. Currently, this also involves a large degree of personal choice, allowing students to define a specific trajectory that aligns well with their own interests.
The study programme currently consists of 69 credits of compulsory courses , 27 credits of elective courses and a master's dissertation of 24 credits. The **compulsory courses**, 58% of the programme, consist of three blocks.

1. Courses <u>shared by the two main subjects</u>. They deal with topics preparing the students for professional practice (Law, Fire Safety, Deontology), and with building engineering topics that further develop previously acquired knowledge (Soil Mechanics, Reinforced Concrete).
2. A <u>design studio</u>. The programme offers a choice between five studios (Studio A, B, C, D and E), which treat design problems ranging from the technical and constructional aspects of architecture to research into design problems on the scale of the territory. The topics treated in these studios are closely related to the work and research of the studio principals. The range of topics reflects the orientation of the two subjects. The students are required to take one studio in the first term. Their choice allows them to either specialize further in the main

subject of their choice, or to retain a broad outlook on the discipline and to continue working on all levels of scale.
3. Courses specific to the main subjects. They offer a thorough exploration of topics proper to each main subject (such as Theory of Urban Design and Urbanism or Building Acoustics, Foundation Engineering). At the heart of these courses is the subject specific studio, which is taken in the second term (Workshop Spatial Analysis or Architectural Design Studio: Design Development).



Left: Programme structure MSc in Engineering: Architecture, main subject Urban Design and Architecture
Right: Programme structure MSc in Engineering: Architecture, main subject Architectural Design and Building Technology

The **electives** consist of two distinct blocks.

1. The first block, out of which students are required to choose the majority of the electives, are research related seminars and studios (minimum 12 credits).

The research related seminars (Advanced Topics) each cover a general subject already dealt with in the bachelor's programme (ranging from architectural theory to the building detail). For each subject, each year different topics are selected according to the ongoing research of staff members. These subjects might introduce students in state-of-the-art research, often in collaboration with other departments our research groups, but also involve hands-on involvement of students in publication or exhibition projects, or in the construction of objects, small buildings or installations. In the third term of the master programme, students have the option to again choose one of the five studios (Studio A, B, C, D and E) as an elective, allowing a further development of their individual programme as a designer. These options also allow students to prepare for their master's dissertation. This dissertation can take the form of (i) a written dissertation based on original research of sources, literature and/or projects in architecture, urbanism, construction or art; (ii) a design project; or (iii) a hybrid of the former options. Students can select one of the many topics that are proposed by the lecturers of the architecture programme, or they can propose a topic themselves, subject to acceptation by a supervisor and the SPC.

2. The second block of electives consists of a range of courses that can again support the choice of a student to become highly specialized in one particular area of architecture, urbanism or construction, or to retain a broad profile (maximum 15 credits). For a full list, we refer to the programme catalogue.

Evolution of the programme

Considering the positive comments we received in the previous CTI-report, the overall structure of the programme has remained largely the same. In the Option Architectural Design and Building Technology (ADBT) the course on the History and Theory of Interior Design has been reoriented to History of Contemporary Construction, following a change in staff, but also to include a module that filled a lacuna in the curriculum related to Construction History and Building analysis. As large part of the master program consists of close interaction between staff and students in smaller groups, the restrictions imposed by COVID-19 did pose particular

challenges over the last year and a half. However, the forced change to online teaching also allowed to experiment with new formats and some of these have proven to be very successful, especially for developing a stronger Internationalisation@Home component.
In response to some comments in the previous CTI-report regarding the heavy study load, we have been permanently monitoring and finetuning the program, in close dialogue with students. An important measure in this respect has been to reorganize the Advanced Topics to align them more with broader themes: architecture, construction techniques & building physics, design theory and methodology, urbanism and landscape, and theory, history and criticism of architecture. Furthermore, the possibility to offer Advanced Topics of 6 instead of 3 credits has triggered more opportunities for collaborating across fields, but also has allowed student to focus more profoundly on a limited number of topics. In line with the *Bachelorkrant* discussed above, we have introduced since the academic year 2020-2021 the so-called *Masterfiles*. This document contains an overview of the themes that are addressed in the five master design studios and the two option-related design workshops, as well as of all Advanced Topics organized. For each a detailed description is provided, allowing students to make well informed choices.
Despite the suggestion made during the previous CTI-visit to offer a complete master programme in English, we have opted to retain Dutch as the main instruction language. Our choice to retain Dutch reflects the reality that architecture and its attendant field are deeply embedded in a local intellectual, cultural, social and administrative context. It is in the interest of Flemish students to become acquainted with this context and its own terminology and issues, while foreign students interested in working in Flanders will have to acquire a certain level of Dutch to be able to work successfully. Our programme is, however, fully embedded in the international context by means of international guest lectures and guest critics. Moreover, we do offer 60 ECTS (2 terms) package of English taught courses at master level. With the newly recruited staff, we will be able to expand this package, including offering some courses at Bachelor level in English. This will make our curriculum more attractive for incoming Erasmus students from prestigious architectural schools in Europe and abroad.
While we are overall satisfied with how the master programme has evolved over the last couple of years, we feel that recent shifts in the profession of architecture and the emergence of new forms of practice, urge us to rethink part of our master program (see SWOT analysis).

Admission

The Bachelor of Science in Architecture automatically qualifies for admission. There are preparatory programmes for students from a range of bachelor and master's programmes (see programme catalogue).

The programme's context

Students are organized in a very active student association specific to the architecture programme, '*De Loeiende Koe'*. DLK publishes its own newspaper and organizes activities ranging from entertainment to highly valued lecture series by staff members and guest lectures. The journal is an important site of debate about the programme and the work that is being done there. Crucially, DLK is deeply involved in the organization of the *Jokerweek*, and we are developing this as a more student-led activity, providing students with more agency and responsibility. The *Jokerweek* is typically also the moment of the year in which we reach out to alumni (including a ceremony of awards of master dissertations). Alumni are also invited to the events set up by the department (guest lectures, exhibitions,…) and they can subscribe to the newsfeed on our website.
The SPC has set up an Advisory Board including members from the professional field, the broad cultural field of architecture, the Architect's association ('*de Orde van Architecten'*) and of industry. While this board currently consists exclusively of members from Belgium, we have concrete plans to expand it with some colleagues from abroad, including some key figures from our Erasmus partners and other international architectural schools. Each of our staff members at professor level has extensive networks in their respective domain, which are tapped into for guest lectures, juries of design studios, the guidance of master dissertations.

SWOC-analysis Bachelor/Master of Science in Engineering: Architecture

Strengths

- **A coherent programme with ample possibilities for choice**: The level and orientation of the programme are highly appreciated. The aims of the programme are based on a global vision of architecture with design at its centre, while giving ample and equal attention to construction techniques and architectural sciences. This vision distinguishes the programme at Ghent from other comparable programmes. The programme is coherent and well ordered, and offers a wide variety of teaching formats, ranging from lecture courses over seminars to studios. These forms include specialized seminars (Advanced Topics) and the *Jokerweek*, key components that are specific to the programme. There is a good balance between compulsory and elective courses.

- **A diverse staff:** The staff provides a good mix of expertise in academic research and practice-based knowledge. It is made up of both junior and senior academics, as well as practicing architects from different generations, including established and (inter)nationally respected architects as well as young, upcoming practices.
- **A population of engaged students**: The program is attracting (very) competent students, matching the level of the program. The students are strongly involved in the programme, esp. through their student association '*De Loeiende Koe*'.
- **Alumni with diverse professional profiles**: Our alumni develop a wide range of career paths and occupy a diversity of professional positions. They return very positive feedback to the programme. We also regularly receive laudable comments from the professional milieu on the quality of our graduates.
- **A strong international embeddedness**: The staff is very well embedded in international research networks, and via guest lectures, consultancy in design studios and for master dissertations, etc. expertise from abroad is introduced in the teaching. There is a long standing exchange with prestigious partners in Europe and abroad, and the portfolio of exchange agreements is expanding. Department has an excellent reputation, as can be seen from the large number of strong applications received in recent recruitment campaigns for professors, but also from the growing quality of incoming Erasmus students.

Weaknesses

- **Heavy workload for students**: Despite our efforts to monitor the workload of students and the measures taken, it remains still very heavy. Students are simultaneously engaged in studio work, which requires a continuous production of work, and in theoretical courses, many of which include assignments (e.g. writing of papers and reports). Such multiplicity of assignments is inherent to an architectural curriculum, yet a constant monitoring remains crucial to keep the workload reasonable.
- **Gender imbalance in staff composition:** Since long the department is confronted with a major imbalance in terms of gender, especially among professors. While this has been taken into account explicitly in recent recruitments, it will require a long and sustained effort to adjust it. Specific attention is now also paid to arrive at a gender equilibrium in the composition of the teams supervising design studios, considering the strong interactive nature of the teaching and the significant number of female students.
- **Limited numbers of incoming exchange students**: While major efforts have been made to enhance internationalization, in terms of Erasmus exchange we do not yet arrive at establishing an equilibrium between outgoing and incoming students. There are far more outgoing students than incoming (a ratio of about 3 to 1). A specific communication policy needs to be developed to inform our Erasmus partners better about the specific strengths of the department and of the curriculum on offer.
- **Limited inclusion of internships:** Internships are not compulsory in the program but strongly stimulated. While each year a number of students is taking up an internship, either in Belgium or abroad, their numbers remain rather limited (it should be noted here that not all students who do an internship actually include it officially in their curriculum). Efforts need to be made to strengthen the internship programme in particular with regard to the rapidly changing practice in the architectural field.

Opportunities

A mixed and well networked staff: The high level of research across the different fields and disciplines that shape the programme, often in close collaboration with other departments in the faculty, in the humanities and the sciences, offer opportunities for innovative and cutting edge teaching. One example of this is the '*UGent Stadsacademie'*, that engages with new forms of educational formats in a number of domains, dealing with questions of migration, of food provision in the city and on the circular economy of building materials. The recent recruitment of a staff member in the domain of material-cultural history of architectural practice will allow to expand such collaborations across faculties. The great variety of research output produced by staff, such as exhibitions, prototypes, models, … provides opportunities for hands-on teaching practices with highly visible outcomes through the many existing contacts of staff members with the broader cultural field (museums, cultural institutions,…).

- **The promise of a new accommodation:** A major weakness is the current accommodation and infrastructure of the department, esp. with regard to studio teaching and related activities (such as model building), and seminars. Studios are too small, with insufficient space for working and stocking materials and models. There is no room available to exhibit student work. Students are unable to occupy their own studio space because the spaces are used for other classes and opening times are severely limited. A major improvement is expected with the planned move of the department to one of the Technicum buildings on campus UFO in 2026. The renovation of this building, necessary to implement this move, is becoming a pilot project and the subject of an architectural competition organized under the supervision of the '*Vlaams Bouwmeester'*.

Challenges

- **A growing and more diverse student population:** Over the last seven years, the student population has been steadily growing. Since 2014 we have seen an increase of ~60% in the population of the Bachelor and of a doubling for the Master. This increase poses several challenges, in terms of infrastructure, for instance, but surely also for the organization of interactive teaching with a staff that is not expanding. This challenge is currently taken into account in ongoing discussions on the reshaping of the curriculum (see below). Diversity is also posing major challenges on both staff and student levels: it remains almost completely absent in the composition of the staff, and while the programme has been attracting a growing number of students with a migrant background over the last years, their number remains overall small. The staff is not well equipped to deal with the complexity of diversity in teaching. Therefore an initiative has been taken to ask for support from Ghent University, including for instance specific training on topics like implicit bias, and the appointment of a trust point-person.
- **Limited (career paths for) staff:** The structure of the staff, with a relatively small number of full-time academic staff compared to the number of part-time practitioners, imposes challenges in terms of staff commitment and organization. Because university criteria for hiring and promotion are geared towards research output, and tailored to purely academic careers, we are unable to offer attractive career paths for practitioners, or providing opportunities to conduct practice-based research within their UGent position. A tension also exists between the need to keep good performing practitioners on board who bring continuity to the teaching of design studios, and the desire to recruit new talent on a regular basis.

Strategies for improvement

- **Reshaping the programme**: Despite the clear structure of the programme, the integration of the different forms of knowledge and competences in the design studios does not yet happen in an optimal way. Considering that professional practice is rapidly changing in light of societal challenges (sustainability, circular economy & transition, diversity & migration,…) a partial reshaping of the programme at bachelor but in particular at master level seems timely, also to stimulate more cross-disciplinary forms of teaching. We feel that the two master options to some degree form an obstacle for more cross-disciplinary interaction within the programme, and may need to be redefined. This reshaping is currently being prepared, also in the context of the recent recruitment of a significant number of new staff members (6 staff members leave the department between September 2021 and September 2022).
- **Optimizing Master dissertation research**: every year, excellent master dissertations are produced by our students, as can be seen from the awards the program discerns each year. In response to critiques of students regarding the irregularity of guidance and consultancy, we are currently taking steps to define a general framework for this, including more opportunities for mutual learning among peers.
- **Communication**: Important steps have been taken over the last two years regarding the communication of our curriculum, especially targeting potential new incoming students at Bachelor level. In order to define more clearly our position in the international arena of architectural schools, we are working on our international communication, among others through an improvement of our website.

2.2 Master of Science in Biomedical Engineering

Programme objectives

The Master of Science in Biomedical Engineering (MSc BME) is an interuniversity initiative of Ghent University and Vrije Universiteit Brussel. Students acquire a profound technical know-how (integrating mathematics, physics, chemistry and life sciences with engineering techniques) to operate in the biomedical and health care sector, while being introduced into the specificities of working for and with the patient and with living matter, and to learn the perspective of the clinician and all stakeholders in the biomedical and health care industry.

Students acquire the necessary research and engineering skills to independently analyse and solve complex problems and are capable of developing new materials, devices, tools, systems and methods for the early diagnosis, prevention and treatment of disease in order to improve and guarantee the health care and quality of life of society. Students are aware of the ethical and socio-economic aspects of the biomedical engineering profession and have knowledge of the organisation of our health (care) system. In the fast-evolving area of biomedical engineering, the master's programme also stimulates an attitude of permanent learning.

This programme delivers academically formed engineers of an outstanding international level, naturally trained to function in a multidisciplinary and international team through the multidisciplinary programme (with lecturers from diverse faculties and research areas) and work on multidisciplinary projects together with international students solving multidisciplinary problem cases in group. Students acquire excellent communication skills in oral and written reporting.

Programme specific competences

As explained in Section 3.2 (SER, Part A), the master's programme objectives are formalised as a list of competences and associated learning outcomes, many of them common to all MSc in Engineering programmes. Below, we list only those competences specific for the MSc in BME:

Competence field 1: Competences in one/more scientific discipline(s)

- Be familiar with and have an understanding of the basic concepts and principles in the field of anatomy, (cell- and molecular) biology, chemistry, physiology, biomechanics and medical and health sciences.
- Be familiar with and have an understanding of standard methods for the quantitative measurement of structures and functioning of biological systems on molecular, organic and system level.
- Be familiar with the functioning of medical devices and have insight in the relations between the results of measurements and the observed or controlled biophysical parameters.
- Be familiar with and have an understanding of state-of-the-art methods for data analysis and the principles of artificial intelligence in data processing and medical decision support systems.
- Have a fundamental insight in the physical principles, technological possibilities and limitations of medical signal and imaging modalities.
- Have a good understanding of the physical and chemical properties of body tissues, supplementary or substituting (synthetic) biomedical materials and their interactions.
- Be able to apply algorithms for the assessment and optimization of radiation doses based on a profound insight into the absorption of the dosage and the functioning of radiation-generating and detecting machinery.
- Be able to estimate the consequences of the interaction between radiation and living tissues and biomedical materials.

Competence field 2: Scientific competences

- Analyse complex multidisciplinary biomedical problems based on (recent) scientific research and transform them into a logically structured, technologically realisable and ethically justifiable research plan.
- Answer a concrete and relevant biomedical engineering question on a basis of recent technical, scientific and medical knowledge.
- Apply complex concepts, techniques and methods in order to solve real problems in physiology and clinical medicine.
- Critically and permanently evaluate the quality, (bio-)ethical aspects, innovative value and (bio-)safety of (own) research.

Competence field 4: Competences in cooperation and communication

- Have the ability to work as a member of a team in a multi-disciplinary working-environment, as well as being capable of taking on supervisory responsibilities.
- Critically discuss a research plan with fellows, doctors and researchers working in disciplines related to biomedical sciences and health care.

Competence field 5: Societal competences

- Take up a well-founded position about socio-economic and societal aspects of biomedical engineering.
- Take into consideration the medical ethics and laws and rules with respect to the implementation of medical-technical actions and scientific research in a clinical environment.
- Be aware of ethical and safety aspects in biomedical practice.
- Strive for a continuous improvement and guarantee of health care and quality of life of the individual and society.

Competence field 6: Profession-specific competence

- Have sufficient knowledge and understanding to develop and technically evaluate new materials, equipment, tools, systems and methods for prognosis, (early) diagnosis, prevention and treatment of illness and for convalescence.
- Mathematically translate complex biomechanical, biological and physiological processes under normal and pathological conditions into advanced models and paradigms, knowing their limitations and finding creative solutions for these limitations.
- Apply the most suitable instruments, concepts, techniques and methods for the solution of real problems in physiology and clinical medicine on molecular, organic and system level.
- Target-oriented implementation of algorithms for the extraction of clinically relevant information from biomedical signals or images, including the most suitable method for the reduction of measurement artefacts (baseline drift, noise, interferences, mistakes in the models,...).
- Be aware of the importance of maintenance, quality control, safety and risk management and regulations for the specific application level.
- Correctly assess the role and possibilities of data-processing systems in a local (hospital) and regional environment while being aware of potential problems associated with the implementation of such systems.
- Specify the physical and technical-chemical properties of synthetic materials for a wide range of biomedical applications and implement adequate tests.

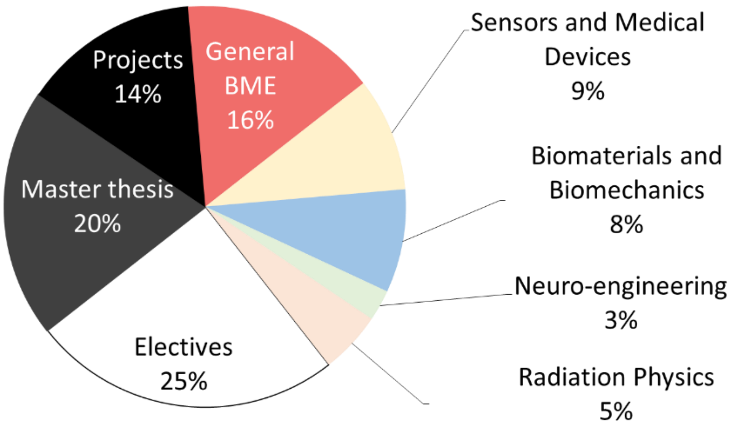
Competence field 7: Expert in Medical Radiation Physics

- Introduce measures and procedures in hospitals to ensure the safety and protection of radiation of persons (primarily patients) exposed to radiation for medical purposes.
- Accept radiation-generating medical devices and products as well as radiation-detecting equipment prior to their first use.
- Elaborate, implement and follow-up of quality control procedures.
- Perform device-specific dosimetry.
- Provide assistance, in collaboration with the medical staff, to patient-specific dosimetry and projects on optimisation of doses.
- Provide professional advice for the preparation of specifications for the purchase of radiation-generating and -detecting devices and products.
- Adequately choose, accept and calibrate instruments and devices for dosimetry and measurement of radiation activity.

Structure of the programme

The study program consists of 120 credits (66 compulsory, 30 elective and 24 credits for the master thesis), spread over four semesters of twelve weeks each with specialized courses in established (biomaterials, biomechanics, medical imaging, sensor technologies) and newer emerging fields (neuro-engineering, data science and decision support techniques, medical robotics). The 30 credit space, together with the master thesis, allows the students to shape their individual track. Students have the option to specialize in biomechanics and biomaterials, radiation physics, neuro-engineering, sensors and devices or opt for a broader, more general track. Students get the specialization after acquiring minimally 18 credits electives and the master thesis in a specific domain. Together with the master thesis, the curriculum entails 41 credits of project work, spread over the 1st and 2nd master and including a computational project course, a biomedical product development assignment in year 1 and a project within the hospital in the second master. Internships are not compulsory, but students are encouraged to take an internship in the biomedical industry or in a hospital environment. As described elsewhere, internships can be valorised in the student's curriculum as an elective course for a maximum of 6 credits.

The figure below schematizes the overall structure of the programme, while the table below provides details on how the curriculum of 120 credits is spread over 4 semesters.



Schematic structure Master of Science in Biomedical Engineering

Master 1		**Master 2**	
semester 1	**semester 2**	**semester 3**	**semester 4**
Elective	**Elective**	**Elective**	**Elective**
Artificial Organs (UGent)	Medical Equipment, Safety and Regulations (UGent)	Clinical Study Design and Biostatistics (UGent)	Leadership in Health Care (UGent)
Biomedical Robotics and Assistive Technologies (VUB)	Micro- and Nanotechnologies for Medical Device Design and Fabrication (joint)	Hospital Project (parallel)	Health Information and Decision Support Systems (VUB)
Neuro-engineering Science (UGent)	Data Analytics in Healthcare and Connected Care(parallel)	Master thesis	Master thesis
Biomaterials and Tissue Engineering (joint)	Computational Project Course (Compulsory Elective)		
Medical Imaging (joint)	Biomedical Product Development (Parallel)		
Biomedical Product Development (Parallel)			

Courses in the Master of Science in Biomedical Engineering. Courses are organised either at UGent, at VUB, in a joint collaboration (joint) or in parallel at both institutions.

Expert in Medical Radiation Physics

Unique for the MSc in Biomedical Engineering is a track that can lead to the legal recognition of 'Expert in Medical Radiation Physics'. This track consists of a package of eight specific elective courses. When students opt for this track, also the subject of the master's dissertation needs to be situated in the domain of medical radiation physics. Note that the formal recognition by the Belgian Federal Agency for Nuclear Control (http://www.fanc.fgov.be/) as 'Expert in Medical Radiation Physics' requires an additional clinical training of minimum 1 year.

Evolution of the programme

Following up on a recommendation of the CTI visitation in 2016, a BSc in Biomedical Engineering programme was formally introduced in 2019-2020 which subsequently led to a redesign of the master curriculum. Basic life science courses and broadening engineering subjects such as biomaterials, bio-electronics and biomechanics were added to the bachelor curriculum. Major modifications to the master curriculum included

- 6 extra credits of elective courses so that students have a window of 30 credits that will allow them, even more than before, to define their own curriculum either at UGent and/or VUB, either as part of an Erasmus exchange with a partner university. With 30 credits of elective courses, it becomes easier to take up a complete semester abroad.
- Introduction of new compulsory courses (sensor design and fabrication, data analytics, biomedical robotics) to meet recent evolutions in biomedical engineering and better prepare the students for the job market.
- All students take a 6 credit computational course, but have the freedom to opt for a biomechanics or a neuro-engineering course.
- The course *Human and Environment, Safety and Regulations* disappears but the safety and regulations aspects is integrated in *Medical Equipment*, which changes name and becomes Medical Equipment, Safety and Regulations.
- Biomaterials was extended to also cover principles of Tissue Engineering.
- The hospital project is increased in credit weight (from 3 to 5 credits), so that students can finalize a meaningful project together with a medical doctor.
- Per request of the students, we created the possibility to formally specialize (mentioned on the diploma supplement) in Biomechanics and Biomaterials, Radiation Physics, Neuro-engineering or Sensors and Devices.

In parallel and interwoven with the MSc in Biomedical Engineering, we ran the International MSc in Biomedical Engineering (CEMACUBE programme) together with the University of Groningen (coordinator), RWTH Aachen, Trinity College Dublin and the Czech Technical University in Prague. Students were admitted via the University of Groningen, and studied year one with one partner and year two with another partner to receive a double degree. Following a progressive decline in the number of students and difficulties to run the programme in a sustainable way, the consortium decided to stop the programme. The last generation of students was admitted in 2019-2020. The consortium will maintain collaboration via bilateral Erasmus exchange and/or dedicated double degree programs. The first contacts have been made with The Czech Technical University in Prague. The impact of stopping CEMACUBE on the international student population will be very limited as we only received very few CEMACUBE students over the past years, and the number of international degree students applying for the local programme is increasing steadily (to about 30% of the total student population).

Admission

The Master of Science in Biomedical Engineering is open to national and international students. National students with an academic BSc degree in Biomedical Engineering automatically qualify for admission. Students with BSc in another engineering discipline and few other diplomas can be admitted after taking a preparatory programme. International students with a BSc in Biomedical Engineering: admission after assessment of individual application where the equivalence with BSc in Biomedical engineering programs at UGent or VUB is checked. Applicants should master the English language at the B2 level.

The programme's context

The BSc/MSc in Biomedical Engineering is a still relatively young programme with a quite unique multidisciplinary identity that has established its position alongside the "traditional" engineering programmes. In Gent, there is the initiative to materialise the BME ecosystem through "Engineering for Health", a community of like-minded individuals with the same purpose: accelerating medical technology and medical device innovation; also in Brussels, a similar BME ecosystem is developed. Hospitals, corporate business and spin-offs in medical technology and health care are important partners for the BME programme, and we stimulate active collaboration and interaction through interaction with the industry advisory board, company visits and the yearly organization of a Biomedical Industry Day. The BME engineering student organisation, BEAM, plays an important role in our BME ecosystem and, more and more, plays the role of interface between the programme board and industry. Since a few years, BEAM has successfully taken over the organization of our yearly Biomedical Industry Day, organizes frequent events with industry and aims for an active engagement in Alumni activities.

It has always been an important ambition of the programme to create a genuine international atmosphere among our students and to actively involve and empower international students in the programme. More and more international degree students find their way to our MSc programme, and we have active Erasmus exchange with excellent international universities as the Politecnico di Milano, Ecole Polytechnique de Lausanne, Norwegian Technical University in Trondheim and several others.

