MECHANICAL ENGINEERING

MECHANICAL, MARITIME AND

MATERIALS ENGINEERING

DELFT UNIVERSITY OF TECHNOLOGY

QANU
Catharijnesingel 56
PO Box 8035
3503 RA Utrecht
The Netherlands

Phone: +31 (0) 30 230 3100
E-mail: support@qanu.nl
Internet: www.qanu.nl

Project number: Q0710

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This report was finalised on 3 April 2019

REPORT ON THE BACHELOR'S PROGRAMME AND THE MASTER'S PROGRAMME MECHANICAL ENGINEERING OF DELFT UNIVERSITY OF TECHNOLOGY

This report takes the NVAO's Assessment Framework for Limited Programme Assessments as a starting point (September 2016).

ADMINISTRATIVE DATA REGARDING THE PROGRAMMES

Bachelor's programme Mechanical Engineering

Name of the programme:	Werktuigbouwkunde
CROHO number:	56966
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Specializations or tracks:	-
Location(s):	Delft
Mode(s) of study:	full time
Language of instruction:	Dutch, English
Expiration of accreditation:	31/12/2019

Master's programme Mechanical Engineering

Name of the programme:	Mechanical Engineering
CROHO number:	60439
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	Biomechanical Design (BMD) Energy and Process Technology (EPT) High-Tech Engineering (HTE) Transport Engineering and Logistics (TEL) Vehicle Engineering (VE)
Location(s):	Delft
Mode(s) of study:	full time
Language of instruction:	English
Expiration of accreditation:	31/12/2019

The visit of the assessment panel Mechanical Engineering to the Faculty of Mechanical, Maritime and Materials Engineering of Delft University of Technology took place on 13-14 December 2018.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	Delft University of Technology
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 20 August 2018. The panel that assessed the bachelor's programme and the master's programme Mechanical Engineering consisted of:

- Prof. K.G.S. (Sören) Östlund, professor of Packaging Technology at the Department of Solid Mechanics of the KTH Royal Institute of Technology (Sweden) [chair];
- Prof. H.J. (Henry) Rice, professor, Mechanical Engineering and head of the School of Engineering of Trinity College (Ireland);
- Dr. M. (Maddalena) Velonà, coordinator of studies at the Department of Mechanical and Process Engineering (D-MAVT) at Eidgenössische Technische Hochschule (ETH) Zürich (Switzerland);
- Drs. J.J. (Jan) Steen, consultant Quality of Education at Wageningen University & Research;
- Prof. R.W. (Richard) Birmingham, professor in Small Craft Design at the Marine Technology Group of the School of Engineering, Newcastle University (United Kingdom);
- Ir. J. (Jan) Leideman, new business development manager at DEMCON Advanced Mechatronics;
- A.J. (Alicia) Knijnenburg, BSc, master's student Mechanical Engineering at the University of Twente [student member].

The panel was supported by dr. B.M. (Barbara) van Balen, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The site visit to the bachelor's and master's programme Marine Technology at the Faculty of Mechanical, Maritime and Materials Engineering of Delft University of Technology was part of the cluster assessment Mechanical Engineering. In December 2018 the panel assessed eleven programmes at three universities. The following universities participated in this cluster assessment: Delft University of Technology, Eindhoven University of Technology and the University of Twente.

On behalf of the participating universities, quality assurance agency QANU was responsible for logistical support, panel guidance and the production of the reports. Dr. Alexandra Paffen was project coordinator for QANU. Dr. Barbara van Balen acted as secretary in the cluster assessment. She is a certified NVAO secretary.

Preparation
On 9 December 2018, the panel chair was briefed by QANU on his role, the assessment framework, the working method, and the planning of site visits and reports. A preparatory panel meeting was organised on 9 December 2018. During this meeting, the panel members received instruction on the use of the assessment frameworks. The panel also discussed their working method and the planning of the site visits and reports.

The project coordinator composed a schedule for the site visit in consultation with the Faculty. Prior to the site visit, the Faculty selected representative partners for the various interviews. See Appendix 4 for the final schedule.

Before the site visit to Delft University of Technology, QANU received the self-evaluation reports of the programmes and sent these to the panel. A thesis selection was made by the panel's chair and the project coordinator. The selection existed of fifteen theses and their assessment forms for each programme, based on a provided list of graduates 2016-2017. A variety of topics and tracks and a diversity of examiners were included in the selection. The project coordinator and panel chair assured that the distribution of grades in the selection matched the distribution of grades of all available theses.