SWOC-analysis

Strengths

- Biomedical engineering is an attractive discipline, bridging engineering and medical/biological sciences.
- The discipline continues to grow; engineering technology leads and supports evolutions in healthcare and will provide solutions for the socio-economic impact of the ageing population.
- Redesigned attractive and updated BSc/MSc curriculum providing a solid BME basis in the different subdisciplines yet with the opportunity for students to design their own master curriculum for a total of 60 credits.
- The BSc/MSc in BME programme stimulates a problem-solving and solution-driven entrepreneurial attitude through project work throughout the complete BSc/MSc track (60 credits in total, of which 41 in the master programme).
- Open and diverse BME ecosystem incorporating students (BEAM) and academia, hospitals, industry and other stakeholders that dynamically supports and stimulates students and teaching staff in their personal development and in their professional careers.
- Strong research teams backing up the educational programme and providing excellent opportunities for master's dissertations and continued PhD research.
- The involvement of the medical faculties of UGent and VUB in the programme is quite strong; the programme is truly interdisciplinary with students taking up a project within the hospital.
- A gender balanced and diverse student population with a genuine international atmosphere among our students.

Weaknesses

- The inter-university organisation of the MSc in BME brings along a number of organisational problems that seem difficult to solve structurally due to the use of two parallel administrations, e-learning systems, the physical distance and difficult mobility between campuses at UGent and VUB

Opportunities

- The excellent international networks and partnerships provide the opportunity to students to specialise in several biomedical engineering domains in a partner university.
- The redesigned curriculum should attract the best students worldwide.
- More and more alumni find their way into (leading positions) in industry. They will help to shape and develop BME not only on national but also on an international level and have the potential to become important partners of the programme in providing feedback on the programme and the learning objectives and offer internship and job opportunities.
- Worldwide, biomedical engineering attracts proportionally more female students than the more traditional engineering disciplines. A better promotion, also in secondary schools, could increase the number of female engineering students.

Challenges

- Although the implementation of the BSc in BME only dates from 2019-2020, it seems that the programme attracts an increasing number of students in the BSc and, hence, in the MSc in BME. This, together with a growing number of international degrees students in the master programme will lead to larger student groups than we are used to. Larger groups will require special attention for the practical organisation of some courses requiring a vivid and close interaction with the students.
- There are few large companies with large R&D or production facilities in Belgium. At the same time, the BME ecosystem is dynamic with an increasing number of start-ups, scale-ups and a growing number of biomedical engineering in hospitals. If the number of students would grow faster than the domain, this might pose problems with internships and job opportunities.
- It remains difficult to assess the level and background of incoming international students. This might threaten the level achieved and imbalance the envisioned mix between local and international students.

Unfortunately, university policy does not allow us to impose an entrance test (as the GRE) to assess the level of students in especially quantitative reasoning.

Strategies for improvement

- In the next few years, we will closely monitor the effect of the recent curriculum redesign and assess whether further finetuning and optimization is required in the BSc/MSc curriculum.
- Reflection with the industry advisory board learns that the technical level of graduates is excellent, but there could be more attention for acquiring social skills in the programme, such as the skills to communicate within a team and to provide/receive feedback.
- In addition to an attractive Erasmus portfolio, it may be relevant to pursue structural double degree partnerships with a select number of reputed institutions.

2.3 Master of Science in Chemical Engineering

Programme objectives

The Master of Science in Chemical Engineering offers students a comprehensive training to master the fundamental chemical engineering principles. A chemical engineer has to ensure the design, construction, improvement and maintenance of installations and equipment in the chemical industry. A graduate in chemical engineering is skilled to innovate, to manage an entire installation as well as to acquire a detailed insight in the performance of its individual parts and their interaction. This requires a combination of abstract reasoning but also of common sense, aiming at a practical implementation. Of course, a graduate in chemical engineering is trained to be involved in and lead research and development in the broad chemical industry.

Programme specific competences

As explained in Section 3.2 (SER, Part A), many competences are shared with the other Master of Science in Engineering programmes and are not repeated here. Below are the programme specific competences in 5 relevant fields. In particular the strive towards innovation and creativity in complementary specific competences 1.3-1.5 deserves to be mentioned, which go hand-in-hand with complementary specific competence 2.6 and 2.9. Safety is embedded in the generic societal competences. Given the programme's attention towards this aspect, an additional complementary specific competence could be formulated in this respect. Another aspect are the mathematical/analytical skills that are targeted as evident from complementary specific competences 1.6-1.9, 2.7, 2.8, 3.6 and 3.7.

Competence field 1: Competences in one/more scientific discipline(s)

3. Innovative use of expert-knowledge in all parts of chemical installations and the processes taking place in them.
4. Creative use of expert-knowledge for design and optimisation of chemical installations.
5. Original, constructive and innovative use of different and supporting engineering-disciplines during design and research.
6. Apply knowledge of basic chemistry to chemical installations, especially during development of chemical-analytical ways of thinking.
7. Apply knowledge of basic mathematics to chemical installations, especially during the development of mathematical-analytical ways of thinking.
8. Apply knowledge of chemistry and process technology to arrive at a solution-focused approach of reactor design and choice of materials.
9. Apply knowledge of physics and process technology to arrive at a solution-focused choice of apparatus.

Competence field 2: Scientific competences

6. Be able to handle lack of data for multidisciplinary formulations of problems.
7. Compose experimental schemata in view of design and optimisation of models.
8. Perform result-focused scientific research and design.
9. Be prepared to identify, evaluate and eliminate shortcomings in own research and design.

Competence field 3: Intellectual competences

6. Problem-avoiding, problem-solving and system-oriented scientific thinking.
7. Critically analyse scientific and industrial problems in the domain of chemical technology and compare own analysis to that of others.
8. Independently extend the own area of research, taking into account the constant evolution of the area of expertise.

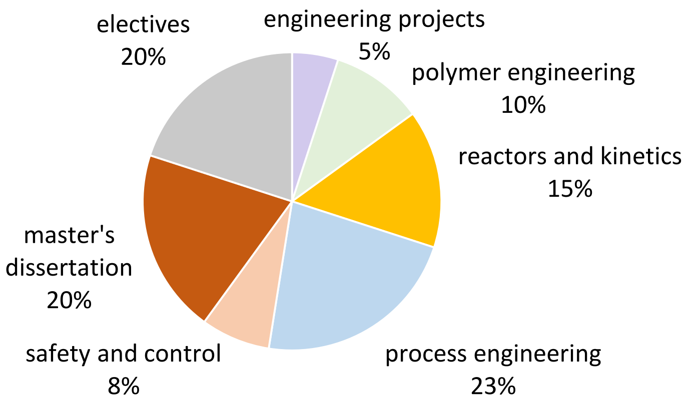
Competence field 4: Competences in cooperation and communication

5. Be integrated in research activities of a department.
6. Work in an international group (students, PhD-students and researchers).

Competence field 5: Societal competences

4. Put research and development in a societal context, taking into account ethical considerations.

Structure of the programme



MSc in Chemical Engineering

Term 1	Term 2	Term 3	Term 4
Unit Operations in Chemical Industry	Chemistry of Industrial Processes	Master's Dissertation	
Sustainable Chemical Production Processes	Polymer Reaction Engineering	Chemical Reactors: Fundamentals and Applications	Safety, Health and Environmental Management
Structure and Dynamics of Polymers	Chemical Process Design	Computer Control of Industrial Processes	
Kinetic Modelling and Simulation	Computational Fluid Dynamics in Chemical Technology	Industrial Project	
Thermal Installations			

The programme structure is built in coherence with the recommendation by the "European Federation of Chemical Engineering" and contains 60% of compulsory courses, amounting to 72 out of 120 ECTS. The master's dissertation accounts for 24 ECTS and the other 24 ECTS credits are reserved for elective courses.

The compulsory courses cover various aspects of chemical engineering and are linked to both research interests and industrial needs. In these courses, chemical engineering is studied in depth from molecular scale towards industrial scale, aiming at acquiring a complete, multi-scale understanding of chemical processes. The courses about "Reactors and kinetics" consider chemical processes at the smallest and medium length and time scales. Examples are elementary chemical reactions, catalyst design and reactor fundamentals. The majority of courses consider medium and large time and length scales, such as unit operations and process modelling. General chemical processes of all types are dealt with. Within several of these modules, economic aspects are considered. The polymer engineering courses study polymers on all length and time scales, taking into account reaction mechanisms, production methods, and macroscopic properties. A unique course is the Industrial Project, in which groups of 4 to 6 students solve an industrially relevant challenge, in cooperation with a company (*e.g.* ExxonMobil, Dow, TotalEnergies, …). This is a typical process engineering task which prepares students for a potential first job. The focus is both on applying the acquired knowledge to a real-life situation (such as process optimization, upscaling, …) and on soft skills (presenting, reporting, teamwork, …). Safety is not only represented in the programme in the specific course on Safety, Health and Environmental Management, but also comes back in courses such as Chemical Process Design and Computer Control of Industrial Processes as well as the Industrial Project.

The student is free to choose 24 ECTS of elective courses. At least 6 ECTS should be taken from a selected list elective social courses. Maximum 18 ECTS credits are left for spending on other electives, which is possible in two ways. The first path allows the student to take courses across different clusters. These clusters are: Economic Aspects, Chemistry, Fundamental Techniques, Materials, and Technology. The second path lets the student obtain a minor in either Operations Management, Biosystems, or Environment and Sustainable Development. The minor is formally acknowledged in the diploma supplement.

An internship is – just like in all other engineering masters at Ghent University – not mandatory, but available as an elective course. Students can acquire 3 ECTS for an internship between 4 and 6 weeks, and 6 ECTS for a longer one. This strongly motivates students to effectively perform an internship. It frequently happens that a student performs an additional or longer internship, i.e., more than strictly required for acquiring the maximum of 6 ECTS. It demonstrates the intrinsic motivation of students in the programme to perform an internship and the importance attached by the programme committee to such internships. Typically, the internship is done during the summer between M1 and M2. Before the COVID-19 pandemic, approximately 100% of students performed an internship. Regularly, the internship resulted in a first contract for the student after graduating.

Independence, critical thinking, and project management skills are explicitly strengthened in the master dissertation (24 ECTS). Students can perform experimental work in the department's research laboratories (high-throughput laboratory, catalyst characterization, polymer synthesis lab, steam cracking pilot plant, …) and/or perform computational work for which access to high-performance computing is granted. Master theses can also be done in collaboration with industry.

Evolution of the programme/follow-up of CTI-recommendations

Since the last CTI visit, the programme's content and its operational governance have evolved in response to the recommendations made, simultaneously allowing to account for (i) recent scientific developments and (ii) changes of interest by industry and society. These evolutions have been supported by the appointment of new lecturers. More particularly, topics about **sustainability** have been included in the curriculum (not only at the bachelor, but also at the master level).

At the time of the previous CTI visit, **process safety** was identified as underexposed in the chemical engineering programme and to be taught in a very mathematical way. Several changes were made since. First of all, the mandatory Health, Safety and Environment course has been transformed into an interactive course, with several guest lectures from industrial and governmental experts. Secondly, students can opt for *"Process Safety: Reactor Technology, Intrinsic Hazards and Process Safety Hazard Analysis*" as an elective **summer course**, taught by UGent professors and industrial experts. The spots available for students are each year filled quite rapidly, with an important share of students participating in this course. In addition, process safety became more important in the Computer Control of Industrial Processes and Chemical Process Design courses. The latter course now also includes a mandatory **hands-on** experience in a TotalEnergies training centre in which students get a full day of **safety training**. The students also get a specific training on safety in the framework of their master thesis organized by the Laboratory for Chemical Technology. This training is not limited to the students performing actual lab work but is extended to all students, to stress once more the importance the programme committee attaches to safety.

The student population in the master of chemical engineering has **diversified** and slightly increased, on average, over the last years. Several reasons can be listed for this diversification:

(i) More students have considered obtaining a master in chemical engineering **after obtaining another master**, such as in chemical engineering technology, bioscience engineering or chemistry. While promoting the master was still a working point (and a CTI point of critique) by the last CTI visit, a large effort has been made to make the master more known.

(ii) The **interest** in studying chemical engineering in Ghent **grew abroad**. Eventually, about 10 to 15% of the international applicants is starting in the master. The other applicants either do not match the requirements (e.g. language criteria), get accepted elsewhere, or do not come because no scholarship is obtained.

(iii) The **percentage** of students from the **bachelor** in chemical engineering and materials science that chooses the master in chemical engineering over another master, slightly **increased**, yet this corresponds with a slight decrease in absolute numbers. This might be related to the creation of a new main subject in the bachelor intended to attract a higher number of students to the Faculty of Engineering and Architecture as a whole, but also proved to be popular among students already within the Faculty. It is therefore assumed that increasing the student flux in the bachelor overall is the main target for increasing the student population in the master.

Internationalization was, is and will be one of the main working points. **Outbound** mobility is low, with about 10% of the students performing a part of their curriculum abroad. Efforts are made to make students more aware of exchange possibilities, but are currently hindered by sanitary measures and travel restrictions. New partnerships are made (e.g. University of Naples) and existing agreements are extended. The number of incoming students increased over the years, mainly by the ERASMUS programme. The aim is to increase the number of international top students to 20% of the student population, while this is currently around 10 to 15%. A new agreement is signed with CPE Lyon and students from Lyon can perform part of their programme in Ghent.

Because the change in the bachelor programme only becomes completely effective by AY 2022-2023, the master programme is yet to undergo a large make-over. The discussions in view of this make-over are currently being started and are envisaged to already account for the results of the discussion of the current CTI visit. Among others, this make-over will follow the line of the bachelor reform in which the focus on sustainability and integration of chemical engineering and material sciences. Hence, a **new chemical engineering master programme** will become effective by AY 2023-2024.

Admission

The Master of Science in Chemical Engineering is open to international students. Students are admitted if they can prove that (i) they hold a bachelor's degree of at least 180 credits, (ii) comply with the required initial competences, (iii) master the English language at the B2 level, and (iv) are strongly motivated to study Chemical Engineering. In case of a positive first, paper-based, evaluation to determine whether the applicant may qualify or not, the applicant proceeds towards an interview after which it is decided whether (i) the candidate can enrol directly into the programme, (ii) a preparatory programme is needed, or (iii) no admission can be granted whatsoever. The UGent BSc degrees in Chemical Engineering and Materials Science automatically qualify for admission. For other national degrees, the admission is subject to passing a preparatory programme.

The programme's context

This topic is presented jointly in the part pertaining to the Bachelor of Science in Engineering – main subject Chemical Engineering and Materials Science.

SWOC-analysis

Strengths

- An excellent relation between theory and practice via a well-elaborated project line. Furthermore, the practically oriented courses are (partially) taught by lecturers with main activities in the industry.
- Access to chemical test installations at lab and pilot scale providing unique hands-on experiences.
- Teaching methods dedicated to the content of the courses, ranging from classical lectures to exercise sessions and individual projects to group projects with a pronounced design component.
- The systematic application of evaluation procedures in the admission of incoming, external students.

Weaknesses

- The spread in time of the international applications for joining the master's programme. Among others, this may lead to missing earlier deadlines for scholarship applications and a difficult to plan work-load for the interviews.
- Guaranteeing a more widespread application of active learning methods.
- Establishing a proper balance between in-depth and broadening course content.

Opportunities

- The recent update of the bachelor programme with an increased focus towards sustainability and more emphasis on the links between chemical engineering and materials engineering will encourage the incorporation of these themes into the master.
- The merger of the programme committees (chemical engineering and materials science) and research groups into a single entity allows for a stronger interaction and cooperation between the stakeholders.
- Recently, a core team has been installed within the programme committee dedicated to the curation and optimization of the education programmes.
- The strong international, scientific reputation of the lecturers in the master's programme provides the opportunity to get the students acquainted with and to contribute to outstanding scientific research.

- The numerous relations of the lecturers with industry and interest groups allow to bring the students in contact with society's most relevant topics, e.g., through internships, company visits and guest seminars.
- Strong position of the chemical industry in Belgium and the neighbouring regions

Challenges:

- Attracting more students from the bachelor programmes offered by the FEA.
- It is important to have a unified branding, via all available communication channels, of the differences between the engineering (ir.) and engineering technology (Ing.) programmes. This is crucial for both programmes when the prospective students have to make a final selection.
- Further increase the external visibility of the English taught master's programme to attract more top students that have a matching background knowledge
- The guaranteed continuity of the practically oriented courses (generally taught by lecturers with main activities in the industry).

Strategies for improvement

- Reform of the master's programme in line with the changes of the bachelor programme considering the total workload and the balance between in-depth and broadening course content
- Evaluating the programme in consultation with the concerned lecturers, among others based on the course evaluations.
- Informing the students in time and comprehensively about (i) the choice of a specific master's programme while in the final year of the bachelor's programme (ii) possible foreign experiences (iii) the master's dissertation possibilities and internships.
- Increasing the visibility of the programmes via participation in the Flemish Science Week, being part of popular science events such as '*boetiek techniek*', alumni activities (AIG-visits, workshops, ie-net) and organizing master classes and summer courses.

2.4 Master of Science in Sustainable Materials Engineering

Programme objectives

The programme aims at the study of the extraction , production, processing, properties, sustainable use and recycling of a whole range of materials. This implies (i) description and modelling of properties of materials, specifically the chemical, mechanical and thermal production and processing aspects in materials engineering, (ii) effect of the chemical composition and processing conditions on the structure and properties of materials in view of optimal performance and application, and, (iii) behaviour of materials in different user circumstances and how degradation (e.g. by its use or by interaction with its environment) can be limited. Dealing with limited resource availability worldwide in a sustainable way is an important objective of the programme. Important materials dealt with are metals, polymers, textiles, composites and ceramics.

Programme specific competences

The master's programme objectives are formalized as a list of competences and associated learning outcomes that are shared with the other Master of Science in Engineering programmes. These are complemented by a list of additional competences (listed below) particular to the MSc in Sustainable Materials Engineering, showing that the programme encompasses the complete design and manufacturing chain of materials and their use. These competences have been benchmarked against other universities in Flanders.

Competence field 1: Competences in one/more scientific discipline(s)

4. Advanced knowledge of characteristics and application fields of materials in order to obtain products with specific properties.
5. Advanced knowledge of and practical experience with the use of techniques and methods to investigate the characteristics of materials.
6. Advanced knowledge of materials science, ability to use general and physical chemistry in an innovative way.

Main subject 'Metal Science and Engineering'

7. Advanced knowledge of the use of chemical, mechanical and thermal process-technological aspects of materials engineering.
8. Use advanced knowledge of mathematics and statistics to develop mathematical models for materials phenomena (especially metals and their alloys) and for metallurgical processes.
9. Advanced knowledge and utilisation of the interactions between the chemical composition of materials (metals, alloys, polymers) and their production parameters in order to obtain products with optimal properties and increased life span.
10. Advanced knowledge of the processes available for recycling of materials.

Main subject 'Polymer and Fibre Engineering'

11. Advanced knowledge of the use of fibrous materials.
12. Advanced knowledge of the use of chemical and mechanical process technological aspects of materials engineering.
13. Use advanced knowledge of mathematics and statistics to develop mathematical models for materials phenomena (in fibrous materials and polymers) and for textile-technological processes.
14. Advanced knowledge of the use of and the interactions between the selection of raw materials and the process-parameters, keeping in mind the properties of fibrous materials and polymers with specific functionalities.

Competence field 2: Scientific competences

6. Autonomously and flexibly study in depth complex, multidisciplinary problems in material science, also in case of limited data inputs.
7. Design experimental procedures and make use of self-developed models.
8. Perform scientific research in the fields of metallurgy and fibre engineering, keeping in mind its industrial relevance.

Competence field 3: Intellectual competences

6. Think in a systematic, scientific way that avoids and solves problems to optimise production processes, to develop new materials and to improve existing ones.
7. Show technical creativity and use relevant knowledge from other disciplines.

Competence field 4: Competences in cooperation and communication

7. Be integrated in research activities of a department.
8. Work in an international group (students, PhD-students and researchers).

Competence field 5: Societal competences

5. Put research and development in a societal context, taking into account ethical considerations.

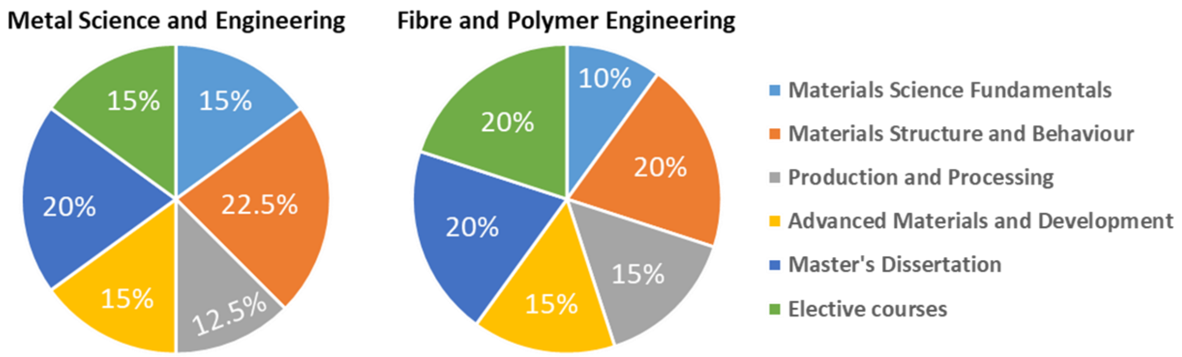
Structure of the programme

The study programme consists of 4 parts: general compulsory courses, a choice between the two majors "Metals Science and Engineering" and "Polymers and Fibre Engineering" each with specific compulsory courses, elective courses and the master's dissertation (see pie chart below). The compulsory courses cover approx. 60% of the programme. They target basic material sciences, specific material types, structure and behaviour of materials and production and processing of materials. The general courses (36 credits) address more generic aspects of materials regardless of the type. The courses in the majors focus more in depth on specific types of materials (metals, polymers and fibre-based materials resp.).

The major "Metal Science and Engineering" (42 credits, compulsory) focuses on metals with emphasis on understanding and developing innovative, light metals used in constructions where these metals have to fulfil increasingly stringent safety and emission requirements. Both optimisation of the chemical composition (alloy formation) and processing are discussed in detail. Ceramic materials are also highlighted. The concept of sustainability is addressed. On the one hand, the student will acquire knowledge to understand why a material deteriorates in contact with its environment and how surface engineering can increase its life span and improve its performance. On the other hand, the student will learn to process metals from secondary sources, such as scrap or e-waste, and will understand that metals can be produced that are equally performing as metals produced from primary raw materials (ores). Further, emphasis is put on modelling: the student will become familiar with the available options to simulate the material properties and their evolution and subsequently will learn to adequately interpret the outcome of these simulations.

The major "Polymers and Fibre Engineering" (36 credits, compulsory) focuses on polymers, fibres and fibre-based materials such as textiles or composites. The programme covers these materials, both natural and man-made, and their physical, chemical and mechanical processing and treatment. Emphasis is put on understanding the fundamental properties and behaviour of the different materials, how they relate to the material structure, and on understanding processing technology and sustainable engineering. Students will learn about additives and colourants and dyes, which are used to give polymers and textile-based materials a specific aesthetic and better or even new properties (flame retardancy, crease resistance, antibacterial, soil resistance…), thus creating added value. As such, students obtain an understanding of textile materials and processes with special attention for the development of products with specific functionalities. They will acquire knowledge on new technologies such as nanotechnology and bio-based materials and processes. A specific type of functional materials relates to intelligent (interactive) textile materials.

Elective courses (18 resp. 24 credits) offer students the possibility to further concentrate on specific materials or on specific themes such as ecology, nanotechnology, smart materials, chemistry or business oriented technical and non-technical topics. As part of the elective courses, a master student can choose for a minor (18 credits) in their curriculum, i.e. a series of subjects grouped around a well-specified theme. The following minors are offered: Operations Management, Environment and Sustainable Development and Automotive Production Engineering. The two main subjects and the minors are formally acknowledged in the diploma supplement. Independence, critical thinking and project management competences are specifically strengthened in the master's dissertation (24 credits). Students can pick one of the many topics that are proposed by the lecturers of the Materials Science Engineering programme, or they can suggest a self-proposed topic.



Course content themes for both majors in the MSc. Sustainable Materials Engineering programme.

Term 1	Term 2	Term 3	Term 4
Materials Science Thermodynamics	**Polymer Processing**	**Master's Dissertation**	
Fracture and Deformation Behaviour of Metals	Physical Materials Science	**Composites**	Microstructural Material Models
Structure and Dynamics of Polymers	Corrosion and Surface Technology	Computational Materials Physics	Ceramic Functional Materials
Micro-analysis and Structure Determination in Materials Science	Metal Extraction and Recycling		
Metals Processing and Technology	Microstructure-Property Control of Metals		
Elective course (18 ECT credits)			

Organisation of the Master of Science in Sustainable Materials Engineering: major Metal Science and Engineering. Common courses for both masters are indicated in bold.

Term 1	Term 2	Term 3	Term 4
Materials Science Thermodynamics	**Polymer Processing**	**Master's Dissertation**	
Fracture and Deformation Behaviour of Metals	Finishing and Coating Technology	**Composites**	Functional Textile Materials
Structure and Dynamics of Polymers	Process Technology in Textiles	Analysis of Products and Processes	
Micro-analysis and Structure Determination in Materials Science	Colour and its Applications in Textiles		
Fibre Materials			
Elective courses (24 ECT credits)			

Organisation of the Master of Science in Sustainable Materials Engineering: major Polymers and Fibre Engineering. Common courses for both masters are indicated in bold.

Evolution of the programme/follow-up of CTI-recommendations

As detailed in the SER of the bachelor programme Chemical Engineering and Materials Science, the past years have resulted in a strong change of the bachelor programme as well as the establishment of the Department of Materials, Textiles and Chemical Engineering (MaTCh) that combines the research groups working on chemical engineering and materials science. Following the change of the bachelor programme, a revision of the master's programme is planned for the coming years. Although several recommendations from CTI have already been taken into account (see the following paragraphs), this revision is an ideal moment to further improve the coherence between courses and both majors. It also provides the opportunity to discuss and potentially implement more generic courses in the programme as compulsory, e.g. those related to (project) management, economics, society and sustainability, which are now often taken by students as elective courses.

The sustainability aspects of the programme were further expanded. As noted in the intermediate report, some courses are completely devoted to sustainability, e.g. "extractive metallurgy and recycling" or "corrosion and surface engineering". In other courses, sustainability aspects such as environmental impact and end-of-life considerations form a significant part, e.g. "polymer processing" or "fibre materials". Many courses however address various aspects of sustainability, such as proper design, material selection, increase of material durability, end of life, consumption of resources. With the revision of the bachelor programme, containing a larger sustainability-related course share, in place from academic year 21-22 onwards, the revision of the master's programme can built further on these fundamentals. Furthermore, students can currently – depending on their interest – choose up to 24 additional credits relating to sustainability (among others) by choosing appropriate elective courses. Those courses are typically given from a different perspective, further broadening the students' view.

Participation in sustainability projects by various research groups of MaTCh has also led to the creation of the interfaculty platform "Centre for Sustainable Chemistry" (CSC). CSC aims at supporting the transition towards an ecological, social and economically sustainable society by joining relevant research activities in order to merge and develop the necessary expertise. MaTCh actively contributes to the visibility of CSC to all stakeholders, including students. CSC is obviously an excellent platform that can contribute further to the visibility of sustainability in education, as well as for bringing in expertise in education.

In addition, new (young) staff members are now actively involved in the master's programme, and their updated course materials and content are appreciated by the students. For the major 'Polymer and Fibre Engineering', this has also resulted in a better differentiation between its master programme and that of the international (Erasmus Mundus) WE-TEAM master's in Textile Engineering which has also been substantially revised. While the latter really focuses on delivering textile engineers aimed at the international job market, the 'Sustainable Materials Engineering' programme focuses much more on delivering materials engineers with profound insight into materials science and for which fibre and textile materials is just one of many applications.

Admission

The Master of Science in Sustainable Materials Engineering is open to international students. Students are admitted if they can prove that (i) they hold a bachelor's degree of at least 180 credits with sufficient grades from an internationally recognized institute, (ii) comply with the required initial competences, (iii) master the English language at the B2 level, and (iv) are strongly motivated to study Materials Science Engineering. In case of a positive first, paper-based, evaluation to determine whether the applicant may qualify or not, the applicant proceeds towards an interview after which it is decided whether (i) the candidate can enrol directly into the programme, (ii) a preparatory programme is needed, or (iii) no admission can be granted whatsoever. The BSc degrees in Chemical Engineering and Materials Science automatically qualify for admission. For other national degrees, the admission is subject to passing a preparatory course or an adapted bridging programme.

The programme's context

This topic is presented jointly in the part pertaining to the Bachelor of Science in Engineering: main subject - Chemical Engineering and Materials Science.

SWOC-analysis

Strengths

- Students appreciate the content of the programme and its build-up. The competences are adequate, clearly formulated and appreciated by the students.
- The master allows students to get a global view on Materials Engineering via the common courses while the major allows a student to obtain a more thorough specialization according to his/her interests. Via elective courses, students are still able to take courses of the other majors, allowing interaction between both specializations.
- Students get in touch with the industrial partners and other universities via guest lectures, courses given by external industry experts or professors and company visits.
- A strong research environment as a whole offers important benefits for the students. There are some unique research competences (e.g. textiles, hydrogen embrittlement, modelling of composite materials, corrosion,…). There is also the presence of the materials research cluster at the campus.

Weaknesses

- The students are immersed in an international environment through the research groups during their master, but only a minority still opts to study abroad.
- Students with an interest in mechanical engineering sometimes prefer more course content related to macroscopic properties and applications of materials, and less on microstructure and physical metallurgy.

Opportunities

- The recent update of the bachelor programme with an increased focus towards sustainability and more emphasis on the links between chemical engineering and materials engineering will encourage the incorporation of these themes into the master.
- The merger of the programme committees (chemical engineering and materials science) and research groups into a single entity allows for a stronger interaction and cooperation between the stakeholders.

Challenges

- Attracting better profiles for international students as current profiles are plenty but often lack sufficient background knowledge to start the master's programme.
- Students do not perceive the master to be sufficiently focussed on sustainability yet.

Strategies for Improvement

- The programme committee is looking at revising the master's curriculum to improve its content and coherency, as well as extending course content related to sustainability in line with the bachelor programme.
- More and earlier promotion of international opportunities such as Erasmus or internships to show students the benefits of international experiences and to increase the international mobility from and towards Ghent University by using testimonials from students whom participated in this exchange and actively informing students of this possibility (e.g. during a materials science course in the bachelor programme).

2.5 Master of Science in Civil Engineering

Programme objectives

The goal of the Master of Science in Civil Engineering is to train broadly educated civil engineers possessing a duly underpinned and wide-ranging field of knowledge in the area of civil and structural engineering, with a prospective specialisation in areas such as construction design, dredging and offshore engineering or operations management. Furthermore, this master trains its graduates to acquire the necessary research attitude and research competences to contribute to the innovation in industry or the scientific research in the discipline of civil and structural engineering. At the same time, graduates should be capable to do so by embracing a lifelong learning attitude. In addition, the master's programme trains its graduates to gain the necessary social skills (among others, by teamwork in ample projects and assignments), which are most useful to take on people management positions.
In order to reach these objectives, the master's programme focuses on the following targets: to possess a very solid and duly underpinned knowledge of civil and structural engineering in a wide perspective, involving all levels of societal interaction; to be duly capable of operating within a wide range of (civil and structural engineering) activities; to have a due level of specialist know-how in a branch of civil and structural engineering (such as 'constructional design and calculation' or 'dredging and offshore engineering') or to have acquired a further additional know-how in a different subject field (such as operations management); to be duly capable of 'conceptual thinking', with the link and association with other disciplines as an element of importance; to have a due command of the methodology involved in conducting research; to be duly able to schematise and model technical processes; to gain a due understanding of concrete problems and the prospective solutions by adopting lines of reasoning that are based on models and diagram representations; to have a due understanding of the societal aspects such as sustainability and to have acquired the appropriate attitudes in terms of ethically and socially responsible action; to have acquired further skills and competences in the area of written, graphic and oral presentation.

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the master's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GM1-GM6). All competences are shared with the other Master of Science in Engineering programmes. The most important additions are the programme specific competences M1.3-M1.9, showing that the programme of civil engineering encompasses all branches of the civil engineering field. This goes from finite element modelling, over roads, bridges, calculation methods, materials and hydraulic engineering to a sense for innovation and problem solving. Furthermore, three programme specific scientific competences, M2.6-M2.8, focus on the application of theoretical concepts to the design, construction and evaluation of civil engineering projects. Profession-specific competences M6.10-M6.11 emphasize the need for a broad education including important social responsibilities.

Field of competences M1: Competence in one/more scientific discipline(s)

- M1.3 Innovative use of expert knowledge in the field of the finite element methods and structural dynamics.
- M1.4 Apply knowledge about roads and bridges (use of materials, way of construction and integration in the environment), bearing in mind the environmental effects.
- M1.5 Having the attitude to use social sciences in an inventive or innovative way during the process of design and research.
- M1.6 Use profound civil engineering knowledge in order to analyze and solve complex civil engineering problems.
- M1.7 Analyze and solve new and complex civil engineering problems by means of advanced calculation methods.
- M1.8 Be familiar with behaviour of materials, models of materials and the application of materials in complex constructions.
- M1.9 To critically apply knowledge of flowing water and its mathematical formulation to hydraulic engineering constructions and problems concerning integral water management.

Field of competences M2: Scientific competences

- M2.6 Contribute to the conception and design of constructions and examine the stability of advanced constructions.
- M2.7 Apply design and research methods and techniques to highly advanced ideas and applications in various civil engineering sectors.

M2.8 Assess, design, calculate and evaluate every building from foundations to construction in an integrated and multidisciplinary way.

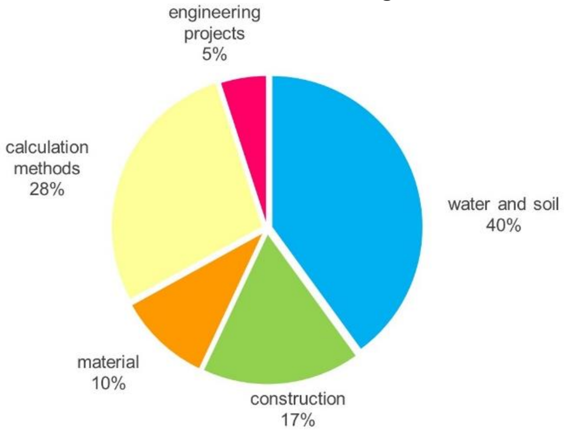
Field of competences M6: Profession-specific competences

M6.10 Be able to perform design and/or research independently in a broad range of advanced civil engineering working situations.

M6.11 Be aware of the social responsibility of a civil engineer.

Structure of the programme

The study programme consists of 64 credits of compulsory courses and 56 credits of elective courses (including the master's dissertation of 24 credits). The content of the master is the result of a careful weighing of all civil engineering components: calculation methods, material knowledge, construction specifics, water and soil.



Programme structure Master of Science in Civil Engineering (compulsory courses)

The compulsory courses (53% of the programme) teach the minimal set of competences that all the graduates should have, and consist of:

- 28% calculation methods (structural stability, dynamics, reliability and risk analysis, finite element modelling)
- 10% material oriented courses (prestressed and reinforced concrete)
- 18% construction specific courses (road engineering and mobility, bridge and tunnel engineering)
- 44% water & soil oriented courses (groundwater flow, water management, inland waterways, coastal engineering, geotechnics)
- 5% projects (design of civil structures)

Term 1	Term 2	Term 3	Term 4
Structural Dynamics	Structural Reliability and Risk Analysis	Advanced Bridge and Tunnel Engineering	Design of Civil Structures
Structural Stability	Concrete Structures: Prestressed Concrete and Slabs	Coastal Engineering and Harbour Construction	Elective Courses
FEM and Constitutive Material Laws in Structural Engineering	Specialised Road Engineering and Mobility	Elective Courses	Master's Dissertation
Groundwater and Contaminant Flow	Inland Waterways and Locks	Master's Dissertation	
Water Management and Environment	Geotechnics		
Elective Courses	Elective Courses		

Courses in the Master of Science in Civil Engineering

The curriculum is organized in such a way that subsequent terms leave increasing room for elective courses and for the master's dissertation in the last year. The master's programme is a logical continuation of the bachelor's

programme with main subject in Civil Engineering. The common courses (the 'core programme') are characterised by four major 'tracks': 'Structural analysis', 'Materials', 'Construction and design', and 'Water and soil'. These tracks started in the bachelor's programme and build upon a set of elective courses associated to the majors (cf. infra). In these tracks ample attention is devoted to research and research capabilities.
In addition to the compulsory part, the master's programme contains 56 credits of elective courses:

- A master's dissertation of 24 credits. The lecturers in the civil engineering field propose a large list of topics with a very wide variety each year. While this list allows for ample choice, irrespective of the elected major or minor, the students also have the opportunity to submit their own choice of subject to the SPC, with the support of a supervisor.
- 20 credits of technical courses from one of the two majors or the minor:
    - Major Construction Design, with a focus on conceptual design, spatial structures, non-linear and plastic methods in structural analysis, seismic design, glass & façade structures.
    - Major Dredging & Offshore Engineering, which focuses on dredging, offshore constructions and foundations, maritime technology and coastal hydrodynamics.
    - Minor Operations Management, with a focus on operations research models and methods, manufacturing planning and control, and electives in e.g. project management, quality engineering and industrial statistics

  The majors and minor are formally acknowledged on the diploma supplement.
- 6 credits of Elective Social courses, chosen from the faculty-wide list of Elective Social courses. This list contains - amongst others - entrepreneurial training, domestic and international internships, soft skills training, …
- 6 credits from the list of elective course for the Master in Civil Engineering. This list contains domain-specific courses such as Prefabricated Concrete construction, Railroads, LCA of Materials and Structures,…

Evolution of the programme

Since 2015-2016, the following changes were implemented:

- Compulsory courses: Structural Reliability and Risk Analysis became a compulsory course, rather than a course in the majors.
- Major Construction Design: the course on Glass and Timber structures was replaced by the course on Glass and Façade Structures.
- Minor Operations Management: Engineering Economy and Business Skills were added as elective courses
- Elective Social courses: A number of courses were added to the list, such as Sustainability Thinking, Sustainable Energy and Rational Use of Energy, Coaching and Diversity, Introduction to Human Resource Management, Financial and Cost Price Reporting in Companies, Macroeconomics
- Elective courses Civil Engineering: Information Management in Architecture and Constructions (BIM) was added to the list.

Follow-up of CTI-recommendations

Besides the appreciation for the outstanding graduate employment, CTI has made the following recommendations in 2016.

Firstly, efforts should be made to increase the number of students taking an internship. As shown in the appendix on internships statistics of FEA (SER, part A), there has been a steady increase in the number of civil engineering students taking up an internship in their curriculum between 2014-2015 and 2017-2018. In 2018-2019, i.e. before the COVID-19 pandemic in 2019-2020 and 2020-2021, the trend reversed. To motivate the students for taking up a domestic or an international internship, specific testimonials of companies providing internships were included in the 2020 edition of Poutrix' "Civil Night" activity. The intention is to sustain this initiative.

Secondly, CTI suggested in 2016 to select certain universities for more intensive cooperation, in order to be able to select the best students and decrease the probability of drop out. As already announced in the intermediate report to CTI in 2019, the list of 38 cooperation agreements for student exchange was evaluated for renewal in November 2020. It has been decided not to renew 17 of them. For 12 other agreements, re-activation measures for a well-balanced bilateral exchange are needed. It is the hope that these efforts will also pay off at longer term for the inflow of good international degree students of the selected partner institutions.

Thirdly, CTI stated in its 2016 report that like for all other first and second year of bachelor, the study load stays high and drop out important.

As to the study load, a survey among the students has taken place in 2017-2018. For the main subject Civil Engineering of the BSc of Engineering programme, the load is perceived as “high” by 78% and “too high” by 18% of the students, whereas the corresponding average percentages for all main subjects of the BSc of Engineering are 65% and 14%. For the MSc in Civil Engineering programme, the scores “high” and “too high” get 65% and 8%, whereas the corresponding averages for all master programmes in the faculty are 57% and 17%. Based on these figures, the SPC concludes that it is mainly the study load of the bachelor’s programme that needs closer attention. After further discussion with the student representatives, it seems that the perception of (too) high load is mainly related to having to (learn how to) deal with multiple (overlapping) projects and other assignments. In any case, deadlines being too close is avoided in both the bachelor’s and master’s programme, and if new conflicts arise, students know they should not hesitate to report them. The SPC’s policy is that they are solved by priority by all lecturers concerned. In addition, due attention is given to the amount and timing of the projects and assignments in the bachelor’s programme. Contacts with graduates reveal they often tend to reconsider their opinion on the study load after some (first) work experience and are grateful for having (gradually) learned to deal with multiple simultaneous projects and deadlines and for having acquired a good working spirit.

As to the drop out, the number of master students that terminate their studies untimely varies since 2016-2017 between 2 to (exceptionally) 4 per year (i.e. 1.4 to 2.8 %). Often it concerns students which entered the master programme through the bridging programme (horizontal intake for graduates of the MSc in civil engineering technology, i.e. holders of a diploma which guarantees an easy access to the job market) or international students, because of difficulties to cope with the level of the master programme.

Admission

The Master of Science in Civil Engineering is taught in English since 2013-2014, and is open to international students. International students (the number of which fluctuates since 2016 between 9 and 12% of the total number of master students enrolled in Civil Engineering) are admitted if they can prove (i) they hold a bachelor’s degree of at least 180 credits, (ii) comply with the required initial competences, (iii) master the English language at the B2 level, and (iv) are strongly motivated to study Civil Engineering. The following degrees automatically qualify for admission: Bachelors of Science in Civil Engineering.

The programme’s context

The SPC encourages the civil engineering students to have their own identity. The civil engineering programme has a dedicated student association called Poutrix (http://www.poutrix.be/). The mission of Poutrix is to act as a bridge between the abstract and theoretical civil engineering world of the university and the “real” civil engineering world. To achieve this goal, Poutrix organizes construction site visits, company visits, lectures, participation in congresses and sector events as well as social activities, commonly supported by the lecturers involved in the Civil Engineering programme. In addition, the student association organizes a yearly civil engineering specific recruitment event, an alumni event and an international (ten day) trip to visit large construction projects and labs abroad.

The Bachelor of Science in Engineering – main subject Civil Engineering and the Master of Science in Civil Engineering jointly have an industrial advisory board. In October 2018, the number of members was increased from 8 to 10, in order to have a more balanced representation of the two majors in the MSc programme (i.e. Construction Design and Dredging & Offshore Engineering).

SWOC-analysis

The SWOC analysis of the former SER (2015) has been recalled and updated wherever appropriate.

Strengths

- Staff: The staff covers a wide scope of expertise, with very good research performance in the different areas. The teaching activities are well founded on academic research.
- Facilities: The laboratories involved in the civil engineering programme are well equipped. Some laboratories are internationally at a high level, and provide extra value for the civil engineering students.

- Level: The obtained level of the civil engineering programme is very good. The objectives of the programme are successfully translated into a relevant study programme. After graduation, students can operate at an international level.
- Poutrix: The civil engineering students have established a very instrumental and efficient student organization, called Poutrix. They organize visits to construction sites, factories, guest lectures, workshops, an alumni event,… Poutrix is contributing in a significant way to the study programme, while inducing a very nice atmosphere.

Weaknesses

- Sustainability: Aspects of the environment and sustainability are incorporated in various course units, but the students do not perceive this as such. In 2020, the common part of the bachelor's programme has been revised. This programme change strengthened the learning pathway on sustainability. In addition, sustainability and climate change adaptation aspects in the civil engineering bachelor's and master's programme check of Fall 2021, will be emphasized in the existing course units. In the meantime, a "Serious Game" on a "Sustainable Port" has been developed on behalf of the programme, which will be introduced as a new teaching activity.
- Work load: see "Follow-up of CTI-recommendations"
- Study progress: Many students need more than three years to complete the bachelor's programme with main subject in civil engineering. The percentage of students completing in 3 years increased from 57 to 63% over the period 2015-2016 to 2018-2019, whereas the percentage of students completing in 4 years decreased from 32 to 28%. These positive trends will hopefully be sustained after the COVID-19 pandemic.

Opportunities

- Teaching in English: Since 2013-2014, the master's programme in civil engineering is taught in English. This gives extra opportunities to attract international students.
- International scholarships: Some countries offer scholarships to foreign students (e.g. CSC-scholarships, China). This provides new opportunities (additional to Erasmus) for our students to spend one or two terms abroad.
- Due to the COVID-19 pandemic, lecturers and students discovered the possibilities and constraints of on-line teaching and evaluation activities. This provides opportunities for designing a careful hybrid mix of on campus and online activities.
- The Faculty of Engineering and Architecture has expressed the need for erecting a new building with lecture rooms on the campus Ardoyen. This would ideally also create opportunities for providing extra space to the students for carrying out group work, a need that is re-iterated in the (master's) students feedback on the programme in 2020.

Challenges

- Level of incoming students: As more international students are entering the civil engineering programme, their level of competences and skills need to be duly monitored, in view of maintaining the excellent level of the civil engineering programme.
- More and more, research staff consists of non-Dutch speakers. This constrains the availability of assistant academic staff for the bachelor's programme, which is still instructed in Dutch.

Strategies for improvement

- Regular programme checks: Within the civil engineering programme, we perform regular programme checks, typically resulting in a (partially) renewed study programme. This keeps the contents up-to-date and at international level. A next check is scheduled in the Fall of 2021.
- International contacts: Staff is very active at international level, keeping contacts with leading groups worldwide. This will help in attracting excellent international students and (guest) lecturers.
- Internationalisation: To motivate students for studying and working in an international context, a yearly event is organized by the Faculty of Engineering and Architecture. A specific event for civil engineering students was organized by the SPC in April 2018, where testimonials were given by graduates (cf. Intermediate report to CTI dd. 2019). No clear impact of these events is already visible, but efforts will be sustained after the COVID-19 pandemic.

- Student representatives: Based on the feedback on the programme of the students in the bachelor's programme, extra efforts will be made to increase the visibility of the student representatives in the SPC, who have an important role in the organization and quality assurance of the programme.
- Master thesis: Based on the feedback of the students in 2020, the SPC has requested the thesis supervisors and counselors to draw the explicit attention of the students to the efforts and methods which are (often tacitly) adopted to secure the scientific quality and integrity (e.g. calibration of instruments, validation of numerical simulations with experimental data or results of more advanced models, careful referencing of sources,…). In addition, it is requested to explain at beforehand the rubric and criteria used for evaluation of the thesis.

2.6 Master of Science in Computer Science Engineering

Programme objectives

The goal of the Master of Science in Computer Science Engineering is to train academic engineers who are capable of, individually or as a member of a team, building complex information processing systems. They master the conception, analysis, design, implementation, testing and management of such systems. Hereby, they will use their in-depth insight of basic sciences and the most recent technological knowledge. They will apply state-of-the-art professional tools to develop such systems. In addition, they will master the required research skills to innovate in industry and research, be able to effectively communicate towards different target audiences, possess the general intellectual competences of an academically trained engineer, and be able to assume leadership in a broad industrial and societal context, also internationally. An important aspect of the master is that it stimulates independent knowledge acquisition and application. Rather than trying to cover the complete domain, the master aims to train students to master one sufficiently large and relevant subdomain of computer science, and to develop the skill and attitude of lifelong learning.

Programme specific competences

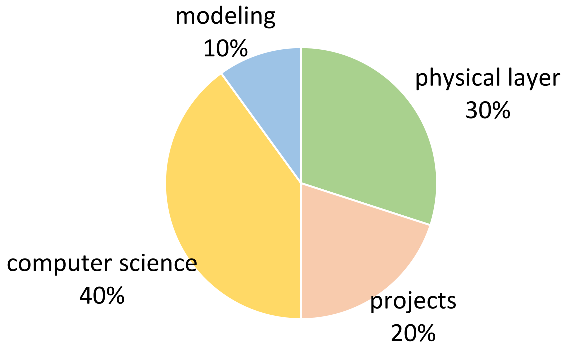
As explained in Section 3.2 (SER, Part A), the master's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GM1-GM6).
All competences are shared with the other Master of Science in Engineering programmes. The sole exceptions are the programme specific competences M1.3-M1.6. These competences show that the programme of computer science engineering encompasses the complete compute stack (from physical layer to application) and focuses on designing such systems. These specific competences have also been benchmarked against the ACM/IEEE Curriculum guidelines for Undergraduate Degree Programmes in Computer Science.

Field of competences M1: Competence in one/more scientific discipline(s)

M1.3 Design complex digital information processing systems with an important hardware component.
M1.4 Design complex intelligent software systems with the help of modern programming models, programming languages and other tools.
M1.5 Design complex communication networks and multimedia applications for various application areas.
M1.6 Have a sound grasp of system models and design methodologies for information processing systems.

Structure of the programme

The study programme consists of 60 credits of compulsory courses and 60 credits of elective courses (including the master's dissertation of 24 credits). The content of the master is the result of a careful weighing of the breadth versus depth, computer science versus engineering, research versus design, foundations versus applications.



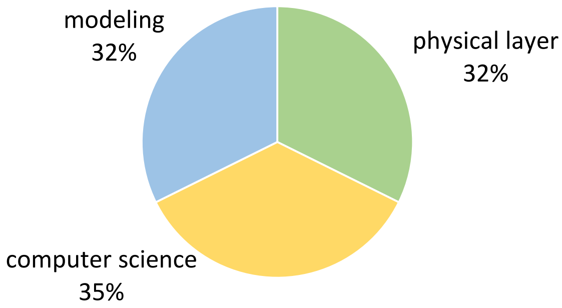
Programme structure Master of Science in Computer Science Engineering (compulsory courses)

The compulsory courses (50% of the programme) teach the minimal set of competences that all the graduates should have, and consist of:

- 40% computer science topics (machine learning, information security, parallel and distributed systems, design of multimedia applications)
- 30% physical layer courses (communication theory, networks, computer hardware)

- 10% modelling courses (queueing theory and discrete event simulation)
- 20% projects (research project and design project)

Students can complete the compulsory part of the programme in the first master year, thus focussing in their second master year on elective courses and the master's dissertation. Another option is to follow the standard learning track, with compulsory and elective parts spread over both years.
This freedom to compose the curriculum is appreciated by the students. The second master year can thus be scheduled to make it the ideal year to consider an Erasmus exchange. It allows the student to maximally benefit from the strengths of the course offering in the host institution without having to deal with detailed course mappings.



Programme structure Master of Science in Computer Science Engineering (elective courses)

The broadening engineering courses make up the other half of the programme (design, projects, telecommunication, networking). In this part, the students can express their personal educational ambitions and can create their own curriculum (be it in research, business, specialising, broadening, working on their personal skills like languages, or a combination of all these, etc.). The choices of the students have to respect the following rules:

- A master's dissertation of 24 credits is obligatory.
- A student's curriculum must have at least 18 credits of technical courses, chosen from the list of elective courses of the Computer Science Engineering programme. This list is well-balanced between Computer Science courses, Physical Layer courses and Modelling/Mathematical courses.
- A student's curriculum must have at least 6 credits of Elective Social courses, chosen from the faculty-wide list of Elective Social courses. This list contains - amongst others - entrepreneurial training, domestic and international internships, soft skills training, etc.
- The remaining credits (at most 12) can be chosen form the course catalogue of the university, but the choices need approval by the SPC.

Some clusters of elective courses can lead to an extra formal recognition in the diploma supplement.
The major Artificial Intelligence and the major Embedded Systems require the student to select 21 credits from a dedicated subset of the list of elective courses in Computer Science Engineering to get recognition. The minor Operations Management and the minor Biosystems require the student to select 18 credits from a dedicated list of courses to get recognition.

The two focal points of the master's programme are research and design. Graduates should be able to carry out independent research in the computer science engineering domain, and should be able to conceive, design, implement and maintain complex information processing systems. The compulsory part of the programme and the master's dissertation of 24 credits are aimed at guaranteeing that students have acquired these learning outcomes upon graduation.