After studying the self-evaluation report, theses and assessment forms, the panel members formulated their preliminary findings. The secretary collected all initial questions and remarks and distributed these amongst all panel members.
At the start of the site visit, the panel discussed its initial findings on the self-evaluation reports and the theses, as well as the division of tasks during the site visit.

Site visit

The site visit to Delft University of Technology took place from 12 to 14 December 2018. During the site visit, the panel studied the additional documents provided by the programmes. An overview of these materials can be found in Appendix 5. The panel conducted interviews with representatives of the programmes: students and staff members, the programme's management, alumni and representatives of the Board of Examiners.

The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the panel's preliminary findings and general observations.

Consistency and calibration
In order to assure the consistency of assessment within the cluster, the following measures were taken:

1. The panel composition ensured regular attendance of (key) panel members, including the chair;
2. The secretary was present at the start of all site visits as well as the panel discussion leading to the preliminary findings at all site visits of Delft University of Technology, Eindhoven University of Technology and the University of Twente.

Report
After the site visit, the secretary wrote a draft report based on the panel's findings and submitted it to the project coordinator for peer assessment. Subsequently, the secretary sent the report to the panel. After processing the panel members' feedback, the project coordinator sent the draft reports to the Faculty in order to have these checked for factual irregularities. The project coordinator discussed the ensuing comments with the panel's chair and changes were implemented accordingly. The report was then finalised and sent to the Faculty and University Board.

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited programme assessments, the panel used the following definitions for the assessment of both the standards and the programme as a whole:

Generic quality
The quality that, in an international perspective, may reasonably be expected from a higher education Associate Degree, Bachelor's or Master's programme.

Unsatisfactory
The programme does not meet the generic quality standard and shows shortcomings with respect to multiple aspects of the standard.

Satisfactory
The programme meets the generic quality standard across its entire spectrum.

Good
The programme systematically surpasses the generic quality standard.

Excellent
The programme systematically well surpasses the generic quality standard and is regarded as an international example.

SUMMARY JUDGEMENT

The panel assessed the standards from the *Assessment framework for limited programme assessments* in the following way:

Bachelor's programme Mechanical Engineering

Standard 1

The bachelor's degree programme Mechanical Engineering is provided by the Faculty of Mechanical, Maritime and Materials Engineering (3mE) of Delft University of Technology. Mechanical Engineering studies the analysis and synthesis of structures, machines, devices, systems, and processes that accomplish a desired objective in a safe, ethical, and sustainable fashion. The 3mE Faculty aims to deliver engineers with a clear Delft stamp, creative team workers and engineers with an open mind for future developments. The programme defined intended learning outcomes (ILOs) in line with this objective and within the framework of the 4TU criteria for Academic Bachelor's and Master's Curricula, known as the Meijers criteria. The panel found the ILOs to be well defined, specific and measurable. They indicate the content, level and orientation of the bachelor's programme ME and match the professional field. There is an evident distinction between the ILOs of the bachelor's and the master's programmes. The ILOs meet the Dutch qualifications framework and sufficiently indicate an academic bachelor's level.

Standard 2

The bachelor curriculum focuses on three didactic goals:

- To give students a broad, in-depth understanding of a selected set of mathematics and all Mechanical Engineering disciplines.
- To train student teams to handle the entire process of mechanical design engineering roughly through a so-called CDIO process (Conception/Design/Implementation/Operation).
- To train student teams to perform research and design on mechanical engineering topics at an academic level.

The bachelor curriculum of 180 EC offers students a basis in fundamental engineering sciences and mathematics in four mathematics modules (4 x 6EC), four solid mechanics modules (4 x 6 EC), a thermo-fluids module (6 EC), and five specialised modules (5x6 EC). In the project modules (8x6 EC), multiple learning lines related to Mechanical Engineering are combined with a variety of teaching and testing methods. The project modules are partly taught in lectures, followed by a written exam, but mainly through individual and/or group assignments and practicals. The third year includes a minor (30 EC), the Bachelor End Project (14 EC) and an Ethics course along with two Mechanical Engineering modules.

The curriculum of the bachelor's programme Mechanical Engineering enables the students to achieve the intended learning outcomes. The panel found the curriculum to be well developed, managed and implemented; there is a good alignment between the ILOs and the curriculum. It was clear to the panel that the programme management took the recommendations of the former assessment panel very seriously and implemented a lot of improvements in the bachelor's programme during the assessment period.