Term 1	Term 2	Term 3	Term 4
Parallel and Distributed Software Systems	Queueing Analysis and Simulation	Machine Learning	Information Security
Design of Multimedia Applications	Mobile and Broadband Access Networks		
Parallel Computer Systems	Information Theory	Elective Course	Elective Course
Elective Course	Elective Course	Elective Course	Elective Course
Design Project		Master's Dissertation	
Research Project			

Courses in the Master of Science in Computer Science Engineering

Research competences are explicitly strengthened in the research project (3 credits) and the master's dissertation (24 credits). In the research project, students have to carry out a literature study, write a survey paper on their findings, and write a review for a manuscript, while being intensively coached by a postdoctoral researcher in the domain of the research project. On top of this, the master courses include the latest research findings, including results by the teams of the lecturers. For the master's dissertation, the students can pick one of the many topics proposed by the lecturers of the Computer Science Engineering programme, or they can suggest a self-proposed topic. In the latter case, the students have to search for a supervisor for the topic.

For the design part, there is a compulsory full year design project of 9 credits. The course is organised as a technopreneurial course which spans two terms. During the first term, the students are developing an idea into a design for a product or a service. Simultaneously, they have to assess the market potential of the product. In that process, 20 projects by teams of 3 students are reduced to 7 projects by teams of 8-9 students. In the second term, the most promising projects are actually implemented. In parallel, the students of the teams are encouraged to take a business model/business plan course together with the students of the Faculty of Economics and Business Administration. All students finishing the first master year co-own a working prototype and a validated business plan. Every year, some students are inspired by this first entrepreneurial experience and start their own business during the second master year, or at the time of graduation. Some of them became very successful entrepreneurs afterwards (Deliverect, Tengu.io, Toqua, Techwolf, Fleetmaster,…).

Evolution of the programme and follow up CTI-recommendations

The current version of the programme has evolved in a number of ways from the original master's programme as conceived in 2001. The current English-taught programme was introduced in 2014. In 2019, the major options Artificial Intelligence and Embedded systems were introduced in the master's programme. This highlights the AI offer in our programme and brings some structure in the long list of elective courses in computer science.

We also continue to keep up with developments in computer science in our educational programme. Including new elective courses about these new topics is a fast and lean way of integrating these new developments in the programme. The large size of the research groups in computer science at Ghent University and the diversity in research that is performed, makes it easier to select expert teaching staff in these new course topics. A few elective courses we have added in recent years: computational challenges in bioinformatics / blockchain technologies and applications / recommender systems / deep learning / natural language processing / deep generative models / probabilistic graphical models / sustainable computing.
In 2022, the last three terms of the bachelor's programme and the master's programme will be more thoroughly revised. The goal is to reassess the full programme and to decide which new developments should be included in the mandatory courses and which elements of the existing programme may be reduced in weight. We also feel that societal implications of computer science should be made more explicit in the programme. This should build on the increased attention for sustainability and ethical aspects of engineering that have been introduced in the reformed first bachelor programme. Another reform goal would be to clarify the structure of the elective

course offering, which we have already started with the introduction of two major options. We consider the introduction of other major options or at least clusters of elective courses.

The gender balance in the student population has improved since 2014. It has now become similar to the average engineering programme (excepting architecture).

As mentioned in the intermediate report sent to CTI, we have stepped up the efforts to increase the international experience for students in the programme, mainly by an increased collaboration with IAESTE for internships abroad and by the negotiation of bilateral agreements with foreign universities for the international exchange of students. We are selective in the choice of foreign universities in order to guarantee the experience of a highly ranked research and education centre for exchange students. We had observed an increase in exchanges before the pandemic struck. We intend to restart these efforts once the uncertainties linked to international travel have dissipated.

Admission

The master of Science in Computer Science Engineering is taught in English since 2014, and is open to international students. Students are admitted if they can prove that (i) they hold a bachelor's degree of at least 180 credits from an internationally recognised institute, (ii) comply with the required initial competences, (iii) master the English language at the B2 level, and (iv) are strongly motivated to study Computer Science Engineering. The following degrees automatically qualify for admission: Bachelors of Science in Computer Science Engineering, Bachelors of Science in Computer Science with a minor in Electronics and Telecommunciation, Masters of Science in Information Engineering Technology and Masters of Science in Electronics and ICT Engineering Technology.

The Programme's context

The SPC wants the Computer Science Engineering students to have their own community. Therefore, the study programme committee supports all initiatives to strengthen the identity of the computer science engineers. At the start of the academic year, the SPC invites a keynote speaker to address all bachelor and master students. These keynote speakers are often managers of industry in computing, helping the students better to understand how the IT-industry works.
The Computer Science Engineering programme has a dedicated student association called CenEka (https://ceneka.be/en). The mission of CenEka is to organise extracurricular activities for all students in Computer Science Engineering and Electrical Engineering: site visits in companies, invited speakers, and social activities too. The student associations VTK and IEEE organise several recruitment events, including panel discussions with a handful of alumni (now working in different sectors) to learn more about the job market.
The students actively participate in the yearly Robot Competition, the Flemish Programming Contest, and the Ethical Hacking Workgroup, and since last year the UGent Racing Team, where interdisciplinary teams of engineering students develop a fully autonomous race car.
Several students run their own business, and are official student-entrepreneurs of Ghent University. They get personal business coaching through Dare to Venture (https://do.ugent.be/) -the student entrepreneurship programme of Ghent University, which originally started in the Computer Science Engineering programme.
The programme maintains links with its alumni and partners in industry through its advice group, which is composed of former students (often former student representatives of the study programme committee) and of representatives from a relatively diverse selection of enterprises involved in hardware, software, telecommunications, start-ups, IT services, etc. We aim at an annual meeting for this advice group to discuss evolutions in computer science education and the evolving needs of the industry. The contacts have been somewhat less continuous in the last couple of years, but we intend to revive this advice group as input from industry and employers is essential in the elaboration of a programme update.

SWOC-analysis

Strengths

- Well-structured and logical study programme, including a strong engineering project line;
- Careful balance between breadth (broad engineering topics) and depth (computer science engineering courses);
- The study programme has a very good reputation, leading to increasing number of students in the bachelor's programme.

- Diverse influx into the master's programme of groups of students from (i) the Bachelor of Science in Computer Science Engineering, (ii) from the Bachelor of Science in Computer Science, (iii) from engineering technology programmes, and (iv) foreign students.
- Strong link with the imec research institute;
- Strong link with Dare to Venture, the student-entrepreneurship programme of Ghent University;
- Strong student ecosystem supported by different student associations (CenEka, Zeus, IEEE student branch).

Weaknesses

- While the influx of female students has improved, it is still relatively small (~15% female students); the influx of students with an immigrant background is also relatively small – this is a general problem for the engineering programs though (except for Architecture);
- Slower than nominal study progress for a large group of students;
- Outgoing internationalisation is still limited (approximately 20% of the students pre-COVID-19, incl. IAESTE-internships).

Opportunities

- The English master creates the opportunity to attract talented foreign students;
- The increased societal interest in ICT and in Artificial Intelligence can attract more students.

Challenges

- Finding the right balance between active learning and the (increased) study load of the programme
- We are still learning how to attract, screen, and admit the best foreign students;
- Dealing with a small number of weak students that use all means available in the Education and Examination Code to obtain their degree after many years.

Strategies for improvement

- We are increasing our efforts to promote computer science engineering in secondary schools (via STEM activities like WeGoSTEM).
- We have a (long term) plan to move the bachelor education to a new auditorium building at campus Ardoyen, which might increase the attractiveness of the programme.

2.7 Master of Science in Electrical Engineering

Programme objectives

Whether on a self-reliant basis or as a member of a team, Masters of Science in Electrical Engineering are expected to be capable of building complex electronic (communications) systems in an efficient and methodical manner within a broad field of applications, ranging from the conception and analysis right up to the design, implementation, testing and management of such systems. In doing so, graduate students are to draw on their in-depth theoretical foundations, technological knowledge, and contemporary professional tools and resources in support of the development of such systems. In addition, they are to have the required research attitudes and competences to support creative or innovative efforts in industry or in scientific research, be able to effectively communicate towards different target audiences, possess the general intellectual competences of an academically trained engineer, and be able to assume leadership in a broad industrial and societal context, also internationally. An important aspect of the master is that it stimulates independent knowledge acquisition and application. Rather than trying to cover the complete domain, the master aims to train students to master one sufficiently large and relevant subdomain of electrical engineering, and to develop the skill and attitude of lifelong learning. Depending on the chosen main subject within the Master of Science in Electrical Engineering, either the focus is more on electrical and electronic circuits and devices (Electronic Circuits and Systems) or on communication systems (Communication and Information Technology).

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the master's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GM1-GM6).
All competences are shared with the other Master of Science in Engineering programmes. The sole exceptions are the programme specific competences M1.3-M1.7, showing that the programme of electrical engineering encompasses the analysis, design and realisation of complex circuits, signal and data processing algorithms and systems containing hardware and software components.

Field of competences M1: Competences in one/more scientific discipline(s)

M1.3 Analyse, specify, design (based on general needs) and realise complex (opto-)electronic systems.

M1.4 Take into account electromagnetic phenomena during the specification, design and realisation of complex (opto-)electronic systems.

Main Subject 'Electronic Circuits and Systems':

M1.5 Know and creatively apply technology of integrated circuits for the specification, design and realisation of micro-systems which integrate mechanical elements, sensors and actuators.

M1.6 Analyse, specify, design (based on fairly generally formulated needs) and implement advanced algorithms for signal and data processing in information and communication systems.

M1.7 Specify and carry out measurements on complex systems that incorporate an important hardware component, and draw conclusions about the next steps in the design flow given the measurement outcomes.

Main Subject 'Communication and Information Technology':

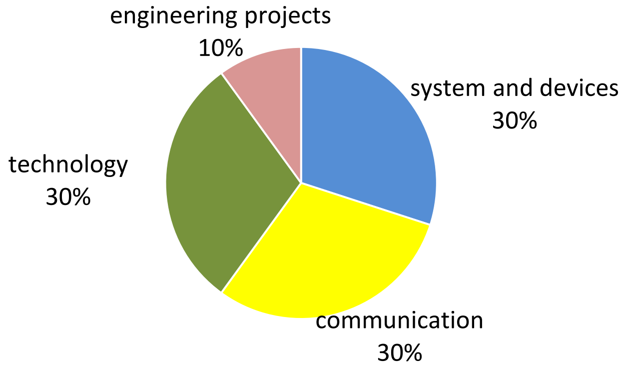
M1.5 Account for technological process limitations during the specification, design and realisation of (opto-) electronic systems.

M1.6 Analyse, specify, design (based on fairly generally formulated needs) and implement advanced algorithms and protocols for data processing and data exchange in telecommunication systems and multimedia systems.

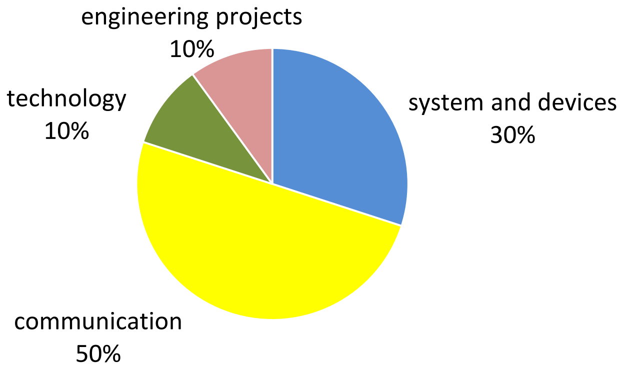
M1.7 Specify and carry out measurements on complex systems that incorporate an important software component, and draw conclusions about the further development path given the measurement outcomes.

Structure of the programme

The study programme consists of 60 credits of compulsory courses and 60 credits of elective courses (including the master's dissertation of 24 credits). The content of the master is the result of a careful weighing of the width versus depth, technology versus circuits and systems versus communication aspects, research versus design, foundations versus applications.



Programme structure Master of Science in Electrical Engineering, main subject Electronic Circuits and Systems (compulsory courses)



Programme structure Master of Science in Electrical Engineering, main subject Communication and Information Technology (compulsory courses)

The compulsory courses (50% of the programme) teach the minimal set of competences that all the graduates should have.
For the main subject 'Electronic Circuits and Systems', these consist of:

- 30% systems and devices topics (high-speed electronics, FPGA Design, EM aware HF design)
- 30% communication courses (information theory, antennas, modulation & detection)
- 30% technology courses (Sensors, VLSI technology, technology of ICs and microsystems)
- 10% projects (hardware project)

For the main subject 'Communication and Information Technology', these consist of:

- 30% systems and devices topics (high-speed electronics, FPGA Design, EM aware HF design)
- 50% communication courses (information theory, antennas, modulation & detection, queueing analysis and simulation, mobile and broadband networks)
- 10% technology courses (Robotics)
- 10% projects (hardware project)

Students can complete the compulsory part of the joint programme in the first master year, thus focussing in their second master year on finalising their main subject courses, elective courses and the master's dissertation. The second master year can easily be scheduled to make it the ideal year to consider an Erasmus exchange. It allows the student to maximally benefit from the strengths of the course offerings in the host institution without having to deal with detailed course mappings.

Main subject	Term 1	Term 2	Term 3	Term 4
Joint programme	Antennas and Propagation	Information Theory	Modulation and Detection	Master's Dissertation
Joint programme	Design Methodology for FPGAs	Hardware Design Project	Master's Dissertation	Master's Dissertation
Joint programme	Electromagnetic-aware High Frequency Design	High speed Electronics	Elective Course	Master's Dissertation
Joint programme	Elective Course	Elective Course	Elective Course	Elective Course
Main subject ECS	VLSI Technology and Design	Sensors and Actuators	Technology of Integrated Circuits and Microsystems	Elective Course
Main subject CIT	Robotics	Mobile and Broadband Access Networks	Queueing Analysis and Simulation	Elective Course

Courses in the Master of Science in Electrical Engineering

The broadening engineering courses make up the other half of the programme (elective courses and master's dissertation). In this part, the students can express their personal educational ambitions and can create their own curriculum (be it in research, business, specialising, broadening, working on their personal skills like languages, or a combination of all these,…). The choices of the students have to respect the following rules:

- A master's dissertation of 24 credits with a research topic in electrical engineering related to their main subject (either ECS or CIT).
- At least 16 credits of technical courses, chosen from the list of elective courses of the Electrical Engineering programme Subject Lists (either ECS or CIT). These lists are well-balanced between circuits and systems, communication, technology and even some Computer Science courses.
- At least 6 credits of Elective Social courses, chosen from the faculty-wide list of Elective Social courses. This list contains - amongst others - entrepreneurial training, domestic and international internships, soft skills training, …

The remaining credits (normally at most 14, but 16 can exceptionally be approved) can be chosen from the course catalogue of the university, but the choices need approval of the SPC.

Some clusters of elective courses, also called 'minors', can lead to a formal recognition in the diploma supplement. Three minors are available: the minor Operations Management, the minor Biosystems, and the minor Photonics Engineering. Students need to select 18 credits from these lists to get the recognition.

Research competences are explicitly strengthened in the master's dissertation (24 credits). The students can pick one of the many topics that are proposed by the lecturers of the Electrical Engineering programme, or they can suggest a self-proposed topic. In the latter case, the students have to search for a supervisor for the topic.

Evolution of the programme

The current version of the programme was introduced in 2014-2015 as an English-taught continuation of the original master's programme. In 2018 the programme underwent a significant change to highlight new evolutions in electrical engineering and hence to make it more attractive for students. In particular the focus of the two main subjects was made much more clear, with the ECS main subject focussing on smart systems and devices and the CIT main subject focussing on the Internet of Things.

Follow up of CTI-recommendations

After the previous CTI-audit there were 4 recommendations

1. *The programme has objectives of scientific and technical excellence, based on electronic area and complex systems.*
   We agree with this observation, which does not require a particular follow-up.
2. *The programme management team seems conservative in terms of pedagogical methods and openness to soft skills and preparation to the job market (other than research).*

With regard to the pedagogical methods used in the programme, we believe that a significant variety of different teaching methods for teaching is used: from classical lecture classes to guided exercises, practical lab exercises, and hands-on learning. Moreover, due to COVID-19 pandemic, over the past 2 years a lot of experience was built up with regard to off-campus teaching methods. While most courses plan to re-install largely on-campus teaching as soon as the situation allows, two courses will continue with mostly online teaching, incorporating flipped-classroom techniques.
With regard to improving the soft skills, the project line is a very important means. Here the students learn to handle deadlines, cooperate in a team, report orally and in writing on their work as well as to defend their work in a public questioning. This project line has been strengthened significantly since the last audit: in the Bachelor (Programme change of 2020) and in the CIT orientation in the Master where the Hardware Design Project course was added to the curriculum (Programme change of 2018, see above). Also, there are many regular courses that now include important elements that help improve the soft skills. A good example of this is that many courses now include Peer Assessments of Lab work where students have to learn how to assess their team members as well as how to deal with their own assessments.
Finally, with regard to the preparation to the job market, it is important to remark that industry is soliciting heavily for our students and our alumni tell us they do not have problems at all to adjust to the company setting. This has also been confirmed by the industrial advisory board. We thus believe our students are well prepared for a job in industry.

3. *The issues of the global energy transition and of the post carbon economy should be addressed.*
   It is important to note that power electrical engineering and electrical energy are not covered in our Master of Electrical Engineering which focusses on electronics and telecommunication instead. This can be confusing to outsiders because in many countries Power and Energy aspects are included in an Electrical Engineering Programme. However, the programme name has been decided by the Flemish Government (for all Flemish Universities) and cannot easily be changed. Instead these Power and Energy aspects are covered in Ghent University's Master of Science in Electromechanical Engineering - main subject Electrical Power Engineering. This information is clearly presented in the master brochure so our students are well aware of this.
   Having said this, we agree that the issue of global energy transition, sustainable energy consumption and renewable energy sources is extremely important. An important step to address this was done in the last Programme change in the Bachelor (in 2020). Now significantly more emphasis is put on sustainability with the introduction of courses such as *Sustainable Business Operations* and *Sustainability, Entrepreneurship and Ethics*. A second ongoing step is that we are encouraging all courses to include aspects of sustainable engineering, which is now incorporated already in several courses.
4. *The attractiveness of the Master must be addressed, in connection with a strategic analysis of the future of the programme to be carried out with all the stakeholders.*
   This was one of the main drivers of the master reform that we have performed in 2018. In particular the CIT programme was significantly improved. This has made it much easier to demonstrate our programme’s vision to prospective students.
   We have seen immediate effects of this with a very large increase in the number of students (up to 50%). Thanks to this, we have now a sound number of students in the Master. Unfortunately our efforts seem to have entirely lost their effect during the COVID-19 pandemic with a worst-ever influx of only 18 new students in the Bachelor Programme in the academic year 2020-2021. We are currently still investigating the cause of this, but it appears that there is a strong link with the online nature of all promotional events during the COVID-19 pandemic, which made it hard to create enough visibility of the Electrical Engineering programme particularly relatively to Computer Science Engineering.

Admission

The Master of Science in Electrical Engineering is taught in English since 2014-2015 for the main subject ECS and since 2015-2016 for the main subject CIT, making it possible for international students to enrol. Students are admitted if they can prove that (i) they hold a bachelor’s degree in electrical engineering (or similar) of at least 180 credits from an internationally recognised institute, (ii) comply with the required initial competences, (iii) master the English language at the B2 level, and (iv) are strongly motivated to study Electrical Engineering.

Student community

The SPC wants the Electrical Engineering students to have their own identity. Therefore, the SPC supports all initiatives to strengthen the identity of the electrical engineers. Many of the students of the Electrical Engineering programme are active in the IEEE student branch Ghent and organise several activities yearly, most notably the free Electronics labs on Tuesday or Wednesday evenings where the students can work on their own robot design, which then competes against the other robots in the yearly IEEE student branch robot competition.
The Electrical Engineering programme also has a dedicated student association called CenEka (https://ceneka.be/en). The mission of CenEka is to organise extracurricular activities for all students in Electrical Engineering and Computer Science Engineering: site visits in companies, invited speakers, and social activities too.

SWOC-analysis

Strengths

- Level: The graduates claim the programme is highly appraised in the industry and therefore they have no problem finding a suitable job of a high level.
- Link with research: Courses are taught by departments that have strong and extensive internationally recognised research activities. This research is partly also in collaboration with industry and strategic research centres such as imec. Also, a large group of Ph.D. students, post-docs and imec researchers are engaged in the educational tasks.
- Master's dissertation and projects: The master's dissertation and project courses are very well organised and the projects and dissertation work are generally of a very high level.

Weaknesses

- Internationalisation: The electronics programme scores less in internationalisation, with a relatively limited number of students making use of the international exchange programmes. To improve this, since the last audit, the list of partner universities was carefully evaluated in 2019 and a much shorter list of partner universities but of higher quality both in terms of the reputability of the University as well as attractiveness of the destination was formed. Due to the COVID-19 pandemic we were unable to evaluate the effect of this.
- Heterogeneous population: Due to the horizontal influx of graduated industrial engineering students, the student population is more heterogeneous than before. This leads to problems for the collaboration in group work assignments. To avoid even larger problems of heterogeneity, a good screening procedure of the influx of foreign students is needed to ensure that only strong enough students can enrol in our degree. Since 2020 incoming international students are also encouraged to submit their GRE score which makes it easier to screen the incoming international students.

Opportunities

- Teaching in English: The master's programme in Electrical Engineering is taught in English. This will allow us to greatly improve our internationalisation. E.g., now we can more easily set up collaboration and exchange programmes with other universities (such as Delft University of Technology, Chinese universities, Politecnico di Milano and others). Moreover it is easier to attract international students. Currently we have a typical influx of only 2 regular international students in the Master, but we see an increase in the number of applications, with 37 applications in 2021 of which 7 students were admitted after screening.
- Contacts with industry: Through student club and the industrial advice group we have good contacts with industry, allowing a fast introduction of new evolutions in the field.
- Internships: thanks to the good contacts with industry there are ample opportunities for students to take up an internship in a local or international company.
- International scholarships: Some countries offer scholarships for foreign students. This provides new opportunities (additional to Erasmus) for our students to spend one or two terms abroad.
- New campus: since the Spring of 2016, the two main departments responsible for the bachelor and master's programme in Electronics, have moved to a new attractive building on the Technology Campus Ardoyen. Currently many initiatives are being developed to make this campus an attractive site.

Challenges

- Number of incoming students (see also the section "Follow up of CTI-recommendations", item 4): The influx of new students from our own bachelor's programme into the Master in Electronics went through a very bad period around the time frame of the previous audit. Subsequently we took several initiatives to increase the attractiveness of our programme which had very good results with an increase of around 50% more students.
  Unfortunately in the COVID-19 academic year 2020-2021, the influx suddenly collapsed to only 18 incoming students. We are currently still investigating this, but it appears that there is a strong link with the online nature of all promotional events during the COVID-19 pandemic, which made it hard to create enough visibility of the Electrical Engineering programme particularly relatively to Computer Science Engineering.
- Logistics: As the main activity is now on the Technology Campus Ardoyen, outside of the city centre, suitable transportation from the city centre to this location is an issue.
  Since the last audit, several initiatives have been set up at the faculty and university level to improve this. In the medium term there should be improved cyclist as well as tram connections with the city centre.

Strategies for improvement

- Programme evaluation: The programme vision includes concrete goals for the programme on a longer term with respect to attracting new students and an evaluation of the programme to further align it with the renewed vision and end goals.
- International students: We are still thinking of suitable ways to attract excellent international students.

2.8 Master of Science in Electromechanical Engineering

Programme objectives

Electromechanical Engineering is a collection of engineering disciplines around the themes motion, force and energy. The world of electromechanical engineering encompasses development, design, manufacturing, testing and control of tools, machines, vehicles and other electrical and mechanical systems, as well as research on these topics.

The Master of Science in Electromechanical Engineering is a two-year degree programme intended to prepare students for a future technical leadership role in a sustainable industry. The programme offers in-depth training in all aspects of Electromechanical Engineering and its economic and societal implications based on a profound scientific basis. Graduates will have acquired an attitude of scientific synthesis, analytical reasoning as well as scientific and technical independency. These skills provide mastery in developing, implementing and monitoring technical and scientific innovations.

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the master's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GM1-GM6).

All competences are shared with the other MSc in Engineering programmes. The sole exceptions are the programme specific competences M1.3-M1.10 and M6.12 and M6.13, showing that the programme of Electromechanical Engineering encompasses the complete design process of machines and electromechanical systems. Attention is also paid to management, innovation and energy efficiency.

Field of competences M1: Competences in one/more scientific discipline(s)

M1.3 Have a thorough insight in the interactions between different electromechanical parts and energy conversions of complex systems.

M1.4 Have a thorough knowledge of measurement techniques, sensors, actuators and ICT and the ability to apply the knowledge.

M1.5 Be familiar with the management of companies, sustainability and operations.

Main subject 'Mechanical Energy Engineering' (ME)

M1.6 Have a thorough insight in mechanical and thermal energy conversion, fluid dynamics, heat transfer and combustion and apply the knowledge to complex problems.

Main subject' Electrical Power Engineering' (EE):

M1.7 Have a thorough insight in the production, transmission, distribution and application of electrical power and apply the knowledge to complex problems.

Main subject 'Mechanical Construction' (MC):

M1.8 Have a thorough insight in the design, behaviour and manufacturing of constructions and machines and apply the knowledge to complex problems.

Main subject 'Control Engineering and Automation' (RA):

M1.9 Have a thorough insight in the design and behaviour of control loops and of system dynamics and apply the knowledge to complex problems.

Main subject 'Maritime Engineering' (MT):

M1.10 Have a thorough insight in the design, construction, functioning and exploitation of maritime systems.

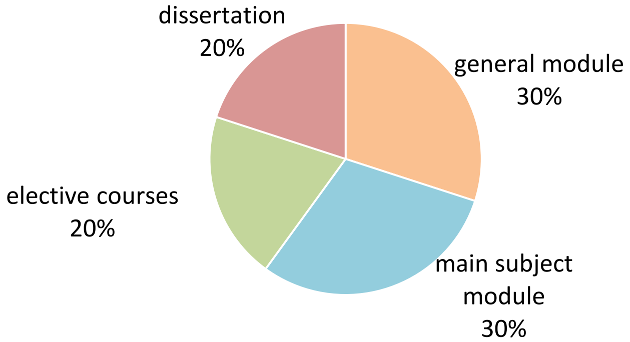
Field of competences M6: Profession-specific competences

M6.12 Integrate the advanced knowledge of mechanical and electrical systems and ICT in order to design, implement and exploit technological innovations.

M6.13 Be familiar with the energy efficiency of (electrical, mechanical and thermal) energy conversion systems and distribution systems.

Structure of the programme

The programme of 120 credits consists of a general module (36 credits), main subject modules (36 credits), elective courses (24 credits) and a master's dissertation (24 credits).



Programme structure Master of Science in Electromechanical Engineering

The general module contains courses on all subjects related to Electromechanical Engineering, ranging from electrical drives over machine manufacturing to management skills. These subjects relate to competences that all graduates should have and can be considered to treat the basics of each main subject module. In line with the BSc in Electromechanical Engineering programme, the MSc in Electromechanical Engineering aims at training engineers with a broad and in depth knowledge on all aspects of Electromechanical Engineering.

Students can choose one out of five main subject modules with specialist courses on different topics:

- Electrical Power Engineering handles all aspects of generation, distribution and use of electrical energy, with special attention to electrical machines, drives and electrical power systems.
- Mechanical Energy Engineering concerns energy conversion and energy use in thermal systems, engines, machines and industrial equipment in general.
- Mechanical Construction focuses on design, manufacturing and maintenance of machines and mechanical equipment.
- Control Engineering and Automation is about control and automation applied to mechanical and electrical systems and processes in general.
- Maritime Engineering treats the design, construction and operation of maritime systems such as ships and offshore constructions.

The main subject modules contain specialist courses to deepen the knowledge and design and scientific skills in the given subject.
The master's dissertation is a final step in the learning process. It aims at training the ability to independently perform scientific research. The dissertation is in general (though not obligatory) related to a topic which links to the main subject module.
Through elective courses students broaden their knowledge and skills in technical and non-technical subjects. Of the 24 elective course credits, 15 are to be taken in year 1 and 9 in year 2. To guide the students in selecting a sufficiently coherent set of elective courses, the following options apply:

Option 1
The student selects 24 credits of elective courses of which at least 6 credits have to be chosen from a list of specific electromechanical engineering courses provided by the SPC and of which at least 6 credits have to belong to the group of elective social courses.
Option 2
Some clusters of elective courses (minors) lead to a formal recognition in the diploma supplement. Four minors are available: the Minor Operations Management, the Minor Environment and Sustainable Development, the Minor Biosystems and the Minor Automotive Production Engineering. Students need to select 24 credits from the course lists of the above minors to get the recognition.
Option 3
The student selects 18 credits form a larger list of minors:

- Environment and Sustainable Development
- Operations Management
- Biosystems
- Computer Science Engineering
- Electronics and ICT

- Materials Engineering
- Chemical Engineering
- Materials Physics
- Control Engineering and Automation
- Photonics Engineering

The 6 remaining credits must again be selected from the specific electromechanical engineering elective courses list.

The two focal points of the master's programme are research and design. Graduates should be able to carry out independent research in the Electromechanical Engineering domain, and should be able to conceive, design, implement and maintain complex electromechanical systems.

<table>
<tr><th>Term 1</th><th>Term 2</th><th>Term 3</th><th>Term 4</th></tr>
<tr><td>Controlled Electrical Drives</td><td>ICT and Mechatronics</td><td>Manufacturing Planning and Control</td><td>Courses Related to the Main Subject</td></tr>
<tr><td rowspan="2">Turbomachines</td><td rowspan="2">Mechanical Vibrations</td><td rowspan="2">Courses Related to the Main Subject</td><td>Courses Related to the Main Subject</td></tr>
<tr><td>Elective Course</td></tr>
<tr><td>Displacement Pumps, Compressors and IC Engine Fundamentals</td><td>Courses Related to the Main Subject</td><td>Courses Related to the Main Subject</td><td>Master's Dissertation</td></tr>
<tr><td rowspan="2">Courses Related to the Main Subject</td><td>Courses Related to the Main Subject</td><td rowspan="2">Elective Course</td><td rowspan="2">Master's Dissertation</td></tr>
<tr><td>Elective Course</td></tr>
<tr><td>Elective Course</td><td>Elective Course</td><td>Master's Dissertation</td><td>Master's Dissertation</td></tr>
</table>

Courses in the Master of Science in Electromechanical Engineering

Research competences are explicitly strengthened in the master's dissertation (24 credits). On top of this, the master courses all focus on the latest research findings, including those of the team of the lecturers. For the master's dissertation, the students can pick one of the many topics (200+ yearly offered) that are proposed by the lecturers of the Electromechanical Engineering programme, or they can suggest a self-proposed topic. In the latter case, the students have to search for a supervisor.

Evolution of the programme

The current version of the programme has evolved in a number of aspects from the original master's programme as conceived in 2001. The current programme was introduced in 2014 and is now taught in English. In 2019 minor changes in subjects and subject titles were made, because of new lecturers and minor changes in subjects for each Main Subject trajectory.

In 2020 the process was started to rework the learning trajectories, introducing learning trajectories on basic technical knowledge in the 4 fields of Electromechanical Engineering, as well as Numerical Techniques, Safety and Sustainability. In 2021 and 2022 we will use these trajectories to rework the program and bring it in line with the bachelor courses.

Follow-up of CTI-recommendations

The CTI report of 2016 gave following conclusions on the program : An attractive programme that allows the enrolment of 80 students per year, a very strong content and in line with expectations of companies, good quality staff with broad expertise, excellent relationship with research.

CTI also indicated that a first step towards internationalization strategy could be implemented to develop the international mobility, attract good international students and allow them to succeed in this Master

This was discussed in the committee. A problem was detected with the admission of foreign students. Our program requires both knowledge in electrical and mechanical engineering. A lot of foreign programs only offer power (electrical) engineering or mechanical engineering separately. Students coming from these programs are

not allowed to enter the master. All bachelor courses offered at Ghent University are taught in Dutch. As such creating a bridging program for foreign students is impossible. In order to create such a program a reform of the bachelor would be necessary, which is currently not possible.
In order to better promote the program abroad, forces are joined with other masters in the faculty. The master program has no financial means, and as such cooperating within the faculty is the only way to go. We support international efforts of the faculty.
International teaching staff mobility is organised by Ghent University and by the faculty. The master program has very little influence on international mobility. On the Ghent University level new regulations were adopted for sabbaticals of professors. The faculty of Engineering and Architecture provides funding support for international mobility. This funding is continuously available and lecturers are informed.

Admission

The Master of Science in Electromechanical Engineering is taught in English since 2014, and is open to international students. Students are admitted if they can prove that (i) they hold a bachelor's degree of at least 180 credits with good grades from an internationally recognised institute, (ii) comply with the required initial competences, (iii) master the English language at the B2 level, and (iv) are strongly motivated to study electromechanical engineering. The following degrees automatically qualify for admission: Bachelors of Science in Electromechanical Engineering.

The programme's context

The Electromechanical Engineering programme has a dedicated student association called PKarus. The mission of PKarus is to organise extracurricular activities for all students in Electromechanical Engineering: site visits in companies, invitation of speakers and a host of social activities. The PKarus student association is actively involved in providing future students with information on the programme, through the creation of a flyer and a yearly meet and greet with current master students. Furthermore, they recently founded UGent Racing, together with student association from other engineering disciplines. The student associations VTK and IEEE also organize several recruitment events, including a panel discussion with a handful of alumni (now working in different sectors) to learn more about the job market.
The programme has established an industrial advisory board, containing representatives (often former students) of relevant companies in the field, like Daikin Europe, Atlas Copco, Arcelor Mittal, Engie, Luminus, Fluvius, Siemens… Yearly a meeting is organised in October. The meeting always consists of an onsite tour with a lab visit and secondly a topical discussion with the board. Past meetings the topics were : sustainability, safety, numerical techniques and learning trajectories.
For reaching out to alumni, mostly the faculty supported AIG-society is targeted. Most of our lecturers cooperate in the activities of the AIG. Several lecturers are active members of the thematic committees of IE-net and are involved in organising workshops and activities.
Our Erasmus program sends out students to several universities like: Grenoble Institute of Technology, Tokyo Institute of Technology, Norwegian University of Science and Technology, Universidade de Lisboa, Université de Lille and The University of Catania, amongst others.

SWOC-analysis

Strengths

- Staff: The staff covers a wide scope of expertise, with very good research performance in the different areas. The teaching activities are thus well founded on academic research. The staff is very motivated and strives for excellence.
- Broad and sufficiently in depth educational program: The curriculum provides a broad general basis for all students. This is an acknowledged strength by industry and permits alumni to be employed in a wide range of professions.
- Main subject choice in the Master: Students see this as an interesting part of their training and industry clearly recognises the value of specialists in these specific fields.
- Main subject Maritime Engineering: This gives us a unique position as we are the only university offering this subject in Flanders.
- Management, sustainability and safety courses: The courses on management, sustainability and safety are very much appreciated by industry and graduates.
- PKarus: The Electromechanical Engineering students have established a very instrumental and efficient student organisation. Company visits, information sessions and social activities intensify and improve the communication among students and about the programme.

Weaknesses

- The course content and the follow up between courses can be better coordinated. Learning trajectories have been developed and are being implemented in 2021-2022.
- Work load of the teaching staff: the teaching staff experiences a high teaching load and a constant pressure for reform by the Ghent University educational services. Often tools are developed by these educational services, which are perceived to have little to no value for the lecturers, e.g. the COVID-19 check and the recent deliberation tools.
- Facilities: The laboratories involved in the Electromechanical Engineering programme are well equipped, but rather old. This often makes the program to be perceived as not according to the current industrial standards. Investments are made for upgrading, but this is a long process.
- Industrial practise: Students point out that often the link with the industrial practise is missing and opportunities to get in contact with industry are limited.
- Inflow of foreign students: It is a challenge to assess the level and background of foreign students. At the moment we see most of them fail in the master. A more efficient screening system is needed. We are discussing this with the international relations officer of the faculty, but no actions have resulted from this.
- International mobility: Students and teaching staff have a limited international mobility. It is difficult to set up Erasmus programmes with foreign universities. For Erasmus programs a screening was done by the international relations officer and non-active agreements were cancelled, so more focus could be given to more active programs.

Opportunities

- The different options in the master have drifted apart. This could be mended by looking for more common ground between courses or a more integrative project in the master.
- The construction of educational lines in 2021 will make the links between and the follow up of courses stronger.
- Blended learning post-COVID-19: Ghent University promotes blended learning. Some lecturers have introduced this in their courses. The first evaluation is positive, but there is room for improvement and a broader adoption.
- Introduction of sustainability can lead to a stronger participation of students and lecturers in the societal debate.
- Integration of new developing technologies like 3D-printing, AI and IOT can give the educational program a more modern look and feel.
- There is a high demand for our master students in industry. Cooperation in lectures, company visits (which were lacking due to COVID-19 in the last 2 years) and cooperation in master thesis research can be strengthened. Frame-work agreements with major companies, like Arcelor Mittal, Daikin Europe, Engie,… can be a starting point for this.

Challenges

- Study load: The study programme is perceived by the students to be very demanding. A lot of basic science has to be combined with practical cases and projects. The study load is quite high, especially in the master the students experience a heavy work load of projects. The study load is followed up regularly with the students in the study committee. The recent restructuring in the bachelor has taken this into account. This demands constant attention to keep the balance.
- New fields (3D printing, IOT, machine learning) and traditional electro-mechanical fields (energy, robotics) are getting a more interdisciplinary nature. This requires more consultation and interaction with other masters to position our programme properly.
- The project line is strongly visible in the curriculum of the Bachelor, but projects are not visible in the curriculum of the master. More coordination between projects and explicit definition in the ECTS-fiches should be done.
- Now that the integration of the engineering colleges is finished, it will be important to maintain and underpin the difference with the master of science in industrial engineering
- Level of incoming students: more students are now entering the bachelor's programme with less competences in mathematics and physics. This puts some pressure on the study programme, in view of maintaining the desired high level.
- Budget cuts have been happening and are expected post-COVID-19. The work load for lectures should be kept at an acceptable level.

- The programme can benefit from the faculty's intention to bring all staff members to the Technology Campus Ardoyen. This will increase coherence between the lecturers and reduce travel time for the students. Student facilities , like the restaurant, lecture theatres, student homes, should be constructed at the campus for this to be successful.

Strategies for improvement

- Regular programme checks: Within the Electromechanical Engineering programme, we perform regular programme checks, typically resulting in a (partially) renewed study programme. This keeps the contents up-to-date and at international level.
- Maintaining the educational monitor documents the different actions and creates follow up via the PDCA-cycle.
- Foreign student screening: Together with the faculty, a strategy for screening foreign students is being developed. This will allow improving the inflow and success rate of these students.
- The SPC has set up a work group on learning lines. This will create the opportunity to strengthen coordination between courses.
- The SPC will set up a work group on the project line in the master. This will create the opportunity to strengthen coordination between the projects, lower the load for students and create links between the options.
- We will take part in the university wide discussion on the core mission of the university. From there we will open up the discussion within the committee to reduce the number of courses and thus the work load on the teaching staff.
- Communication: More effective communication to (international) students about industrial opportunities, optional courses, internships, foreign stays.

2.9 Master of Science in Engineering Physics

Programme objectives

Ghent University is the only university in Flanders to offer a Master of Science in Engineering Physics. Alumni of this master have a solid physical knowhow and the necessary skills to have a leading role in ground-breaking research. At the same time they have the engineering skills that make them wanted as innovators and developers in industry, research institutes, and universities. The engineering component of the master's programme develops skills such as analysis, design and optimisation of existing and new systems, products, machines, and materials. This involves approximating physical reality by system descriptions ranging from simple rules of thumb to expert systems. The physical component follows a reductionist approach where experiment and mathematical modelling aim at understanding and reducing physics to its basics, and deriving its governing equations.

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the master's programme objectives are formalised as a list of generic competences and associated learning outcomes. For the Master of Science in Engineering Physics three learning outcomes are added to the generic discipline competences M1.3-M1.5. One learning outcome is added to the intellectual competences M3.6. These programme specific competences have been benchmarked against similar engineering programmes at other European technical universities.

Field of competences M1: Competences in one/more scientific discipline(s)

M1.3 Possess the broad scientific knowledge, insight, and skills to analyse, model analytically and numerically, specify, design, and test experimentally, systems that are a direct application of the fundaments of physics.

M1.4 Have a thorough understanding of the most important physical theories (logical and mathematical structure, experimental support, known physical phenomena and applications) and the skills to engineer innovative applications in the areas: composition of matter from subatomic to molecular and macroscopic scale, states of matter and their transitions, semiconductors, and wave physics.

M1.5 Have a thorough, in depth scientific knowledge, insight and engineering skills in several of the following areas: nanoscale materials, nano-electronics, complexity and criticality, thin films, advanced electronic and photonic devices, quantum optics, wave physics in living matter, and plasma technology.

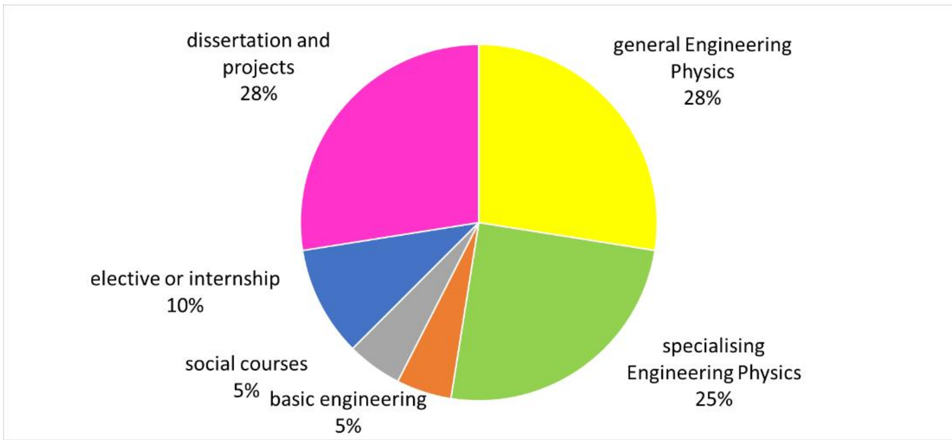
Field of competences M3: Intellectual competences

M3.6 Application-oriented reflecting on new physical insights and physical discoveries.

Structure of the programme

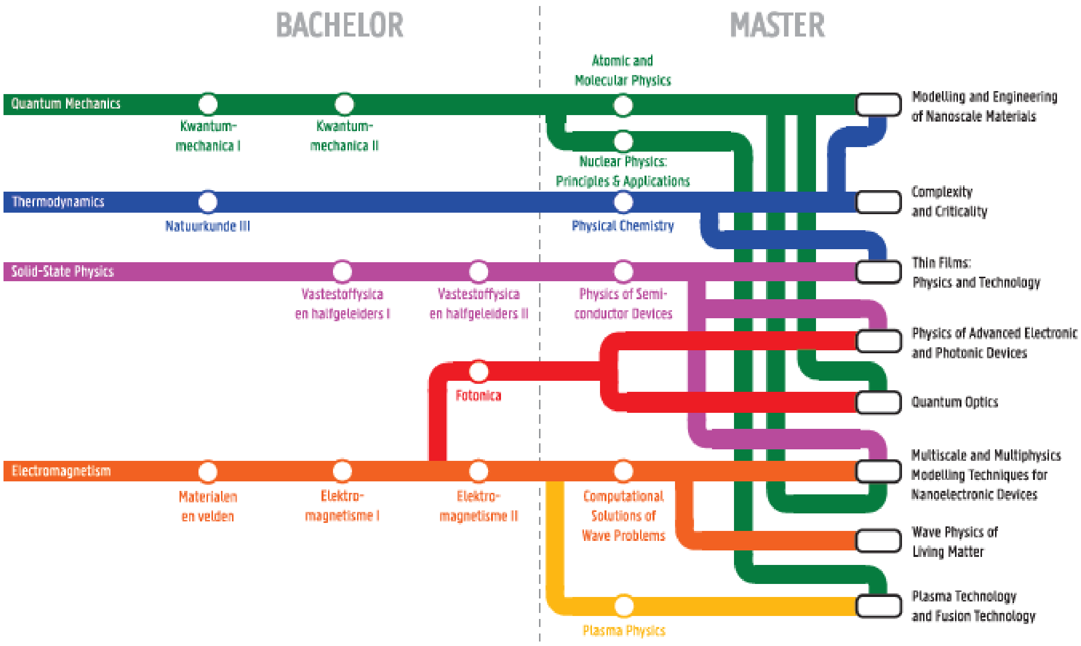
The study programme is carefully crafted to complete the general education in engineering physics and allows for specialisation in five out of eight specific areas, nevertheless assuring that the envisaged general skills and competences are represented in each specialisation track.

The main building blocks, advanced mathematics (5%), general Engineering Physics (28%), and projects and dissertation (28%) are identical for all students. Specialising courses in Engineering Physics (25%) are elected by the students with a limited choice: 30 credits out of 48. This allows us to tune each of the 8 courses specifically to the target group and to assure that all competences can be addressed in each of them, while still maintaining teaching efficiency with 5/8 of students on average following a course. The 5% social courses are selected from a faculty wide list. This list contains - amongst others - entrepreneurial training, soft skills training, … The final 10% are courses that can be elected from all master's programmes available at Ghent University but with approval of the SPC or students can opt for up to 12 credits of internships.



Main building blocks of the MSc Engineering Physics programme

The vast majority of students in the master programme have followed the Bachelor in engineering –main subject Engineering Physics. Hence the learning paths already started in the bachelor are continued in the master (see figure below). Each of the specialising courses connects to one or more learning paths, while the five learning paths emerging from the bachelor not necessarily connect to a specialising course.



Learning pathways MSc Engineering Physics

In the model track students complete the basic engineering courses and the general engineering physics courses in the first year and their master's dissertation in the second year. The specialising Engineering Physics courses, the social courses and the free elective courses can be taken at any convenient time over the two years. As indicated in the **Fout! Verwijzingsbron niet gevonden.**, the semesters for the specialising courses are chosen to (1) assure that these courses can be followed considering the required prior knowledge and skills; (2) there is a bias towards unloading the last semester that requires typically slightly more work on the dissertation. An internship is often conducted during the summer break.

International exchange via the Erasmus programme is promoted by the SPC. When a student opts for a term or a year abroad, equivalent courses have to be selected at the host institution. Given the freedom of choice in specialisation courses this is often easier than for the general engineering physics courses. Therefore, in case of Erasmus exchange during the first year, the latter are sometimes moved to the second year.

Term 1	Term 2	Term 3	Term 4
Mathematical Techniques for Engineers: Advanced Topics	Nuclear Physics: Principles and Applications	Modelling and Engineering of Nanoscale Materials*	Multiscale and Multiphysics Modelling Techniques for Nanoelectronic Devices*
Plasma Physics	Physical Chemistry	Plasma Technology and Fusion Technology*	Wave Physics in Living Matter*
Atomic and Molecular Physics	Physics of Semiconductor Devices	Thin Films: Physics and Technology*	Complexity and Criticality*
Computational Solutions of Wave Problems	Engineering Physics and Industry	Quantum Optics*	
		Physics of Advanced Electronic and Photonic Devices*	
		Master's dissertation	
Social elective course or internship			
Elective course from master from Engineering or internship			

Organisation of the programme over semesters; specialising courses indicated with* can be elected in another year or cannot be elected at all.

The project line that was started in the bachelor's programme, with projects focussing on measurement and design, is continued with the course on computational solutions of wave problems (50% project work) and the Engineering Physics and Industry course. The master's dissertation (24 credits) is regarded as the final step in acquiring many of the profession specific, intellectual, and scientific skills.

Possible topics for master's dissertations are proposed by the teaching staff and approved by the programme committee. Each proposal should contain a clear engineering and a clear physical component to be approved. Most master's dissertations are strongly related to ongoing research lines within the research groups that propose them. This assures that the graduates experience a real-world research environment during the preparation of their dissertation. Together with the specialising courses, this guarantees that the Engineering Physics programme reaches its goal to deliver the innovators that will be shaping our common future.

Evolution of the programme – Follow-up of CTI-recommendations

The current version of the programme is the result of a thorough revision after the evaluation by CTI in 2015. Compared to the MSc programme offered prior to 2019-2020, the choice of elective courses has been limited to eight targeted modules, each containing a physical and an engineering, design and application component. The program committee opted for this approach to ensure that engineering skills that are core outcomes of our programme can be assured no matter what specific topic the students choose. A window of 12 credits allows students to take internships or specialise in a specific topic, often related to the master dissertation.
Since 2019-2020 the industrial and applied focus of the programme has been strengthened by adding a 6-credit project course: Engineering Physics and Industry, that focusses on innovation, system design, socio-environmental-economic impact. Engineering skills are further developed by applying methodologies that are provided in formal lectures on an authentic problem from industry. An attitude focusing on societal and economic value that MSc in engineering physics could create, is trained.

More specifically, the above mentioned major (60% new courses) programme revision aimed at following the CTI recommendations in the following way:

- The fundamentals of the programme are given a more competence-based orientation and a deeper relevance for engineering by allowing only courses that are explicitly designed for engineering students and that embed the engineering and competence based approach, in contrast to allowing 50% of elective courses to be fundamental physics in the previous versions of the programme. Moreover, the project line was strengthened with 6 additional credits: Engineering Physics and Industry. However, more importantly, the process of evaluation and restructuring the programme, that took two years, raised awareness with the teaching staff.

- The “à la carte” organization of the MSc programme has been replaced by a rigid and structured set of study trajectories that find their origin in the bachelor and are continued all the way to the eight available elective courses that are unique for our programme. That is, they are designed by a subcommittee of teaching staff to adapt the content and teaching methods to optimally support the learning outcomes of our programme. None of the courses is a compromise between programmes anymore.
- During the process of reshaping the master programme, the profile of graduates has been refined. Communication to the public and employers has been strengthened.
- In the new programme, soft skills take a more central place.

Some of the weaknesses and opportunities listed in the SWOC have been addressed. Unfortunately, the large event bringing stakeholders from industry together with students and alumni that was planned for the first time in March 2020 had to be cancelled. It is now planned in October 2021. International recruitment has been pushed and collaboration with foreign research institutes was re-examined to include mainly those partner institutes that are strong in engineering. But the inflow of foreign students remains weak. The opportunity of reshaping the master for easier inflow from a variety of backgrounds has not been followed to guarantee the high quality standard of the programme.

The content and teaching methods of each specific course in the programme are continuously adapted to follow evolutions in field knowledge, to mitigate the shortcomings pointed out by the students and to accommodate the changing demands of the recruiting industry. These changes are initiated by the teaching staff and approved by the SPC.

Admission

In view of the in depth specialisation of the Master of Science in Engineering Physics, only students with a Bachelor of Science in Engineering Physics are admitted without any additional preparation. Other students that hold a bachelor’s degree from an internationally recognised institute, are highly motivated to study engineering physics, and master the English language at the B2 level, can be admitted after following a compulsory programme. This preparation programme is proposed based on the specific content of their bachelor’s degree and can amount to anything between 24 and 90 credits. Holders of a Master of Science degree in Physics, Photonics Engineering or Electronic Engineering can be admitted to a condensed programme.

SWOC-analysis

Strengths

- The Bachelor and Master of Science in Engineering Physics are generally perceived as of very high scientific and technological level.
- Bringing engineering together with a strong physical basis allows our alumni to make a difference in highly innovative work environments, especially but not exclusively in R&D departments.
- The programme is unique in Flanders.
- The solid and broad general basis of the programme prepares students very well for a variety of tasks they could take up in society and opens a broad spectrum of possibilities.
- Especially after the introduction of the new programme, the students evaluate organisational aspects very positively.
-

Weaknesses

- The strengths of the MSc in Engineering Physics are insufficiently promoted towards the recruiting field, especially outside the academic environment. This is of course related to the uniqueness of the degree in Flanders.

Opportunities

- The quality of the MSc in Engineering Physics opens opportunities to attract more students from abroad.
- Feedback from students in the programme show that sustainable development and entrepreneurship are not very visible in our programme. This can be seen as an opportunity to broaden the scope to include these aspects.