The panel is positive about the projects and the learning lines that structure the curriculum. The Faculty has a clear vision on education. There is sufficient guidance for students, and they definitely have the possibility to apply acquired knowledge and skills in practice. The panel appreciates the clear connection between the three didactic goals and its implementation in the curriculum, as well as the project modules. The whole bachelor's programme has a clear structure. Students receive a solid basis in scientific knowledge, combined with the development of soft skills and group work. The panel is also very positive about the position of the minor in the programme and the wide range of possible minor programmes students can choose from.

The programme attracts huge numbers of students, and the panel is impressed by the way the Faculty manages to offer all of the students an attractive, high-quality education. The study yields could be improved, however. The panel encourages the faculty management to investigate whether more incentives to encourage the timely progress of the students are possible.

The quantity and the quality of the teaching staff are good.

Standard 3
The Faculty aims to achieve a high level of quality in its teaching and assessment. The Faculty's assessment system and policy are well developed and implemented according to the panel. All teachers are aware of the policies and measures implemented to assure the validity and reliability of the assessments. The Faculty has ensured that the teachers are supported in their tasks by the appointment of an educational advisor.

The courses use a variety of assessment methods, which are very well aligned, with the help of the matrices, with the learning outcomes and the curriculum. The procedures are transparent for teachers and students.

The panel is very positive about the way the Board of Examiners is performing its tasks and concluded that the examinations, tests and thesis assessment are transparent, valid and reliable.

Standard 4
The panel studied a selection of 15 bachelor end projects to assess whether the graduates had achieved the intended learning outcomes. It found the level of the BEP reports to be good. The graduates are well prepared to continue their study in a master's programme. The panel concludes that graduates of the bachelor's programme Mechanical Engineering have achieved the intended learning outcomes.

Standard 1: Intended learning outcomes	good
Standard 2: Teaching-learning environment	satisfactory
Standard 3: Assessment	good
Standard 4: Achieved learning outcomes	good
General conclusion	good

Master's programme Mechanical Engineering
Standard 1
The master's degree programme Mechanical Engineering is provided by the Faculty of Mechanical, Maritime and Materials Engineering (3mE). Mechanical Engineering studies the analysis and synthesis of structures, machines, devices, systems, and processes that accomplish a desired objective in a safe, ethical, and sustainable fashion. The 3mE Faculty aims to deliver engineers with a clear Delft stamp, creative team workers and engineers with an open mind for future developments. The programme defined intended learning outcomes (ILOs) in line with this objective and within the framework of the 4TU criteria for Academic Bachelor's and Master's Curricula, known as the Meijers criteria. The panel concluded that the ILOs are well considered and based on a clear vision on education in mechanical engineering. They are clearly defined, measurable and specific. The ILOs meet the Dutch qualifications framework, sufficiently indicate the academic master's level, and tie in with the international perspective of the requirements set by the professional field and the discipline.

Standard 2
Within the ME programme the students can follow one of five tracks: Biomechanical Design (BMD), Energy and Process Technology (EPT), High-Tech Engineering (HTE), Transport Engineering and Logistics (TEL) or Vehicle Engineering (VE). The first year of the programme consists of four obligatory courses for all ME students. Each of the tracks contains a number of track-specific

obligatory courses and a set of electives. The second year is dedicated to the graduation project, which consists of a literature assignment, a research assignment/internship and the thesis. For the graduation project every student is linked to at least one supervisor/scientific staff member of ME, and the graduation project is always connected to the supervisor's research area. The programme uses a variety of teaching strategies: lectures, practical work and projects, self-study, literature assignments, internship or traineeship, research assignment, thesis project.

The Faculty 3mE offers a solid master's curriculum ME in the panel's opinion, with well-defined tracks and a research-led ethos. The students feel they are well coached to make individual choices. The compulsory courses give the students a common background, and on that basis they can build an individual trajectory in consultation with the master coordinator. The panel appreciates the personalised approach for the students and the individual coaching. The students reported that there is a close connection to research in the department, they get a good idea of the research projects going on, and they participate in the research group from the start of the graduation project. Students have an active role to play in designing their own learning approach.

The panel finds the structure of the curriculum of the master's programme to be comparable to that of other engineering master's programmes. The sound, thorough curriculum enables the students to achieve the intended learning outcomes. The panel appreciates the close connection to the research groups, which enables the students to achieve a high level in research.

The programme attracts huge numbers of students, and the panel is impressed by the way the Faculty manages to offer all of the students an attractive, high-quality education. The study yields could be improved, however. The panel encourages the faculty management to investigate whether more incentives to encourage the timely progress of the students are possible.

The quantity and the quality of the teaching staff are good.

Standard 3
The Faculty aims to achieve a high level of quality in its teaching and assessment. The Faculty's assessment system and policy are well developed and implemented according to the panel. All of the teachers are aware of the policies and measures implemented to assure the validity and reliability of the assessments. The Faculty has ensured that the teachers are supported in their tasks by the appointment of an educational advisor.

The courses use a variety of assessment methods, which are very well aligned, with the help of the matrices, with the learning outcomes and the curriculum. The procedures are transparent for teachers and students.

The panel approves the way the Board of Examiners is performing its tasks and concluded that the examinations, tests and the thesis assessment are transparent, valid and reliable.

Standard 4
The panel studied a selection of 15 master's theses to assess whether the graduates had achieved the intended learning outcomes. It found the level of the theses to be very good. It concludes that graduates of the master's programme Mechanical Engineering have achieved the intended learning outcomes. They are well prepared for continuing in a PhD programme or a career in industry.

Standard 1: Intended learning outcomes	good
Standard 2: Teaching-learning environment	satisfactory
Standard 3: Assessment	good
Standard 4: Achieved learning outcomes	good
General conclusion	good

The chair, prof. Sören Östlund, and the secretary of the panel, dr. Barbara van Balen, hereby declare that all panel members have studied this report and that they agree with the judgements laid down in it. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 3 April 2019

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED PROGRAMME ASSESSMENTS

General remarks cluster Mechanical Engineering

This report constitutes part of the limited programme assessment of the NVAO Assessment cluster Mechanical Engineering representing 11 bachelor and masters programmes in Mechanical Engineering, Automotive Technology, Marine Technology, Offshore and Dredging and Materials Science and Engineering at University of Twente, Eindhoven University of Technology and Delft University of Technology. The findings for each programme are based on the self-evaluations performed by each programme and site visits taking place on December 10-14, 2018.

In the self-evaluation reports and during the site visits, the evaluation panel has encountered many knowledgeable and dedicated programme managers, skilled and engaged teachers, well-educated and enthusiastic students and successful alumni. It is therefore with great pleasure that we can conclude that the overall outcome of the evaluation panel ends on a positive note.

All programmes are based on intended learning outcomes well set in national or international perspective of the requirements currently set by the professional field and the discipline, programme managers, teachers and students work hard to create a motivating and dynamic teaching and learning environment, all programmes have elaborated assessment plans and the achieved learning outcomes are good. Many of the theses read by the evaluation panel are indeed of very high quality, and graduates from the eleven programmes in general have very good career opportunities.

There is of course always room for improvements, and, particularly, the processes around internships, the overall study times and the high dropout rates are areas that should be given continued high attention. The increased internationalisation of the programmes, the growth in number of students and the level of the students are other challenges that needs consideration in the coming years. However, it is the opinion of the assessment panel that the programmes in the Assessment cluster Mechanical Engineering are well prepared to meet these.

On behalf of the Mechanical Engineering assessment panel,
Sören Östlund, chair

Governance structure of the Faculty

The bachelor's and master's degree programmes Mechanical Engineering are provided by the Faculty of Mechanical, Maritime and Materials Engineering (3mE). This Faculty also offers the master's programme Materials Science Engineering, the bachelor's and master's programmes Marine Technology and the master's programme Offshore and Dredging Engineering, which are all being assessed in this cluster assessment. It also offers the bachelor's and master's programmes Technical Medicine and the master's programmes Biomedical Engineering and System and Control.

Standard 1: Intended learning outcomes

The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings

Mechanical Engineering studies the analysis and synthesis of structures, machines, devices, systems, and processes that accomplish a desired objective in a safe, ethical, and sustainable fashion. Modern mechanical engineering is characterized by increasing multi-disciplinarity, overlapping with life sciences, electrical and chemical engineering, and other domains. The collaborating technical

universities in the Netherlands as well as ABET[1], OECD[2], and ASME[3] agreed that the general learning goals of mechanical engineering programmes should cover science (mathematics, physics and thermodynamics), engineering (materials, solid and fluid mechanics, dynamics), and design (specifications, synthesis, modelling and optimisation, manufacturing, evaluation).