Challenges

- The increasing offering of engineering master programmes that may have a more popular profile could reduce the interest of students in the MSc in Engineering Physics.
- The feedback of the students in the programme was overall very positive in 2018 – while the new programme was being designed. The SPC will need to monitor the feedback of students on the new program carefully and share this information also with stakeholders.

Strategies for improvement

- The programme was thoroughly revised, now the interaction with the industrial sectors that employ our engineers will be intensified to make it better known to industrial stakeholders that may be interested in hiring MSc in Engineering Physics.
- Carefully monitor the effect of the new programme on perception of sustainability and opportunities for entrepreneurship by the students after the first cohort will have experienced the new programme in summer 2021 and take the necessary actions to fine-tune if needed.

2.10 Master of Science in Industrial Engineering and Operations Research

Programme objectives

The objective of the M.Sc. in Industrial Engineering and Operations Research (IE/OR) is to educate engineers capable of designing, modelling, and optimising complex operational systems in manufacturing, logistics, transport, and mobility. This requires thorough knowledge of scientific, technological, economic, organizational, and human factors. The programme prepares engineers to tackle real-life problems and challenges in the pursuit of operational excellence within companies and other organizations, relying on a solid knowledge of mathematical models and methods, as well as the supporting technologies and information systems. Graduates have both the technological and soft skills to assume leadership roles and management positions. In addition, they have the necessary skills to conduct scientific research into improved Operations Research techniques, and/or their application in resolving complex issues in Industrial Engineering, while embracing a lifelong learning attitude.

Programme specific competences

As explained in Section 3.2 (SER, Part A), the master's programme objectives are formalised as a list of competences and associated learning outcomes, many of them common to all MSc in Engineering programmes. Below, we list only those competences specific for the MSc in IE/OR.

Competence field 1: Competences in one/more scientific discipline(s)

3. Have a thorough knowledge of fundamental fields of industrial systems engineering such as company- and production management, corporate finance, time study and methods engineering, operations research, quality measurement techniques and ICT.
4. Have a thorough knowledge of supporting fields of industrial systems engineering such as cost price evaluation, investment analysis, project management and ergonomics.
5. Master and apply advanced industrial engineering techniques in industrial production, logistics, service sectors and administrative and management processes.
6. Have a thorough knowledge of the advanced mathematical and statistical foundations of production systems and business processes.
7. Master and apply advanced operational research techniques to the field of production and logistic systems and in operational business processes.

Competence field 2: Scientific competences

6. Analyse business processes under the circumstances of variability and uncertainty through the use of mathematical optimisation, simulation and statistical techniques.
7. Calculate and follow up the costs and benefits of projects and project proposals, taking the uncertainty and impreciseness of data into account adequately.
8. Autonomously develop optimisation and simulation models for complex industrial systems.
9. Creatively develop optimisation and simulation models for realistic industrial systems.

Competence field 3: Intellectual competences

6. Show a holistic conception about the role of the human factor in company processes in order to effectively put the planned process improvements into practice.
7. Show a holistic conception about the role of technology in business processes in order to effectively put the planned process improvements into practice.

Competence field 4: Competences in cooperation and communication

5. Work together with colleagues from the own and other fields of expertise as well as with technical and assisting staff.
6. Provide a training in the developed working methods to the involved assisting staff, bearing in mind multidisciplinary aspects.

Competence field 5: Societal competences

4. Integrate social and societal impacts of new industrial and technological developments into business strategies, systems and processes.

Competence field 6: Profession-specific competence

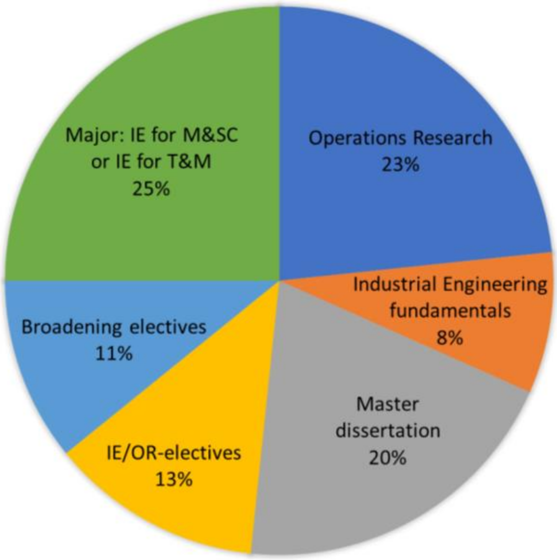
10. Continuously and critically analyse and optimise the stages a product completes in order to improve the efficiency of business processes.
11. Design and improve operational systems that generate products and services, based on scientific principles.

12. Plan and clearly describe operational duties that employees have to perform, taking into consideration the necessary machinery and resources.
13. Develop methods that allow to design new goods and services, avoiding any waste of resources.

Structure of the programme

Since the master IE/OR is open to students from all bachelor's programmes in Engineering Sciences, it contains both introductory and advanced courses in the domain. The study programme consists of five components:

1. **General IE and OR courses**: 28 credits of OR courses (mathematical modelling, optimisation, simulation, algorithms, heuristics), and 10 credits of fundamental IE courses (engineering economy, IT, and data processing).
2. A choice of one out of two **30-credit majors** focusing on a specific IE application domain, namely **Manufacturing and Supply Chain,** or **Transport and Mobility**.
3. At least 15 credits of **IE/OR-electives**, i.e., courses that closely match the IE/OR competences. Within this component, there is room to select a minor *Artificial Intelligence* or a minor *Automotive Production Engineering*.
4. At most 13 credits of **broadening electives,** including technical FEA master courses, a specific list of societal, entrepreneurial, financial, economics, management, etc. courses, and an internship.
5. The final component is the 24-credit **master dissertation**. Thesis subjects are spread across the spectrum between research-oriented, aiming to advance on the current scientific state of the art, and application-oriented, putting technical knowledge to work in a realistic company setting.



Programme structure Master of Science in Industrial Engineering and Operations Research

The first year of the standard learning track is mainly filled with the compulsory courses and the courses from the major. There is more room for electives in the second year.
Erasmus exchanges during the first semester of the second year and (international) internships during the summer break are encouraged.
When choosing the major Manufacturing & Supply Chain, the programme is as follows:

<table>
<tr><th>Year 1, Semester 1</th><th>Year 1, Semester 2</th><th>Year 2, Semester 1</th><th>Year 2, Semester 2</th></tr>
<tr><td>Operations Research Models and Methods</td><td>Algorithms and Data Structures</td><td>Industrial Systems Modeling and Optimization</td><td>Electives</td></tr>
<tr><td>Simulation of Stochastic Systems</td><td>Information Technology and Data Processing</td><td>Heuristics and Search Methods</td><td>Electives</td></tr>
<tr><td>Engineering Economy</td><td>Quality Engineering and Industrial Statistics</td><td>Supply Chain Engineering</td><td rowspan="3">Master dissertation</td></tr>
<tr><td>Manufacturing Planning and Control</td><td>Design of Manufacturing and Service Operations</td><td>Electives</td></tr>
<tr><td>Methods Engineering and Work Measurement</td><td>Electives</td><td></td></tr>
</table>

In the major Transport & Mobility, the balance across semesters is slightly different:

Year 1, Semester 1	Year 1, Semester 2	Year 2, Semester 1	Year 2, Semester 2
Operations Research Models and Methods	Algorithms and Data Structures	Industrial Systems Modeling and Optimization	Advanced Topics in Traffic & Logistics
Simulation of Stochastic Systems	Information Technology and Data Processing	Heuristics and Search Methods	Electives
Engineering Economy	Design of Urban Services	Urban Mobility and Logistics	Electives
Spatiotemporal Analysis and Modelling	Electives	Computational Aspects of Transport and Mobility	Master dissertation
Traffic Flow Modelling	Electives	Master dissertation	

Evolution of the programme

In the intermediate report of 2019, the following important changes were already reported:

- A master-specific Engineering Economy course (in English) was created.
- To deal with the heterogeneity of incoming students, a new module was added to the programme. This module contains two bachelor courses, one on Algorithms and Data Structures and one on Control Theory. None of the incoming students have had both courses before, so as part of the master, they must take one of them (i.e., the one that was not in their bachelor programme).
- The standard learning track was reorganized to have more compulsory courses in the first year.
- Since 2018, the SPC organises a yearly IE/OR Industry Day, where students and staff meet with company representatives (including IE/OR-alumni).
- A stricter standard is set for initial competences w.r.t. mathematics, probability, statistics, and programming literacy before admitting international applicants.

Since 2019, there are two more noteworthy changes in the programme:

- The list of IE/OR elective courses was gradually expanded over the years to include (new) courses on automation and control, stochastic systems, game theory and data science. In 2020-2021, the possibility to take a minor in *Artificial Intelligence* was introduced.
- As of this academic year (2021-2022), the programme has two majors: IE for *Manufacturing & Supply Chain* (with previously existing courses), and IE for *Transport & Mobility* (with new courses) – another IE application domain in which our faculty is very active).

From the improvement strategies listed in 2015, the following have been implemented:

- Monitoring the courses in terms of teaching methods, topics, study effort and evaluation methods was done (a.o. as part of reorganizing the model trajectory).
- Many courses adopted a more blended and active learning strategy over the last years.

Future plans include the following:

- Transforming the majors into full-fledged 'main subjects' for better visibility.
- Participating in the EIT Urban Mobility Master School, which has been enabled by introducing the major *Transport and Mobility*.
- Creating master-specific course contents on Algorithms and Data Structures (in existing courses or in a new course) rather than sending students to the existing bachelor course.
- Working more closely with the student association in organizing activities and attracting bachelor students into the programme.

Admission

The IE/OR programme is taught in English and is open to international students. Students are admitted if (i) they hold a bachelor's degree of at least 180 credits with good grades, (ii) comply with the required initial competences, in particular concerning programming, mathematics, statistics, and probability theory, (iii) master the English language at the B2 level, and (iv) are highly motivated.

For Flemish students, all BSc and MSc in Engineering Sciences automatically qualify for direct admission. All MSc in Engineering Technology are admitted via a bridging programme. Students with other degrees such as Ba or MSc in Business Engineering, MSc in Bioscience Engineering, Mathematics, Informatics, or Physics are required to take a tailored preparatory programme first.

The programme's context

The programme has its own student association, ORLean (https://www.facebook.com/orlean.gent/), that organises various activities such as welcome days, company visits, alumni meet-and-greets, etc. Further, the programme staff have strong connections with companies from various sectors, providing a pool of internship, master thesis, and job opportunities.

SWOC-analysis

Strengths

- The IE/OR engineering profile is highly desired in industry.
- The programme is highly appreciated by students.
- There is a good balance between research-oriented and practice-oriented skills. Many lecturers have strong industry contacts and link theory to practice in their courses.
- Students have mixed educational (and cultural) backgrounds, so they learn from each other in project work and extra-curricular activities.
- The yearly IE/OR Industry Day brings together all stakeholders and is a good event to promote the programme.

Weaknesses

- The IE/OR master does not have a bachelor track, so a large body of general courses in the master is necessary, leaving limited room for elective courses and further specialisation.
- The IE/OR profile is not visible in the bachelor, so it is hard to reach bachelor students and attract them to the programme.
- International students struggle to keep up with course work while getting settled in Gent and being faced with many practical, administrative, organisational, and cultural issues.
- The IE/OR programme combines a lot of theory with many practical cases and group projects. It is hard to strike the perfect balance between these two in terms of student workload.

Opportunities

- Many lecturers have strong links with large national or European consortia (such as the EIT Urban Mobility, imec, Flanders Make), which is a source of interesting new projects, case studies, internships, and master dissertations.
- The network of IE/OR graduates can be exploited to provide a pool of guest lectures, dissertation topics, research partners, sponsors for PR events, etc.

Challenges

- Attracting students from our own faculty's bachelor programmes in Engineering Sciences and master programmes in Engineering Technology.
- It remains difficult to assess initial competences of international applicants. Also, there is very limited room for tailoring curricula of international students who already have an IE background.

Strategies for improvement

- Support the ORLean student association and alumni network to create a broader IE/OR community.
- Promote the programme through various channels and events to better inform potential students.
- Extend the advisory board with more diverse profiles.
- Better accommodate and integrate international students; find ways to tailor their curricula.
- Rethink project work and guidance to improve their learning effect.

2.11 Master of Science in Fire Safety Engineering

The Master of Science in Fire Safety Engineering (MFSE) has the same objectives as the International Master of Science in Fire Safety Engineering (IMFSE) programme. The IMFSE programme is coordinated by Ghent University [UGent], with Lund University [LU] and the University of Edinburgh [UoE] as full partners. ETH Zürich, the University of Queensland [UoQ], University of Maryland [UMD] and University of Science and Technology in China [USTC] are associated partners. In semesters 1 and 3, the MFSE and IMFSE students are following the same classes. Only in semester 2, when the IMFSE students are at LU, there is some distinction in that the MFSE programme offers more structural fire engineering [SFE] courses. Given the strong overlap, both programmes are addressed in a single document, focusing on MFSE. Where needed, differences are highlighted. Otherwise, statements for MFSE also hold for IMFSE.

Programme objectives

The main objective of the (I)MFSE is to provide a top-notch education for graduates to emerge as leading experts in the field of Fire Safety Engineering [FSE]. MFSE graduates are able to demonstrate methodological knowledge and understanding in FSE, including broad knowledge in the field and substantially deeper knowledge of certain parts of the field, together with deeper insight into current research and development. They are able to critically and systematically integrate knowledge and to analyse, assess and deal with complex phenomena, issues and situations, even when limited information is available. They can clearly present and discuss conclusions and the underlying knowledge and arguments, in dialogue with different groups, orally and in writing, in national and international contexts. They have acquired the skills required to participate in research and development work or to work independently in other advanced contexts. They can make assessments in the frame of FSE, taking into account relevant scientific, social and ethical aspects, and develop an awareness of ethical aspects of research and development work. They have insight into the potential and limitations of science, its role in society and people's responsibility on how it is used, and starting from their broad and profound knowledge of state-of-the-art FSE. They are also able to identify the needs for further knowledge and to take responsibility for developing knowledge in the field of FSE.

Programme specific competences

All generic competences of the Master of Science in Engineering programmes are covered. The programme specific competences are listed below. These are in line with the ‘model curriculum’ as communicated on the websites of the International Association for Fire Safety Science [IAFSS][1] and the Society for Protection Engineering [SFPE][2].

Field of competences M1: Competences in one/more scientific discipline(s)

- M1.3 Master and apply knowledge of physics, chemistry, thermodynamics, heat and mass transfer, fluid mechanics and computational fluid dynamics to critically analyse and evaluate the development of fires in enclosures.
- M1.4 Master and apply knowledge of structural fire engineering to critically analyse, design and evaluate the performance of structures in case of fire.
- M1.5 Master and apply knowledge of explosions to critically analyse and evaluate the associated risk.
- M1.6 Master and apply the advanced knowledge of fire dynamics, risk assessment, human behaviour, passive fire protection systems and active fire protection systems.
- M1.7 Master and apply the principles necessary to develop a performance-based fire safety design [PBD].

Field of competences M2: Scientific competences

- M2.6 Elaborate problems of fire risk assessment in a critical, autonomous and flexible manner with a limited amount of data.
- M2.7 Perform valid computer simulations of development and consequences of enclosure fires.
- M2.8 Perform valid computer simulations to assess the performance of smoke and heat control systems as means of active fire protection measure.

[1] https://iafss.org/wp-content/uploads/modelcurr.pdf
[2] https://higherlogicdownload.s3.amazonaws.com/SFPE/93e7d31c-6432-4991-b440-97a413556197/UploadedImages/Core_Competency/Minimum_FPE_Competencies_FIN.pdf

M2.9 Perform valid computer simulations of the behaviour of structural systems in case of fire.

Field of competences M3: Intellectual competences

M3.6 Develop scientifically sound arguments to optimise passive and active fire protection measures.

M3.7 Develop scientifically sound arguments to develop a performance-based fire safety design.

Field of competences M4: Competences in cooperation and communication

M4.5 Function in an international environment (students, PhD students, scientific co-workers, scholars).

Field of competences M5: Societal competences

M5.4 Master and apply critical insight in existing fire safety legislation and regulations in the development of a fire safety design.

M5.5 Act in an ethical, professional and social way when developing and presenting a performance based fire safety design.

Field of competences M6: Profession-specific competence

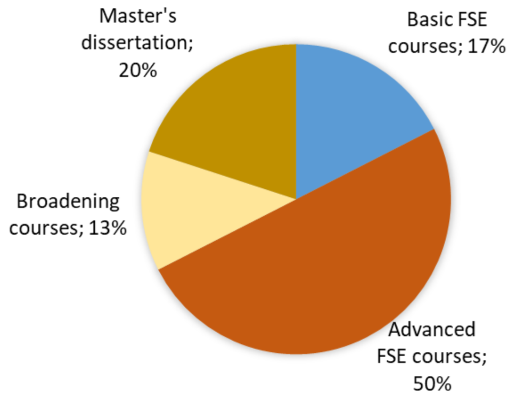
M6.10 Integrate Fire Safety Engineering related knowledge to develop a performance-based fire safety design.

Structure of the programme

The courses and topics in the MFSE programme fit very well with the model curricula as mentioned above. The distribution of the MFSE courses over the 4 terms of 30 ECTS credits each, is shown in the table below. In term 1, mainly basic FSE topics are taught, covering basic knowledge on thermodynamics, heat transfer, structural engineering, fire dynamics and fire science in general (at master level). Already one more practical and advanced course is taught (on explosions and industrial fire safety), so the students already get the taste of this. There is also room for broadening courses. More advanced FSE courses are taught in terms 2 and 3. A broad perspective on FSE is pursued, with attention for both SFE and active fire protection measures. Term 4 is largely devoted to the master's dissertation.

<table>
<tr><th>Term 1</th><th>Term 2</th><th>Term 3</th><th>Term 4</th></tr>
<tr><td>Fire dynamics</td><td>Structural fire engineering</td><td>Active fire protection I: Detection and suppression</td><td>Fire safety strategy project</td></tr>
<tr><td>Thermodynamics, heat and mass transfer</td><td>Interaction between people and fire</td><td>Active fire protection II: Smoke and heat control</td><td>Elective</td></tr>
<tr><td>Material behaviour at ambient and elevated temperatures</td><td>Risk management</td><td>CFD for Fire safety engineering</td><td rowspan="6">Master's dissertation</td></tr>
<tr><td>Analysis of structures (1)</td><td>Compartmentation strategies</td><td>Fire safety and legislation</td></tr>
<tr><td>Explosions and industrial fire safety</td><td>Fluid mechanics applications in fire</td><td>Passive fire protection</td></tr>
<tr><td>Design for structural fire resistance (2)</td><td>Elective</td><td>Performance-based design</td></tr>
<tr><td>Fire research seminar</td><td rowspan="2"></td><td>Design for structural fire resistance (3)</td></tr>
<tr><td>Elective</td><td>Applications for advance structural fire engineering (4)</td></tr>
</table>

Programme organisation over semesters: (1) for students without background in structural engineering, (2) for students with background in structural engineering, (3) for students who did not take this course in semester 1, (4) for students who had the course 'Design for structural fire resistance' in term 1, elective for others.



Programme structure Master of Science in Fire Safety Engineering

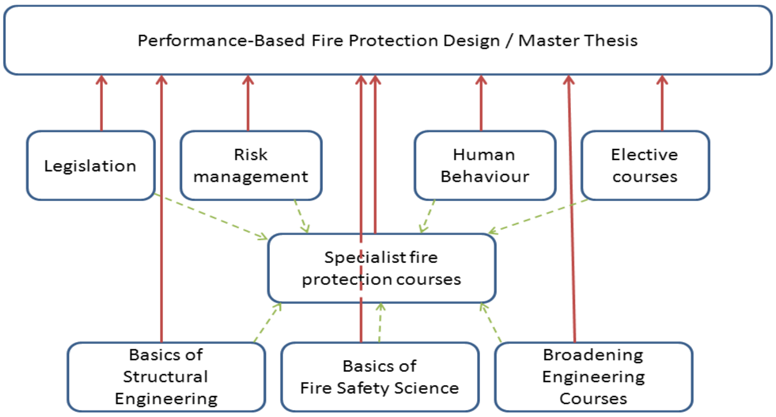


Illustration of how the courses support performance-based fire protection design [PBD].
Red solid arrows: direct input for PBD; green dashed arrows: indirect support.

Another way of visualising the programme is through learning tracks: active fire protection, structural fire engineering (including passive fire protection) and industrial fire safety. The learning track on industrial fire safety is less extensive, because the MFSE programme primarily focuses on the built environment. The overarching learning track concerns Performance based fire protection design (PBD) in support of the worldwide trend towards PBD for fire safety and fire protection. The MFSE programme is unique in covering all these FSE related aspects in a single MSc programme. This relates to the choice of combining broad and in-depth education of all these ‘ingredients’ for a fire safety strategy in the PBD context.

Evolution of the programme

The IMFSE program received very positive comments at the previous CTI visit. The MFSE programme was not evaluated then, because the program started in 2015, but given the strong connection to IMFSE, the starting point was deemed very good. There has been an evolution towards including more SFE related courses over the past few years, the vast majority of the courses being taught by academic staff of the Department of Structural Engineering and Building Materials. Special attention has been given to the inflow of students with different background (i.e., structural engineering background or not), through two different tracks. This is particularly relevant as the majority of the students stem from abroad. Another improvement has been the introduction of a course on data driven management of fire incidents, taking advantage of the modern evolution towards the use of big data. The IMFSE programme has been updated accordingly, as the courses at UGent are identical. At UoE, some courses have been renamed and reorganized, but the main change is the replacement of a course on project management by a basic course on structural mechanics. There has been no drive for more significant changes in the programme, given that it is very well aligned with the mentioned model curricula as advocated by the leading research and engineering associations in the field of FSE (IAFSS and SFPE). Moreover, the very positive assessment at the occasion of the previous CTI visit encouraged us not to induce drastic changes.
Where possible, theory is illustrated by lab experiments. The students also complete a relatively high number of assignments, so that real-life case studies enlighten theoretical aspects.

The student numbers have been growing steadily, in particular thanks to an increase in the number of self-sponsored students. This is partly thanks to targeted publicity campaigns. Over the years, also more and more guest lecturers have been invited, so the students are exposed to top-notch FSE specialists.
The future plan is to keep the FSE programmes up-to-date, using suggestions and advice from the Industry Advisory Board, while maintaining the back-bone of the programme.
As a final note, it is mentioned that the number of companies, contributing financially so that an IMFSE scholarship mechanism can be installed for top students, has grown over the years.

Admission

There is no BSc programme in FSE. Immediate admission is granted to holders of a BSc degree in engineering: civil / structural / (electro-)mechanical / chemical / material sciences / architecture. A 'bridging programme' exists for MSc holders of a similar degree in engineering technology. BSc holders of a similar degree in engineering technology can be admitted, subject to passing a preparatory course. For IMFSE, the minimum admission requirements are essentially the same. The language requirements are slightly stricter. Moreover, all application files are screened individually. Additional assets are higher academic degrees and excellent transcripts of records, a strong motivation statement, letters of recommendation and, if any, relevant work experience. A limited number of scholarships are available for students. Candidates for scholarships are, in addition to the screening of their CV, interviewed. Finally, a ranking is made by consensus by the programme directors and scholarships are proposed to students from top to bottom of the list until they are all granted. Also self-sponsored applicants are screened and interviewed prior to admission.

The programme's context

The FSE students constitute a strong community. They bond as a group in continuously changing circumstances: IMFSE students move to partner universities and benefit from each other's knowledge and experience. While at UGent, the MFSE and IMFSE student groups intermingle well. This is stimulated by group assignments, creating mixed groups of MFSE and IMFSE students, so both groups have a very international experience.
Although personal communication is possible at any time, communication between the programme directors and the students primarily happens through the student representatives (elected by the students themselves).
The alumni join a common mailing list (for IMFSE, coordinated by an IMFSE alumnus) which is actively used (e.g., to communicate job opportunities or job changes), or the alumni association FireProNet (mainly MFSE, https://www.firepronet.eu/). There is also the IMFSE SFPE Student Chapter, organizing many relevant activities (e.g., lectures or a job fair).
The joint organisation of the IMFSE programme constitutes a strong partnership between UGent (coordinator), LU and UoE. Furthermore, the associated partners are heavily involved in the partnership. Geographically there is clearly a strong distribution around the globe, allowing the best institutions in FSE education to join force for the benefit of the IMFSE.
The FSE programmes also have an Industry Advisory Board [IAB], consisting of representatives from industry, authorities and fire service. This IAB provides feedback and input on the curriculum on an annual basis. This has already led to additions in the curriculum (e.g., the introduction of the elective course 'FSE based firefighting' or on data driven management of fire incident). Many FSE alumni are currently employed by members of the IAB. Moreover, for IMFSE many companies[3] contribute financially, so that scholarships and tuition fee waivers can be provided to excellent applicants. This helps attract the best international and local students.

SWOC-analysis

Strengths

- MFSE/IMFSE are unique MSc programmes at MSc level of the size of 120 ECTS credits.
- Students adapt to the PBD attitude, relying on profound knowledge of basic and advanced FSE science.
- The education is backed by world-class research of leading experts in the FSE community, who are very active in the major international societies in the field of FSE (in particular IAFSS and SFPE).
- A number of lecturers, particularly for the specialised courses, are professionally active in FSE.
- The international flavour is very strong.
- On top of the regular QA in place at the Faculty level, an External Examiner [EE] is in place for IMFSE, who provides feedback on an annual basis through the EE report.

[3] https://imfse.be/sponsors

Weaknesses

- No significant weakness has been reported by stakeholders or students. The study load is perceived as heavy by the students, but there is lack of accuracy and reliability of the study time measurements, due to low participation rate by students. This is considered a weakness.

Opportunities

- Input/feedback from the EE.
- Support (also financial) from industry.
- Worldwide increased interest in education in FSE (e.g., by IAFSS and SFPE).
- Worldwide trend in the direction of PBD (in regulation, industry …).
- FSE related research with industry partners.

Challenges

- Financial sustainability (high tuition fees are problematic for self-sponsored students).
- The input from guest lecturers is essential. Hence, such lecturers must remain available.
- Internships cannot be obliged due to visa issues.

Strategies for improvement

- Targeted publicity to increase the number of self-sponsored students.
- Continued effort to consolidate and expand the group of companies and institutes supporting IMFSE.
- Continued effort to attract guest lecturers.
- The Faculty can promote the (I)MFSE programme with MSc of Engineering Technology students.

2.12 Master of Science in Bioinformatics – Main Subject Engineering

The two-year Master of Science in Bioinformatics programme (120 ECTS) was established in 2015 and is supported by three faculties: a) the Faculty of Engineering and Architecture; b) the Faculty of Sciences; and c) the Faculty of Bioscience Engineering. The programme consists of three main subjects (also called 'tracks'): 'Engineering', 'Systems Biology' and 'Bioscience Engineering'. Only the main subject 'Engineering' is part of the CTI visitation.

Programme objectives

The general objective of the master's programme is to provide students with the scientific knowledge, skills, attitudes and insights that enable them to function professionally and value-conscious in the domain of bioinformatics as well as in a broader context of biotechnology and engineering. Holders of the Master of Science in Bioinformatics degree are capable of critically using existing knowledge generated from scientific research to make improvements and to contribute in an original and innovative manner to the knowledge society.

The Engineering track is aimed at training bioinformatics software engineers who can develop on an independent basis new algorithms and complex software implementations to improve current techniques or to respond to new developments in the domain of bioinformatics and systems biology.

Programme-specific competences

As explained in Section 3.2 (SER, Part A), the master's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GM1-GM6)

Competence field 1: Competences in one or more scientific disciplines

- Having advanced knowledge of mathematics, informatics, machine learning and statistical techniques and their application within bioinformatics and systems biology.
- Having knowledge of experimental techniques for the generation of 'omics' data.
- Understanding the specificities of 'bioinformatics' and 'systems biology' in relation to its composing subdomains, i.e., having insights in the interdisciplinary character of the research domain.
- Application of basic statistical, computer science and other data analysis techniques to solve well-delineated problems (skill).
- Having an overview of the most important methods in computational biology.
- Having insight in the way bioinformatics evolves (fastly evolving domain).
- Knowledge of software-engineering techniques and advanced programming skills.
- Advanced knowledge of data structures and algorithms for the application of well-delineated problems.
- Broad knowledge of the bioinformatics application domain.
- Broad knowledge of the genetics and molecular biology.

Competence field 2: Scientific competences

- Implement previously described models and methods to solve a bioinformatics problem.
- Design novel analysis tools and methods to solve a new bioinformatics problem.
- Design the proper simulation studies to evaluate state-of-the-art methods.
- Recognize a biological problem and determine the proper method to solve it with a bioinformatics approach.
- Interpret the results of a model or simulation from a computational or biological point of view.

Competence field 3: Intellectual competences

- Define a complex systems biology problem and subdivide this in subproblems.
- Choosing the most appropriate principles to solve each of the subproblems, if needed in collaboration with experts in each of the subdomains (informatics, statistics).
- Make a well-educated choice between the theoretically most elegant and most pragmatic methods and estimate the effects of approximations on the final results.
- Showing an active attitude towards life-long learning.

Competence field 4: Competences in collaboration and communication

- Communicate in English.
- Work in a project-driven way: formulating goals and focused reporting, taking into account the end goals, the development trajectory and the background of the vocational field (bioinformaticians, biologists, clinicians, statisticians, computer scientists).
- Function as a member of a team in a multidisciplinary environment and as starting manager.
- Oral, written and graphical reporting on a scientific topic and placing it in a broader framework.

Competence field 5: Competences in social responsibility

- Having an insight in the ethical questions raised by the fastly evolving domain of bioinformatics and systems biology (personalized medicine, successful aging, sustainable agriculture, synthetic biology, …).
- Being aware of the social and bioethical discussions that relate to the data and the analysis results.
- Taking into account the running ethical norms in scientific research (e.g., dealing with patient data).

Competence field 6: Professional competences

- Gaining insight into the complexity of the problem with quantitative methods.
- Formalize a biological problem taking into account the properties of the data and the assumptions of the method.
- Extract useful information from abundant, incomplete and contradictory data.
- Test the results of complex calculations and approximations.
- Have attention for running times, performance, memory requirements and user-friendliness of the algorithms and bioinformatics tools.
- Have attention for aspects such as reliability and confidence during storage and transmissions of big data.
- Having an insight in the understanding and role of entrepreneurship.
- Show attitude of perseverance, innovation and added value creation.
- Plan and execute in an independent and results-driven way an engineering project at the level of a beginning professional.

Structure of the programme

The main subject 'Engineering' of the Master of Science in Bioinformatics is open to students with a degree 'Bachelor of Science in Engineering: Computer Science Engineering' or 'Bachelor of Science in Computer Science'. In contrast to bioinformatics students in the other main subjects ('Systems Biology' and 'Bioscience Engineering'), no background in biology or life science is assumed. Therefore, a '**Biology for engineers**' module (9 ECTS) provides students with the basic knowledge to understand a data-driven biological problem. This module comprises 2 courses taught in the first semester of the first year: 'Cellular and Molecular Biology' (6 ECTS) and 'Introduction to Bioinformatics' (3 ECTS).

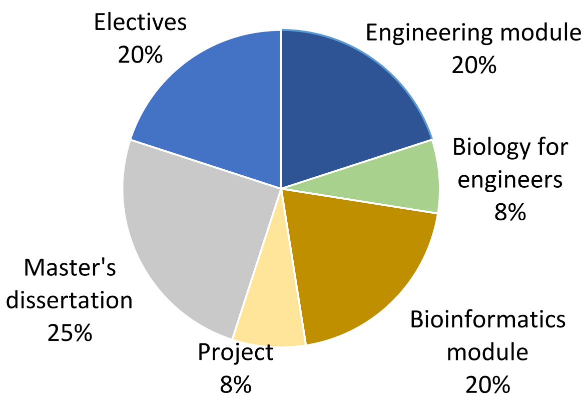
The '**Applied bioinformatics module**' (24 ECTS) is joint between the three main subjects. These courses familiarize students with the data specificities of the bioinformatics domain (pre-processing techniques, noise and potential biases, assumptions etc.) and allow them to acquire the essential interdisciplinary skillset that is needed to be successful in modern science and engineering: 'Applied High-throughput Analysis' (6 ECTS), 'Statistical Genomics' (6 ECTS), 'Integrative Biology' (3 ECTS), 'Genome Biology' (6 ECTS) and 'Capita Selecta in Bioinformatics' (3 ECTS). The latter course involves national and international renowned scientists and researchers who discuss state-of-the-art applications of bioinformatics in different domains.

In the course '**Design Project**' (9 ECTS), students work in heterogeneous teams (students from different main subjects are mixed) in order to create innovative solutions for bioinformatics problems. This course aims to sharpen both technical and intellectual skills in the field of bioinformatics and to apply theoretical knowledge from other courses to practical problems. The project involves different components: project management, requirement analysis, design and implementation, evaluation, testing and documentation. This course also sharpens oral and written communication skills and sparks interdisciplinary collaboration between students.

The '**Engineering module**' (24 ECTS) focuses on advanced engineering and computer science techniques that are relevant for the bioinformatics domain. Courses in this module build on the knowledge obtained during the bachelor's programme: 'Parallel and Distributed Software Systems' (6 ECTS), 'Computational Challenges in Bioinformatics' (6 ECTS), 'Machine Learning' (6 ECTS) and 'Optimization Techniques' (6 ECTS).

The '**Electives module**' (24 ECTS) consists of two parts: 12 credits that can be chosen from a pre-defined list of relevant engineering courses and 12 credits that can be chosen from the entire Ghent University offering. The former contains elective courses such as 'Big Data Science', and 'Information Security', that allow students to further deepen their engineering skills in subjects of their own preference. The latter allows students to either further broaden their knowledge towards the life sciences domain (or even other domains) or to further specialize as engineers. It also allows students to do an internship.

Finally, the '**Master's dissertation**' (30 ECTS) focuses on a research topic of choice. The master's dissertation has an important engineering component.



Structure of the Master of Science in Bioinformatics: Engineering

Term 1	Term 2	Term 3	Term 4
Parallel and Distributed Software Systems	Computational Challenges in Bioinformatics	Machine Learning	Optimisation Techniques
Cellular and Molecular Biology	Elective Course (Engineering)	Elective Course (Engineering)	Elective Course (UGent) or Internship
Statistical Genomics	Introduction to Bioinformatics	Elective Course (UGent)	
	Integrative Biology		
Applied High-throughput Analysis	Genome Biology	Master's dissertation	
Capita Selecta in Bioinformatics			
Design Project			

Programme organisation over semesters

Evolution of the programme

The programme of the Master of Science in Bioinformatics consists of three main subjects (also called 'tracks'): 'Engineering', 'Systems Biology' and 'Bioscience Engineering'. This allows training students with well-defined and different profiles (bioinformatics scientist, bioinformatics engineer) and herewith meets the needs of the work field. Each track consists of (1) a generalization module in which students are introduced to the disciplines complementary to the ones they studied in their pre-education. This allows students to understand the interdisciplinary context in which they will need to work. (2) A specialization module in which the disciplines of their prior education are further strengthened and (3) a common module in which all students of the different tracks/backgrounds follow bioinformatics-related courses together.

Because of the trade-off between generalization and specialization, (1) the master programme respects the primary domain of interest of the student (which is usually reflected by his/her bachelor degree). The goal is not to turn an engineer into a biologist or vice versa, but to provide sufficient domain knowledge to be able to understand the intricacies of the bioinformatics domain. The latter is essential given that the specificities/properties of the data/domain knowledge in bioinformatics are very different from the specificities encountered in other domains). (2) The vocational field therefore highly appreciates engineers with experience in handling the domain-specific data.

The curriculum for the Master of Science in Bioinformatics programme was established based on the recommendations by a task force of the International Society for Computational Biology (ISCB) Education Committee (EduComm)[4].

Admission

Admission to the 'Master of Science in Bioinformatics: Engineering':

1. Holders of a degree 'Bachelor of Science in Engineering: Computer Science Engineering' or 'Bachelor of Science in Computer Science': **direct admission**.
2. Holders of a degree 'Master of Science in Industrial Sciences: electronics – ICT': **direct admission with modified programme**.
3. Holders of a degree 'Bachelor of Science in Engineering' with a main subject different from 'Computer Science Engineering' or 'Bachelor of Science in Bioscience Engineering Technology' or 'Bachelor of Science in Biochemistry and Biotechnology' or 'Bachelor of Science in Mathematics' (with minor 'Life Sciences' or minor 'Informatics'): **admission after the completion of a preparatory programme**.

Note that the other main subjects ('Systems Biology' and 'Bioscience Engineering') of the Master of Science in Bioinformatics have different admission rules.

The programme's context

Recent technological advances have dramatically changed our view on life science research and have turned biology in a data-driven science. It is in this context that bioinformatics, a booming interdisciplinary field, has evolved from a new research domain to a basic discipline in only 15 years. Bioinformatics aims at gaining a better and preferentially more quantitative molecular understanding of cellular processes by integrating and modeling large amounts of molecular data.

The bioinformatics programme aims to train interdisciplinary scientists and engineers who can develop or use state-of-the art statistical and computer science techniques to mine molecular data in order to answer fundamental or applied biological and biomedical questions. Ghent University offers an interfaculty Master of Science in Bioinformatics programme, which - depending on the chosen track - can result in an Engineering or Bioscience Engineering degree.
The pharmaceutical and biotechnology sector in Belgium is at the world's forefront. Despite its small size, Belgium represents nearly a quarter of the European biotech market value. The Master of Science in Bioinformatics prepares students for employment in leading pharmaceutical companies (such as Janssen Pharmaceutica R&D (Johnson & Johnson), GalaxoSmithKline, Pfizer and UCB), large-scale biotechnology companies (such as Ablynx (Sanofi), arGEN-X and Galapagos) and over 140 mid-scale biotech companies (such as Agilent, Biocartis, Celyad, MDXHealth, Mithra Pharmaceuticals, Hyloris Pharmaceuticals, etc.). This high density of biotech companies is a fruitful ecosystem for a large number of companies that provide specialized software and/or consultancy services (such as Applied Mathematics, BioLizard, BISC Global, Biogazelle, etc.). The flanders.bio network currently lists over 330 companies active in life sciences in Belgium. The link between the Master of Science in Bioinformatics and the industry is established via courses taught by leading researches from industry (e.g., the course Capita Selecta in Bioinformatics), master theses in collaboration with industry, and internships by our students during the summer holidays. Additionally, external stakeholders (professionals from industry, alumni, peers, etc.) are regularly asked for feedback with respect to programme-specific competences as well as content of the programme.

The programme is also embedded in a strong bioinformatics and biotechnology research environment, located at the Faculty of Sciences, Medicine, Bioscience Engineering and Engineering and Architecture and is affiliated with the VIB (Flemish Institute for Biotechnology) and imec (interuniversity microelectronics center).

[4] Lonnie R. Welch, Russel Schwartz and Fran Lewitter, "A Report of the Curriculum Task Force of the ISCB Education Committee", PLOS Computational Biology, June 28, 2012.

International mobility is encouraged through Erasmus exchange and/or international internships, e.g., the International Association for the Exchange of Students for Technical Experience (IAESTE) program. To facilitate incoming international students, the programme is taught in English. The education develops international and intercultural competences in all students through internationalisation@home (IaH).

SWOC-analysis

Strengths

- A diverse and interdisciplinary team of teachers from three faculties that are highly specialized in their respective course(s). Highly research-based teaching.
- Structure of Master preserves and strengthens the individual profile of its students: students with a background in engineering further strengthen their engineering skills while broadening their knowledge towards the application domain of life sciences.
- Through projects, students are trained in acquiring the essential programming, software engineering, modeling and interdisciplinary communication skills.
- Bioinformatics is a fastly evolving domain so students are trained to be critical towards progress in the state of the art (stimulate lifelong learning).
- The professional domain is actively involved in the master through master projects, internships and courses (Capita Selecta). This allows students to become familiar with the way bioinformatics is applied in the industry, in research or governmental institutes.

Weaknesses

- General courses should provide a sufficient learning effect for students with different background and learning styles. This requires increased attention for both remediation and differentiation. Steps have already been taken for specific courses to provide students with an overview of expected background knowledge, and pointers to appropriate documents for self-study. Differentiation involves the design of dedicated tasks for students with different backgrounds and/or stimulation of self-study.

Opportunities

- The bioinformatics domain is growing quickly and Master programmes are increasingly established at other universities such as KU Leuven, Wageningen University, Université Paris-Saclay, Université de Paris, Freie Universität Berlin, University of Edinburgh, University of Copenhagen, etc. This creates opportunities to establish bilateral exchange.
- Trained and skilled bioinformaticians are increasingly needed by industry.

Challenges

- The bioinformatics domain is evolving quickly with new emerging technologies and analysis methods rapidly replacing older methods. This requires lecturers to quickly adapt their courses and keep up with the latest developments in their respective fields.
- Specifically for the ‘Engineering’ track, the Master of Science in Bioinformatics has little visibility among Bachelor students in the Faculty of Engineering and Architecture as there is no matching preparatory Bachelor programme.
- The recruitment of international students from good universities is challenging.

2.13 International Master of Science in Textile Engineering

Programme objectives

The International Master of Science in Textile Engineering is a two-year master's programme in the field of textile engineering. The programme is supported by the European Commission as an Erasmus Mundus Joint Master Degree (www.WE-TEAM.education). It was and still is a unique programme offering advanced education in Textile Engineering in which the latest developments in the textile field as well as contemporary teaching methods are incorporated. The most renowned specialists from all over the world in the multidisciplinary domain of textiles are brought together and contribute to the educational activities.

The programme's objectives are acquisition of advanced knowledge in textile science and engineering, personal development and international networking. Knowledge addresses textile materials, processes and applications. Horizontal learning lines include digital technologies, scientific thinking, entrepreneurship and sustainability. Intensive mobility, multicultural student groups and immersion in local cultures guarantee the development of Intercultural competences.

Upon completion of the programme, students are awarded a master degree from the universities where they have spent a semester (apart from UPV, that awards a degree to every edition):

- At UGent: International Master of Science in Textile Engineering (every edition)
- At UPV (Valencia, Spain): Máster Universitario en Ciencia en Ingeniería Textil (Master of Science in Textile Engineering) (every edition)
- At UNIWA (Athens, Greece): Advanced Master in Textile Technology (edition 21-23)
- At UHA (Mulhouse, France): Master in Mechanic and Fibrous Materials (edition 23-25)
- At KIT (Kyoto, Japan): Master of Engineering (if the 3rd semester is spent at KIT)
- At UB (Boras, Sweden): Master of Science (120 credits) with a major in Textile Engineering (if 3rd semester is spent at UB)

Programme specific competences

As already explained in Section 3.2 (SER, Part A), the master's programme objectives are formalised as a list of competences and associated learning outcomes (see competence fields GM1-GM6). These competences are shared with the other Master of Science in Engineering programmes. However, a number of competences have been added in some of the competence fields:

Competence field 1: Competences in one/more scientific discipline(s)

3. Apply advanced knowledge of fundamental sciences (physics, chemistry and mechanics), using an analytical way of thinking.
4. Advanced knowledge of characteristics and application fields of textile products to develop products with specific characteristics using dedicated product design methods.
5. Advanced knowledge of and practical experience with use of techniques and methods to investigate properties of textile materials.
6. Advanced knowledge of physical foundations of materials, ability to use general and physical chemistry and material science innovatively.
7. Advanced knowledge of applications of fibrous materials.
8. Advanced knowledge of use of chemical and mechanical process-technological aspects of textile materials.
9. Use advanced knowledge of mathematics and statistics to develop mathematical models for the generation of textiles and textile-technological processes.
10. Advanced knowledge of the use of and the interactions between selection of raw materials and process-parameters, keeping in mind the usage-properties of fibrous materials and derived products.

Competence field 2: Scientific competences

6. Thoroughly examine complex, multidisciplinary problems in material science autonomously and flexibly, also in case of limited data.
7. Create an experimental set-up for textile materials to develop own models.
8. Identify suitable methods and procedures and apply them accurately.
9. Define and carry out research-plans, keeping in mind their chance for implementation.
10. Manage multidisciplinary problems in a flexible and creative way.

Competence field 3: Intellectual competences

6. Think about the optimisation of production processes, the development of new fibrous materials and the improvement of existing ones in a scientific, system-focused, problem-avoiding and solving way.
7. Apply knowledge from other disciplines to applications in the field of textiles engineering.

Competence field 4: Competences in cooperation and communication

5. Integrate in research activities of a department.
6. Work in an international (European and/or global) group.

Competence field 5: Societal competences

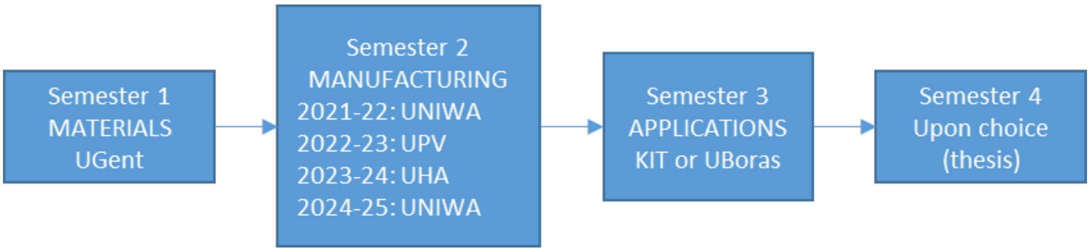
4. Put research and development in societal context, taking into account ethical considerations.
5. Demonstrate a multicultural attitude.
6. Comprehend, accept and respect cultural values of people with different cultural backgrounds.

Competence field 6: Profession-specific competence

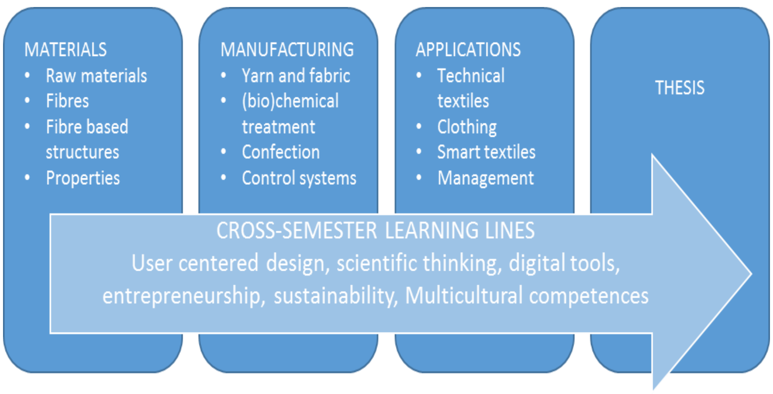
10. Deal successfully with problems that imply a multidisciplinary approach.
11. Estimate roughly problems and situations in a quantitative way.

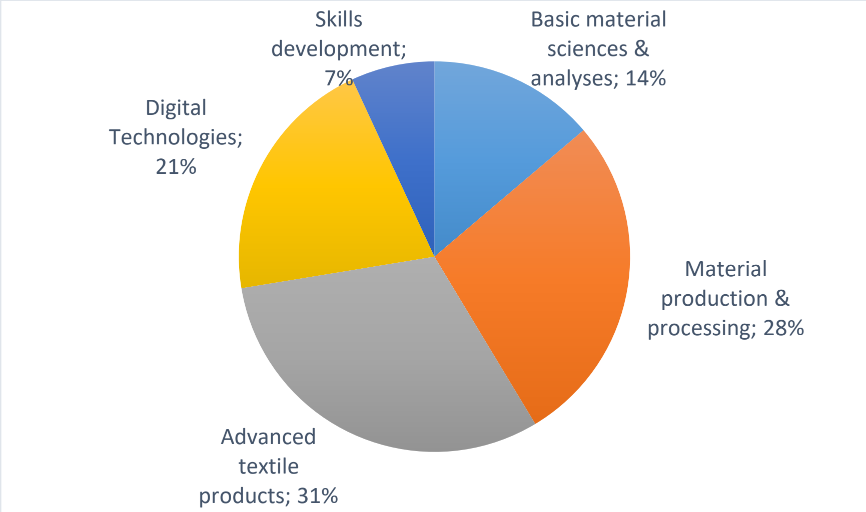
Structure of the programme

The EMJMD consortium consists of 11 partners, 6 full and 5 associated, 9 from EU and 2 from Japan.
UGent (Belgium) is the EU project coordinator, whereas Kyoto Institute of Technology (KIT) is the Japanese/Asian leader. Other full partners who also organize a semester and award a MSc degree are: University of Haute Alsace (UHA-France), Boras University (UB-Sweden), University of West-Attica (UNIWA-Greece) and Polytechnic University of Valencia (UPV-ES).
Associated partners contribute to the teaching and/or welcome students for their master dissertations: Ecole Nationale Supérieure des Arts et Industries Textiles (ENSAIT-FR), Technical University of Lodz (TUL-Poland), Technical University of Dresden (TUD-Germany), Kaunas University of Technology (KTU-Lithuania) and Shinshu University (Japan). They could not participate as full partners because of national or institutional regulations.
Partners take responsibility for specific project tasks following their strengths and interests (promotion (TUL and KIT), industry liaison (ENSAIT and KIT), ICT tools (UB and UNIWA), student induction (UHA)).
The programme consists of 3 thematic semesters, which are organised at different full partners, with a fourth semester that is dedicated to the master dissertation.
The mobility scheme depends on the edition, it looks as follows:



The first year, students have no choice about the location. The third semester they can choose between Boras (Sweden) and Kyoto (Japan), the fourth semester depends on their choice of master dissertation.
The semesters are thematic; cross semester learning lines ensure specific competences are developed throughout the semesters. Students can make their own accents through an elective course, summer school, internship and the master dissertation. Programme structure:





Programme structure International Master of Science in Textile Engineering

Term 1	Term 2	Term 3
Polymer Technology	Advanced and Specialized Textile Processing – Finishing	Applications of Technical textiles
Advanced Fibre Technology	Advanced and Specialised Textile Processing – Mechanical I-III	Technical Textiles Manufacturing Technology
Mechanics of Textile Materials	Industrial Information Systems	Management, Logistics and Distribution
Biomaterials	Biotechnology	Innovative Methods for the Product Development Process for Garments and Technical Applications in the Ready-Made Industry
Instrumental Analysis	Automation and Process control	Sustainable textile design
Computation Sciences and Engineering Principles	Garment Technology	Comfort and computation of textiles
Composite Materials	Nanotechnology in the Textile Branch	Intelligent Textiles
Advanced and Specialized Textile Processing – Dyeing	Elective course	Scientific Thinking
Co-creation		

Courses in the International Master of Science in Textile Engineering

Evolution of the programme

The most important recent change is the transition to an Erasmus Mundus Joint master Degree.
To achieve this recognition, a detailed proposal had to be elaborated, submitted and approved by the EACEA expert panels. Although the programme in itself is not new, during the preparation phase of the proposal all aspects of the master programme had to be evaluated by each of the consortium full members and adjusted to meet their national and institutional regulations and requirements. The objectives, concept and structure of the programme were approved by all institutions. The changes needed overall concerned organizational aspects such as the selection of students, appointment of lecturers, calendar, etc..

The programme revision that was submitted in 2018 (for implementation in 2019 as preparation for the EMJMD application) included:

- The introduction of thematic semesters
- Inclusion of Kyoto as hosting partner

- Clustering of courses (e.g. mechanical and chemical processes, technical textiles)
- Introduction of new topics: comfort, modelling in textiles co-creation, specialist course, scientific thinking,
- Introduction of learning lines (e.g. sustainability, design thinking, multicultural competences)

In order to support the education in some of the new fields, several partners are actively involved in Erasmus+ projects in order to develop high quality educational materials (e.g. T-CREPE for design based learning and entrepreneurship, ICT-TEX for digital technologies)

Follow-up of CTI-recommendations

- Students are encouraged to take an **internship**; we offer them positions, some come up with their own proposal. In the future the WE-TEAM Industry Liaison Board is to enhance the ties with industry, including offers for internships
- **Sustainability** is not only a course, it has also been identified as a learning line; efforts are currently being made to set up an Erasmus+ project to support the elaboration of educational materials for education in this field
- The **number of students** in both MSc in Sustainable Materials Engineering (major textiles) and the International MSc in Textile Engineering has steadily increased (around 10 students/year resp. around than 20 expected in the next edition)
- The students confirm the **difference** between the two programmes is clear for them.