The 3mE Faculty aims to deliver T-shaped[4] engineers with a clear Delft stamp, creative team workers and engineers with an open mind for future developments. It wants to achieve this aim by offering programmes that are at the leading edge of societal trends, while providing a thorough grounding in the professions. The programmes the 3mE Faculty offers have a substantial focus on ethics, the environment and Bildung, using both challenging teaching methods and massive online material in projects.

Bachelor's programme
The intended learning outcomes (ILOs) for the bachelor's programme Mechanical Engineering (ME) are defined within the framework of the 4TU criteria for Academic Bachelor's and Master's Curricula, known as the Meijers criteria (Appendix 2). The panel established that the ILOs are formulated in line with the mission and sufficiently indicate what could be expected from students at a bachelor's level. It also ascertained that the ILOs meet the internationally accepted description for academic bachelor's programmes, the Dublin descriptors, which are elaborated for the engineering programmes in the 4TU (Meijers) criteria. It found the ILOs to be well defined, specific and measurable. They indicate the content, level and orientation of the bachelor's programme ME and match the professional field. The distinction between the ILOs of the bachelor's and the master's programme is clear.

Master's programme
The critical reflection described how in reaction to the recommendations of the former assessment committee, the ILOs of the master's programme ME were revised in 2017 to make them more specific and measurable. The result of this revision process is included in Appendix 2. The Industrial Board was closely involved in the process of developing the new ILOs. The panel appreciates the careful and thorough way the programme has taken up the recommendations and worked on improvement. The ILOs are well defined, measurable and specific according to the panel. They are formulated in line with the objectives of the programme's mission and sufficiently indicate what could be expected from students at a master's level. The panel also ascertained that the ILOs meet the internationally accepted description for academic master's programmes, the Dublin descriptors, which are elaborated for the engineering programmes in the 4TU (Meijers)[5] criteria. The panel appreciates in particular the process of redefining the ILOs and the involvement of the Industrial Board in this process.

Considerations
The panel concluded that the ILOs of the bachelor's and the master's programmes Mechanical Engineering are well considered and based on a clear vision on education in mechanical engineering. The ILOs of both programmes meet the Dutch qualifications framework and sufficiently indicate the academic bachelor's or master's level, respectively. The alignment with the ABET, OECD and ASME requirements demonstrates that the ILOs tie in with the international perspective of the requirements set by the professional field and the discipline.

[1] ABET – Criteria for accrediting engineering programs
[2] OECD – A tuning –HELO conceptual framework of expected/desired learning outcomes in engineering
[3] ASME – An Environmental Scan for ASME and the Global Summit on the Future of Mechanical Engineering.
[4] T-shaped professional is a person with sufficient depth of related skills and expertise in a single field, and the ability to collaborate across disciplines with experts in other areas and to apply knowledge in areas of expertise other than one's own.
[5] https://www.ram.ewi.utwente.nl/embedded2017/doc/Meijers_summarised.pdf

Conclusion
Bachelor's programme Mechanical Engineering: the panel assesses Standard 1 as good.

Master's programme Mechanical Engineering: the panel assesses Standard 1 as good.

Standard 2: Teaching-learning environment
The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings
Bachelor's programme
The bachelor curriculum focuses on three didactic goals:

- To give students a broad, in-depth understanding of a selected set of mathematics and all Mechanical Engineering disciplines.
- To train student teams to handle the entire process of mechanical design engineering roughly through a CDIO (Conception/Design/Implementation/Operation) process.
- To train student teams to perform research and design on mechanical engineering topics at an academic level.

The bachelor curriculum of 180 EC offers students a basis in fundamental engineering sciences and mathematics in four mathematics modules (4x6 EC), four solid mechanics modules (4 x 6 EC) and a thermo-fluids module (6 EC). These modules are scheduled in the first two years and shared with the bachelor's programme Maritime Technology. The students also follow five specialised Mechanical Engineering modules in the second and third years. Along with the more traditional modules that are taught as lectures with self-study assignments, there are project modules scheduled during the first two years of the programme. In the project modules (8 x 6 EC), multiple learning lines related to Mechanical Engineering are combined with a variety of teaching and testing methods. The projects are the best demonstration of how the CDIO concept is used in the curriculum. The project modules are partly taught as lectures, followed by a written exam, but mainly in individual and/or group assignments and practicals.
The first semester of the third year is reserved for the minor, a cohesive unit of modules worth 30 EC. Students can choose from a wide variety of thematic minors offered by TU Delft and the partner universities Erasmus University and Leiden University or at a university abroad. In the last semester students do their Bachelor End Project (14 EC) and follow an Ethics course along with two Mechanical Engineering modules. During the Bachelor End Project (BEP) students may form their own teams and define their own research or design project.

Before the start of the programme, students are invited to an introductory weekend organised by the study association Gezelschap Leeghwater, in order to create social cohesion in the cohort. During the first year students are subdivided by the programme management into groups of 6-7 students for the projects. Each group is mentored by an older student, who pays special attention to group dynamics and helps new students to develop a good study flow. The student groups and their mentors are divided into parallel clusters of 8 project groups, each led by a cluster teacher (a professional from industry) and a cluster mentor. These cluster leaders are coached by a Faculty student counsellor and the overall project module lecturer. Most teaching activities during the first year are organised along the lines of the clusters. The clusters have their own tutorial classes to practise problems in the fundamental courses in the first year. These classes are led by a 3mE staff member with the help of two older students acting as teaching assistants. After the second quarter, the groups are reshuffled, and open spots created by early dropouts are filled. To support students in the transition from high school to university, they are stimulated through regular study assignments, tutorial classes, attendance monitoring and frequent feedback. This guidance is gradually scaled down in the first semester. The panel thinks that with the introduction of this system, the Faculty has made a very good effort to support the students with the transition to university education. Students expressed during the site visit that they like the project groups and that it really helps them to develop a study flow.

At the start of the second year, the reregistered 3mE bachelor students are invited to participate in a ceremonial Bachelor Belofte (promise), during which students and professors formally express their professional position as adult teachers and learners. In the second year students have more freedom to choose design projects; they can form their own project teams and are responsible themselves for organising working groups for studying.

The panel was impressed by the structure and organisation of the curriculum. It was clear that the programme management has taken the recommendations of the former assessment panel very seriously and implemented a lot of improvements in the bachelor's programme during the assessment period, as described above. The programme management is obviously focused on continuously improving the quality of education. In particular, the organisation of the project groups, the tutoring and the mentoring of the first-year students form a major operation with so many students. It seems that this system does work out very well. The students report that the structure of the curriculum is very clear. The panel appreciates the clear connection between the three didactic goals and the curriculum, as well as the implementation of the CDIO in the project modules. Another positive aspect of the programme is the space reserved for the minor and the wide range of possible minor programmes the students can choose from.

Master's programme
The master's programme focusses on three connected didactic goals:

- To give students an understanding of all mechanical engineering disciplines, with a firm anchoring in theory and a wide focus on applications.
- To train students to handle the entire process of innovative design, manufacturing and operation.
- To coach students to perform research on mechanical engineering topics at an academic level.

Within the ME programme the students can follow these tracks:

- Biomechanical Design (BMD)
- Energy and Process Technology (EPT)
- High-Tech Engineering (HTE)
- Transport Engineering and Logistics (TEL)
- Vehicle Engineering (VE)

The first year of the programme consists of four obligatory courses for all mechanical engineering students worth a total of 19 EC. The goal of these courses is to give all students a solid common background in mechanical engineering. Students also take a social course, and many choose an ethics course related to their track.

Each of the five tracks contains a number of track-specific obligatory courses. Master coordinators have the freedom to decide which and how many track-obligatory courses their students should take. Each track also offers a set of electives.

In the first week of the first year, each track organises a social event or introduction programme with the new students to work on team building and give them an overview of the education and research done in the department. During the first semester, students have to think about their individual study programme and discuss their preferences with the master coordinator. The individual study programme (ISP) must be signed off by the master coordinator and the Board of Examiners.

The second year is dedicated to the graduation project, which consists of a literature assignment, a research assignment/internship and the thesis. The goal of the second year is to let students work individually and in groups on a complex problem, working independently with the tools and methods provided, to develop new theory or design methods to solve complex mechanical engineering problems. Students must finish their literature survey or problem definition before they are allowed

to start the thesis project. An internship is not obligatory for all tracks; while an internship is crucial for some tracks, other tracks choose to let students work on a research assignment in-house. Some tracks offer the internship as an elective.

For the graduation project, every student is linked to at least one supervisor/scientific staff member of ME, and the graduation project is always connected to the supervisor's research area. It can be carried out in one of the labs of the Faculty, at an affiliated Faculty, within a company, within a research institute or at another university. The programme uses a variety of teaching strategies: lectures, practical work and projects, self-study, literature assignments, internship or traineeship, research assignment, thesis project.