How did programme address its own SWOC of previous SER?

- A programme board was installed; it meets at least twice a year physically (apart from the last year due to COVID-19 restrictions) plus additional discussions via electronic means. This is even more formalized in the EMJMD setting. In addition, the main conclusions of the programme board are reported in the AUTEX meetings. These measures contribute to the recruitment of new lecturers
- The programme board aims at revising the full programme monitor every 3 years.
- The international character was further strengthened by including a Japanese partner
- Benefits of stakeholders have been analysed; addressing them has been elaborated during the preparation of the WE-TEAM proposal; measures are now being implemented.
- The EMJMD label has a huge impact on the attractiveness of the programme, resulting in more high quality students
- The EMJMD label also gives access to new channels of promotion; for the 21-23 edition students from 13 countries from all over the world have already confirmed; response from north and south America is weak, promotion there is to be improved. This is a task for the PR team
- The EMJMD funds provide financial means for the administrative support needed to develop and implement the necessary procedures for smooth functioning
- Students need to be clearly informed about the planning of the courses, what is expected from them, the challenges they will face; this is a permanent point of attention
- The industry liaison board is to strengthen the ties with industry, in view of participation in and contribution to education, financial support to students, internships etc.
- The organization of practicals is work in progress
- COVID-19 brought along many challenges, but it also forced us to rethink our ways of teaching and this has led to new and better teaching approaches, it speeded up the introduction of online learning, thus facilitating blended learning as well.
- COVID-19 was a challenge in terms of learning outcomes that concern interaction between students and other stakeholders, especially personal development and networking
- The communication with the students is excellent; they are very open, give clear feedback and participate to the meetings in a very constructive way

Admission

The selection procedure consists of an eligibility check, quality assessment and ranking.
Eligibility criteria:

- BSc in Engineering or Science
- Minimum 180 ECTS/3 years or equivalent

- min 15 ECTS in maths, min 10 ECTS in chemistry and physics or equivalent
  (for Japanese University graduates: min 10 credits in maths, min 5 credits in chemistry and min 5 credits in physics)
- English certificate

The procedure also includes an interview. The quality of the student is also proven by for instance study grades, ranking, awards, references, publications. Each application is assessed by at least 3 members of the consortium. The admission as well as ranking are unanimously decided by the management board. The best ranked students are granted a scholarship. This selection procedure is to ensure high level students as well as students with the proper background and sufficient knowledge in dedicated fields, in spite of their various background.

The programme's context

WE-TEAM is all about jointness, balance and maximum benefits for all stakeholders. It finds its origin in AUTEX, (http://www.autex.org/) which is the global network of high-level textile universities with PhD programs. The AUTEX mission (as written in the statutes) is to "facilitate co-operation in high-level textile education and research".

AUTEX joins almost 40 members from all over the world. Universities are accepted as (associated) members after passing a quality screening. AUTEX has its own annual conference and SCI journal (http://www.autexrj.com/). WE-TEAM offers the best students the greatest possible academic textile education by exploiting its quality in terms of staff expertise and facilities and geographical coverage. No other network in the world can offer such a platform of academic expertise in the field of textiles. The program targets maximum benefits to all stakeholders (students, staff, hosting universities and industry, both local and international). We address following benefits:

- students to receive a top quality education through top quality lecturers available in the AUTEX network and a multiple international experience,
- lecturers to get to know their colleagues, expertise and facilities and also to be known
- hosting universities to take advantage from incoming students and lecturers and internationalisation@home
- local industry to have the chance to meet visiting lecturers from all over the world as well as high level students, potential future employees.

Mobility is very strong, for students, lecturers and location. Apart from elective courses, the program is fixed and so are the lecturers. Courses are taught by local as well as visiting lecturers, all from AUTEX, guest lectures are provided by invited lecturers, scholars and industry. All of them are amongst the best in their field and have a strong research background or specific expertise. For practical reasons, visiting professors teach during one week full time as intensive courses.

Consortium partners take responsibility for specific project tasks following their strengths and interests (promotion (UNIWA and KIT), industry liaison (ENSAIT and KIT), ICT tools (UB and UNIWA), student induction (UHA)).

Future plans

The plan for the next 6 years has been described in detail in the WE-TEAM proposal.

The objectives are clear, the targeted benefits for all stakeholders are clear, the tasks have been distributed and funds are available.

The focus now is to meet all formal requirements in terms of quality for awarding the multiple degrees. Proper procedures are being installed and the new organization has to be implemented. The second year the focus can move to evaluation and further improvement. Apart from the aspects mentioned above, attention has to be paid to organization and communication (for students), to promotion, coherence of the programme, selection of students, optimization of the parallel semester Sweden/Japan. Quality should become a true joint task of all. On a longer term financial sustainability of the programme and a true joint degree are important goals, as well as structural involvement of industry. Also the community of alumni has to be strengthened.

SWOC-analysis

Strengths	Weaknesses
Unique concept with clear profile Supported by international consortium agreement Committed partners EMJMD framework and financial support (incl. scholarships) International character with multiple degrees AUTEX platform offers pool of high level lecturers Focus on addressing all stakeholders' benefits Focus on personal development and networking Intensive mobility for students and lecturers Diversity Openness Student groups become like a family	Insufficiently known by stakeholders Risk on low level students Organization of lectures and timely information of students thereof Lecturers are from different institutions (coherence of the programme, tools used, teaching style, expectations)
Opportunities	**Challenges**
EMJMD funds and communication channels Participation of international consortium AUTEX platform Erasmus+ calls Industry liaison board Digital technologies Role of community of alumni	Administrative load is enormous National and institutional requirements may conflict Coherence of the programme Uniformity of tools used Organization of practicals Good communication in an international consortium Long term sustainability

2.14 European Master of Science in Nuclear Fusion and Engineering Physics

The European Master of Science in Nuclear Fusion and Engineering Physics (FUSION-EP) is an international study programme, funded by the European Commission in the framework of the Erasmus Mundus Joint Master Courses. It is organised by a consortium of eight Core Partners: Ghent University, Aix-Marseille Université (AMU, France), Institut National des Sciences et Techniques Nucléaires (INSTN, France), Universidad Carlos III de Madrid (UC3, Spain), Universidad Complutense de Madrid (UCM, Spain), Université de Lorraine (France), Universität Stuttgart (Germany) and Czech Technical University in Prague (CTU Prague, Czech Republic). At the consortium level, the governing structure of the master programme consists of the Steering Committee (SC), with representatives from each participating institution. Aix-Marseille Université is the coordinating institution and as such provides the chair of the Steering Committee.

More information about the FUSION-EP programme is available through the Consortium web pages (https://www.em-master-fusion.org/) and in a recent journal publication (G. Van Oost et al., Eur. J. Phys. 42, 024002, 2021).

Programme objectives

The aim of the FUSION-EP master programme is to provide high-level multinational research-oriented education in fusion-related engineering physics, in close relation to the research activities of the partners, and with a well-integrated language and cultural experience. The combined and harmonised teaching and research activities of the partner universities provide a great variety of competences in the field of fusion science and engineering physics. Although the master is situated in the context of fusion energy, students receive education in general master-level engineering physics, in addition to more specific, yet multidisciplinary training targeted at the development of fusion energy. Hence, the FUSION-EP programme trains engineers capable of performing and leading technical and scientific research in universities, research establishments or industry, where interdisciplinary R&D requires engineers with an in-depth knowledge of physics.

Programme specific competences

The FUSION-EP programme offers an opportunity, unique in its interuniversity scope, for European master level studies in a field that can contribute in a crucial way to the solution of the urgent and vital world energy problem. Like all engineering master's programmes, FUSION-EP complies with the generic competences and associated learning outcomes, see Section 3.2 (SER, Part A), competence fields GM1-GM6. Additionally, the following domain-specific learning outcomes have been formulated:

Field of competences M1: Competences in one/more scientific discipline(s)

- M1.3. Have advanced knowledge of fusion plasmas, design and master their technological applications.
- M1.4. Have knowledge of fusion processes on subatomic level.
- M1.5. Design and master advanced technological applications in the field of plasma physics, and plasma-wall-interactions.
- M1.6. Perform advanced studies on technological applications of fusion plasmas in fields like nuclear technology, materials engineering, magnetohydrodynamics, RF technology and plasma diagnostics, based on personal, well-considered choices.
- M1.7. Have a sound grasp of plasma heating by means of different techniques like RF radio waves or injection of neutral particles.

Field of competences M2: Scientific competences

- M2.6. Analyse complex problems that arise during the process of generation and maintenance of fusion plasma and transform them into a scientific problem.
- M2.7. Be capable of performing literature research in English.
- M2.8. Select the best fitting simulation models and apply them to the field of plasma dynamics and magnetohydrodynamics.
- M2.9. Show a critical attitude towards own research and dare to deviate from standard presuppositions about nuclear generation of energy in general and nuclear fusion in particular.

Field of competences M3: Intellectual competences

M3.6. Defend positions about complex situations in the field of nuclear energy on international fora in an independent manner.

M3.7. Apply creatively own knowledge about fusion plasmas during research, design and production.

M3.8. Adapt flexibly to diverging research environments.

Field of competences M4: Competences in cooperation and communication

M4.5. Report in English on technical or scientific subjects in the field of plasmas and nuclear fusion orally, in writing and in graphics.

M4.6. Be able to work in multidisciplinary and international teams.

Field of competences M5: Societal competences

M5.5. Be aware of corporate and legal aspects and implications of the research in the field of fusion plasmas.

M5.6. Be aware of the implications of nuclear fusion for the environment and be able to communicate them in a social and responsible way.

M5.7. Profound knowledge of the historical evolution of nuclear physics, nuclear energy and nuclear fusion and ability to interpret their societal relevance.

Field of competences M6: Profession-specific competences

M6.10. Introduce technological innovations to the field of nuclear fusion.

M6.11. Approach the complexity of nuclear fusion and derived technical problems creatively, using system and process models.

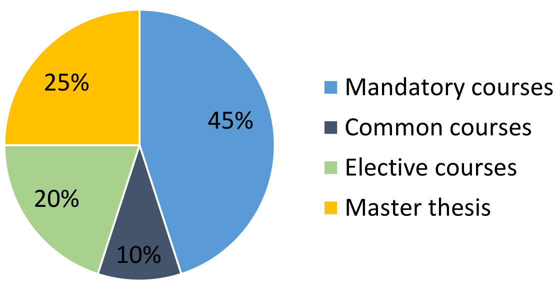
M6.12. Pay attention to entire life cycles of fusion reactors as well as for energy efficiency, environmental pressure, use of raw materials and labour costs.

M6.13. Pay attention to aspects of reliability and safety, that are characteristic for fusion plasmas and radioactive environments.

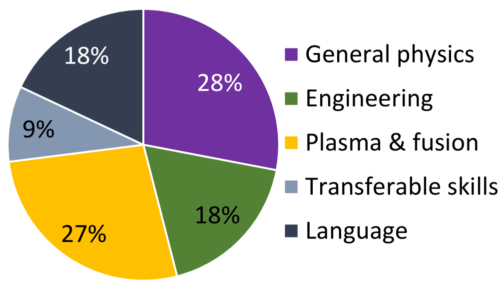
Structure of the programme

All students follow a mobility path that is assigned to them by the Steering Committee upon acceptance to the programme, based on the student's preferences. It consists of studies of the student at two Core Partner universities in two different countries: terms 1 and 2 at university A; terms 3 and 4 (including master's dissertation) at university B. During terms 1 and 2, students mainly acquire general physics knowledge and skills at the master level, while terms 3 and 4 focus on a number of topics selected from a broad range of disciplines directly related to fusion R&D.

Overall, the study programme consists of 54 credits of mandatory courses taught locally at each partner university, 12 credits of common mandatory courses taught at the *same* location for *all* students, 24 credits of elective courses taken at the local universities and 30 credits for the master's dissertation carried out at the local universities and/or at one of the Associate Partner institutions. The mandatory course units in terms 1 and 2 provide the foundations in engineering physics and are harmonised across all partner institutions. The elective courses are organized according to two tracks, chosen by the student. In the track Fusion Science, the focus lies on the fundamental physical mechanisms required for understanding and control of the fusion plasma. The track Fusion Engineering puts the emphasis on the technological aspects of fusion devices. This distribution is shown in figure (a), while the distribution of mandatory course units according to content type is given in figure (b).



(a)



(b)

Distribution of course units according to (a) category and (b) content.

Near the end of term 3, *all* students attend a common two-week Joint Experimentation and Analysis Session (EMTRAIC) at the Institute of Plasma Physics (IPP) in Prague on the COMPASS (Upgrade) tokamak. During term 4, *all* students also attend a common two-week Joint Practicum at CEA Cadarache (France). In addition, at the end of terms 2 and 4, a two-day Summer Event is organised (no credits). The Summer Event hosts a number of invited speakers and includes social activities. In addition, the master thesis topics offered by the Consortium are presented to the first-year students and the second-year students defend their thesis in front of the jury and their fellow students. These joint activities are part of the international mobility experience and further contribute to the strong networking aspect of the programme, making student mobility an inherent component of the programme structure and philosophy.

The table below shows the distribution of the programme content over the terms (number of credits in parentheses; actual course names may vary across partner universities).

Term 1	Term 2	Summer Event	Term 3	Term 4	Summer Event
Plasma physics (6)	Computational physics (6)	Choice of master thesis topics	Joint Experimentation and Analysis Session (IPP Prague) (6)	Joint Practicum (CEA Cadarache) (6)	Master thesis defence
Atomic and molecular physics (6)	Instrumentation and fusion technology (6)	Invited talks	Elective c (6)	Master thesis (30)	Invited talks
Electrodynamics and charged fluid dynamics (6)	Lab project (6)	Attendance of master thesis defences of 2nd - year students	Elective d (6)		
Continuum mechanics (6)	Elective a (6)	Social events	Start master thesis work		Social events
Language and culture (6)	Elective b (6)		Language and culture (6)		

Programme content over the terms, with colour coding according to figure (b).

Evolution of the programme

In this section the evolution is sketched that the programme has undergone since its inception. We then specifically address the comments and recommendations made in the previous CTI report from 2016.

The programme started in 2006 and was evaluated in 2010, at which point all aspects of the programme were evaluated to be good or excellent. As a result, the programme was extended for another five years in 2011, again with European funding. After this second funding period, the programme ran for a number of years on its own Consortium funding, with reduced grants awarded to a select number of students. In 2016, two additional Core Partners joined the Consortium: Aix-Marseille Université and INSTN, both French institutions closely linked to the CEA research centre at Cadarache and the ITER Organization.

In 2019, the Consortium decided to transfer the programme coordination to Aix-Marseille Université (AMU). This was partly motivated by organizational reasons, as the management and administrative support at AMU allows enhanced coherence and supervision of the programme's operation. Another important motive is the geographical, topical and professional proximity to AMU of two key fusion research centres: the CEA-IRFM Cadarache and the ITER Organization. Furthermore in 2019, the Czech Technical University in Prague joined the Consortium as a Core Partner – a valuable addition to the Consortium due to its strong ties with the Institute of Plasma Physics in Prague, operating the COMPASS (Upgrade) tokamak.

Then, also in 2019, the FUSION-EP programme was awarded again a European grant (Erasmus+) for another four cohorts of students, after having been supported by internal funds for a few years. With the outbreak of the COVID-19 pandemic, it was decided to delay the start of the new cohort by a year, ensuring a fresh start in September 2021 under optimal conditions for student mobility and development of transferable skills. The newly funded period will be used to look for opportunities to develop a long-term stable business model, in order to secure self-sustainability of the programme beyond the end of the funded period.

Follow-up of CTI-recommendations

1. In the final report of the CTI panel following the previous evaluation period, it was remarked that the programme should **focus more on plasma physics and plasma technology**. To address this issue, the following steps have been taken since 2016:

    a. With the addition to the Consortium of **three new Core Partners** since 2016 (Aix-Marseille Université and INSTN in France and Czech Technical University in Prague) and the transfer of the coordinating role to AMU, the programme is now in the position to offer additional and more flexible direct access for students to a comprehensive set of experimental facilities (the WEST tokamak at CEA Cadarache and the COMPASS (Upgrade) tokamak at the Institute of Plasma Physics in Prague). The geographic proximity of the ITER headquarters to AMU and CEA is another important asset, notably thanks to the offering of master thesis projects at the ITER Organization. Furthermore, the Core Partner Universität Stuttgart now offers technological courses and master theses in close cooperation with the Karlsruhe Institute of Technology (KIT).

    b. The programme has achieved an enhanced focus by grouping the elective courses in two tracks: **Fusion Science** and **Fusion Technology**. This is to be compared to the narrower scope of the three main subjects that characterized the programme before: plasma physics, computational methods in physics, and instrumentation and radiation. At the same time, the mandatory course units in the first master year continue to ensure a sufficiently general physics engineering training, preparing students for a broad range of employment opportunities after their studies.

    c. Furthermore, as of the academic year 2021-2022, **the specific implementation of the curriculum at UGent has been revised**, in both master years. In the first master year, the students now have more plasma-related and fusion-relevant mandatory courses, leading to an increased harmonization of the programme over all Core Partners. Specifically, **a new mandatory course unit Magnetohydrodynamics of Plasmas** has been introduced. In addition, the list of elective courses has been amended, now including a broader range of disciplines relevant to physics engineers in general, and fusion engineering in particular.

    d. Also since the academic year 2021-2022, **a new programme-wide practical course unit has been introduced** (no extra credits), involving group work of all master one students near the beginning of the second semester. Under the guidance of several experts, the students perform experiments on the GOLEM tokamak located at CTU Prague. This small student-centred experiment can be controlled fully remotely over the internet, such that students can participate in small subgroups from their local host institutions. Together with the Joint Experimentation and Analysis Session in Prague and the Joint Practicum at Cadarache, both in the second master year, this new practical course ensures ample time for students to be trained and perform experiments in a realistic professional environment.

2. A further comment made by the CTI panel reflected the concern that the programme contents are rather specific to nuclear fusion and therefore do not necessarily lead to learning outcomes that can be considered sufficiently general for engineering physicists. The report stated:
   The wording "Engineering physics" in its title is somewhat misleading, the curriculum is that of a high-level research-based Master in a specialized domain of Physics.

   For this we would like to point out that the contents of the first master year at all Core Partners are very similar to that of the Engineering Physics programme in Ghent. Furthermore, the skill set that students receive training for and the outcome of the second master year are comparable to those of other engineering programmes at UGent. This has been a deliberate design choice from the very start of the programme, which at the time was coordinated at UGent. This correspondence with a more general engineering physics programme is ensured by the Core Partners through the Consortium Agreement. Undersigned by all Core Partners, the Consortium Agreement is the main document describing the goals, contents and expected outcomes of the programme.

3. Another comment was made by the panel regarding the variability of study conditions across the programme:
   The study conditions are variable in the different universities; some students complain about the lack of supervision and the facilities in some cases.

   In order to be able to address complaints by students regarding such matters, we have introduced an item in the biannual meeting of the FUSION-EP Steering Committee, where a student representative reports about potential issues on behalf of all fellow students in both master years. The student representative acts as a confidential advisor, ensuring that all comments made by students remain anonymous. Any discrepancies in the study conditions or course contents are subsequently discussed within the committee and, if needed, action is taken by the representative of the relevant Core Partner. While this procedure does not guarantee an absolute uniformity across the Consortium (nor is this desirable), we believe that this way the programme management and the Coordinator are in the position to address study issues in an efficient and open manner.

4. It was stated that it is difficult to assess whether the learning outcomes of the programme are equally understood and applied in all partner universities, in such a way that all students within the programme acquire the competences expected at UGent for engineering graduates. Specifically, the panel opinion mentioned the following:
   The admission conditions and processes and the diversity of study tracks do not insure that all graduates achieve the outcomes expected from an engineering degree, according to the UGent and international standards. Attention to the soft skills in the training does not seems equally shared in the consortium.

   In response to this comment we would like to note that, with the transfer of the coordinator role to AMU in 2019, the Consortium Agreement was amended and then, in 2021, it was thoroughly revised by AMU. The learning outcomes are now clearly listed in the Agreement text, to which all Core Partners are required to adhere. Moreover, the new Agreement was reviewed in detail at UGent by the Educational Quality Control Committee of the faculty of Engineering and Architecture and by the central Department of Educational Policy. Several meetings were organized between the administrations of UGent and AMU (by video conference), leading to a number of iterations of the Agreement text. A similar procedure was followed for the recent FUSION-EP curriculum revision in Ghent, in full accordance with faculty and university regulations at UGent. Hence, the FUSION-EP master programme is subjected to the same procedures for quality control as the other engineering programmes organized by the faculty. The coherence of the learning outcomes at consortium level is furthermore ensured by the biannual meetings of the Steering Committee. An example of this is the recent restructuring of the curriculum at UGent, which was extensively discussed and revised within the Steering Committee, in particular regarding the consistency of the learning outcomes across the various partner institutions. We also believe that attention to soft skills is shared by all Core Partners through the mandatory courses on Language and Culture, through the joint practical sessions organized in the first and second master years and through presentation and networking at the yearly Summer Events.

Admission

Admission to the programme occurs through an application (https://fusion-ep.eu/) and selection process organized by the Consortium. The main selection criteria are prior studies and study results, requiring sufficient background in fundamental physics and engineering. This is supplemented with motivation letter, CV, recommendation letters and other criteria like language proficiency and gender. The top 15 students are awarded a European grant, the next two receive a limited grant from the Consortium and typically another five students are admitted that are fully self-funded.

The programme's context

The main governing body of the FUSION-EP programme is the Steering Committee (SC). It is assisted by the Advisory Board, which includes representatives from scientific, academic and industrial stakeholders. The Advisory Board helps guaranteeing academic quality by assisting the SC in the student selection process, by suggesting updates to the teaching content and by advising the SC on the master thesis topics proposed to the students. The Advisory Board enables a solid contact with industry and the proper consideration of employability needs, thereby ensuring favourable prospects for long-term sustainability. The Consortium also has 14 Associate Partners in the EU and 11 more outside the EU, consisting of universities and research institutes that include the

ITER Organization and the European Fusion Education Network (FuseNet). The role of the Associate Partners is to encourage their students to participate in the programme, while offering research infrastructure and expertise that FUSION-EP students can benefit from during their training and master thesis work.

As of 2021, the programme has nearly 200 alumni, many of whom maintain a link to the programme via the FUSION-EP Facebook group. In addition, a number of students have set up the Fusioneers Wiki[5], providing an insider view on the FUSION-EP programme, activities and study destinations. Furthermore, the alumni-run FUSIONEPtalks[6] organizes monthly webinars by researchers and PhD students, themselves often FUSION-EP alumni.

With ITER located in Europe, the EU has the opportunity to firmly establish its prominent place in nuclear fusion research. This is also leading to an increased involvement of European industry in fusion R&D. Aix-Marseille Université and the ITER Organization have a memorandum of understanding on academic and scientific cooperation, including the joint supervision of master theses. Hence, the FUSION-EP Consortium aims to develop a "thermonuclear fusion higher education area", raising the world-wide visibility and attractiveness of the programme, and at the same time ensuring an optimal alignment with the professional needs of the emerging nuclear fusion industry.

SWOC-analysis

Strengths

- This is a unique programme with its combination of fusion engineering sciences and various subdisciplines of physics.
- The programme is well known in the fusion community, owing to its extensive network of partner institutions and alumni.
- While the master focuses on the physics of fusion plasmas and the technology of fusion machines, the overall training is similar to that of a more general engineering physics programme, with similar general learning outcomes.
- The extent and quality of support for the students is excellent (ratio of prof/student, structure with Steering Committee and Advisory Board).
- The master has a very international and multicultural profile.
- The success rate of students is relatively high, with almost 70% of the alumni continuing into a PhD and another 20% finding employment in industry directly after their studies.

Weaknesses

- Students continue to perceive practical problems (e.g. visa) and substantial logistic work as a result of the intense mobility scheme.
- Self-sustainability has become an urgent point of attention.
- It remains relatively difficult to attract EU students.
- Some of the top students eligible for admission to the programme eventually decide to pursue their studies elsewhere (mainly in the US). As a consequence, sometimes students with a lower ranking on the selection list are promoted into the programme. This appears to be a general issue with European international masters.
- Presently, due to specific institutional constraints and national legal requirements, not all FUSION-EP Core Partner universities can award a nationally recognised joint degree (generic problem of EMJMDs).

Opportunities

- The recent transfer of the programme coordination to Aix-Marseille Université (AMU) has inevitably caused a few additional administrative hurdles during the transition period. Meanwhile the support for management and administration of the programme at AMU has been brought up to speed, ensuring optimal conditions for the student cohort that started in September 2021 in the new EU-funded period. There is an important opportunity that will be seized by the new coordinator to minimize administrative load for the students, to continue ensuring coherence of the programme and to provide feedback of evaluations to students in a consistent way.

[5] http://thefusioneerswiki.nfshost.com/FusioneersWiki/index.php/Main_Page
[6] https://www.facebook.com/fusioneptalks/

- Concrete opportunities for a prolonged existence of the programme are being explored. This includes the possibility to reduce costs by pooling resources among the partner universities, e.g. by enabling remote participation by students to a subset of the mandatory courses. Proactive promotion of the programme within the regular Erasmus+ scheme could attract an alternative stable funding source, as well as a slightly increased financial contribution from students.
- With the stronger link to the ITER Organization following the transfer of coordination to AMU, the attractiveness of the programme for top students and the ratio of EU applications is likely to still increase.
- An increased industry involvement is being sought, by offering master thesis topics in collaboration with the private sector.
- A stronger use of non-EU partner universities for master thesis work is a point of attention.
- The Erasmus Mundus brand accompanying the EU funding is a great asset to the programme's attractiveness, and it is important that the EU foresees the possibility for selected programmes to retain the brand after the end of a funding period.

Challenges

- Continuity and sustainability beyond the current Erasmus+ funding period
- The relatively low proportion of EU students
- The loss of the most excellent students to other programmes abroad