The Faculty 3mE offers a solid master's curriculum ME with well-defined tracks in the panel's opinion. The introduction programme/social event at the start of the programme is greatly appreciated. The students reported that the communication within the master's programme is good, they feel they are well coached in making individual choices. The compulsory courses give the students a common background, and on that basis, they can build an individual trajectory in consultation with the master coordinator. The panel appreciates the personalised approach available to the students and the individual coaching. The students reported that the content of the courses is close to ongoing research in the department, which is in line with the information in the study guide. Teachers and students find that this gives the students a good idea of the research projects going on. Students participate from the start of the graduation project in the research group. They have an active role in designing their own study path in the master's programme.

Students and study yield
The intake of students in the bachelor's programme fluctuates between 500 and 650, of which about 11% is female. Only 50% of this group continues in the second year, which means that half of the group receives a negative Binding Study Advice at the end of the first year or has already stopped earlier. The panel discussed its concern about this high drop-out rate with the programme management and learnt that this is a deliberate choice of the programme management to focus teaching efforts on those students who are motivated and have the capabilities to achieve the programme's ILOs. The first year is therefore also aimed at selecting the students.

The intake of students in the master's programme has increased in the last years to 250-300 per year. The critical reflection gives several reasons for the increase: a growing number of ME bachelor graduates, increased intake from other bachelor's programmes, and an increasing international intake. Recently, the Faculty set a cap on the intake of non-EU students. Other measures taken to cope with the numbers include a reduction in the number of electives in the master and a system to distribute the students working on their graduation projects over departments and staff. The average study duration of the master students is 2.7 years; 55% of the enrolled students finishes within 3 years. Students also reported doing double master degrees, which usually takes an extra year. The Faculty reported that the average study duration is increasing. Measures to reduce the average study time are aimed at finishing the graduation project on time. They include cutting the project into phases. The first phase is the literature survey or problem definition which students have to finish successfully before they are allowed to start their internship and thesis project. The two phases are each credited separately.

Both students and teachers reported that the causes for study delay are usually time spent on other activities, such as participating in study associations, contributing to successful university student teams or working part-time. Students mentioned that some courses and their exams form impediments in the programme, which can lead to a study delay of six months to a year when they fail those exams. Students and staff do not experience the average study duration as an urgent problem. They call this the Delft culture. Students choose Delft University because of the atmosphere, the city and its reputation. They like to be part of the Delft community, participate in the study associations, the successful student teams and spin-off activities and companies. The panel is of the opinion that the university should take responsibility for the slow study progress of the students; it

noticed and appreciates that the Faculty management is starting to think about it. There is still a 'laissez faire' attitude, however. The panel encourages the Faculty management to investigate whether more incentives to encourage timely progress of the students are possible. It likes the idea behind the 'Bachelor Belofte' day but thinks that this could have a stronger effect when this 'belofte' is less informal and includes, for instance, a contract between the Faculty and the student. One of the other measures to consider could be to put a limit on the number of resits for exams or to incentivise earlier completion with higher grades. For the master's programme the panel advises considering accepting students on the basis of a motivation letter.

Teaching staff
Overviews of staff involved in teaching the bachelor's and the master's programmes are included in the self-evaluation reports. As a large number of students have to be guided and supervised, the panel appreciates the solutions found by the Faculty to involve student mentors and professionals from industry in this teaching. This significantly increases the amount of coaching and guidance the students receive. In the master's programme many PhD students are involved in the day-to-day supervision of the students.

The Faculty is strongly committed to developing and maintaining the quality of its teaching staff. To promote involvement and improve mutual communication, an Education Day is organized each year in August for all teaching staff in the Faculty. At this event, the staff receive information on the latest developments in education and professional practice from experts in the field of education. Educational policy and new developments in education are discussed, and attendees participate in workshops organized around various educational themes. Lecturers are academic staff members with a PhD degree. A high percentage (94%) of the teaching staff holds a UTQ (University Teaching Qualification).

The students are satisfied with the teaching quality, although it can take a long time before they have contact with an academic staff member. Students report that the first time they had a 'real' meeting with an academic staff member was during the bachelor end project, but the guidance of mentors and student-assistants is frequent and much appreciated. Overall, the panel thinks that the quality of the teaching staff is good.

Facilities
The panel received a video tour of the Faculty 3mE facilities for education in Mechanical Engineering plus a short guided tour during the site visit. The Faculty has clearly managed to make optimal use of the space in the building to accommodate all students and provide a good quality working space for the project groups. The lab facilities for practicals are limited, but the programme prepares a schedule for optimal use in order to facilitate use by all students. The panel is also very positive about the tool boxes that are available to the students. These tool boxes encourage self-directed learning, performing measurements and pursuing project group work in their own time.

Considerations
The curriculum of the bachelor's programme Mechanical Engineering enables the students to achieve the intended learning outcomes. The panel found the curriculum to be well developed, managed and implemented, and there is a good alignment between the intended learning outcomes and the curriculum. It was clear to the panel that the programme management has taken the recommendations of the former assessment panel very seriously and implemented a lot of improvements in the bachelor's programme during the assessment period.

The panel is positive about the projects and the learning lines that structure the bachelor's curriculum. The Faculty has a clear vision on education and impressed the panel with the project group and mentoring system. This system, developed to cope with the very large student numbers, ensures that there is sufficient guidance for students and that they have the possibility to apply their acquired knowledge and skills in practice. The panel appreciates the implementation of the three didactic goals in the curriculum, as well as of the CDIO in the project modules. The whole bachelor's

programme has a clear structure. Students receive a solid basis in scientific knowledge, combined with the development of soft skills and group work. The panel is also very positive about the position of the minor in the programme and the wide range of possible minor programmes students can choose from.

The Faculty 3 mE offers a solid master's curriculum ME with well-defined tracks in the panel's opinion. The introduction programme/social event at the start of the programme is greatly appreciated by the students. The panel thinks that this is a very good measure to further social cohesion between the students. The students reported that the communication within the master's programme is good; they feel they are well coached to make individual choices. The compulsory courses give the students a common background on which they can build an individual trajectory in consultation with the master coordinator. The panel appreciates the personalised approach available to the students and the individual coaching. The structure of the curriculum of the master's programme is comparable to that of other engineering master's programmes. The sound, thorough curriculum enables the students to achieve the intended learning outcomes. The panel appreciates the close connection to the research groups, which enables the students to achieve a high level in research.

Both the bachelor's and the master's programmes attract huge numbers of students. The panel is impressed by the way the Faculty manages to offer all of the students attractive, high-quality education. The study yields could be improved, however. The panel is of the opinion that the university should take responsibility for the slow study progress of the students; it noticed and appreciates that the Faculty management is starting to think about it. It encourages the faculty management to investigate whether more incentives to encourage timely progress of the students are possible.

The quantity and the quality of the teaching staff are good.

Conclusion
Bachelor's programme Mechanical Engineering: the panel assesses Standard 2 as satisfactory

Master's programme Mechanical Engineering: the panel assesses Standard 2 as satisfactory

Standard 3: Student assessment
The programme has an adequate system of student assessment in place.

Findings
Assessment policy
The Faculty aims to achieve the highest possible quality standards in relation to validity, reliability and transparency for assessments, within the limits of feasibility. The Faculty's full vision and policy on assessment are described in the document 'Toetsing bij 3mE'. In order to determine adequately whether a student has achieved the final qualifications, every form of assessment is tailored to the learning objectives and teaching formats (constructive alignment). An examiner should have the UTQ certificate or be in the process of obtaining one. All examiners in the bachelor's and master's programmes are employed by TU Delft.

In the process of constructing tests, examiners have to apply the 'four-eyes' principle with a colleague in the interests of safeguarding the quality of assessment. This can vary from the provision of feedback to doing trial tests, discussing the answer model and jointly determining the pass mark. Examiners have to prepare a test matrix in advance as a blueprint for their exams to guarantee the constructive alignment.

Once every three years, the educational advisor provides the examiners with feedback on test issues such as reliability, validity, construction and safeguarding of the learning objectives. Examiners who are not in the procedure are expected to keep working on improving quality and using the relevant

instruments. The educational advisor is always available for support at the examiner's request. At the end of every semester, the educational advisor submits an evaluation with findings and recommendations to the Board of Examiners and the Director of Education.

For written exams, students receive their grades within 15 working days after the exam date. Students have the right to feedback on their exam work within 20 working days after the grade publication date. Most lecturers organise offices hours or something similar for students to check their exams and ask questions. Students increasingly receive digital scans of the exams they have taken and handle the feedback procedure online as well.

During the site visit the panel learned about the test matrix that is used to align the programme-wide intended learning outcomes, the learning outcomes of the course, the course exam and the assessment. It found this matrix to be very helpful and a good instrument to improve the validity and quality of assessment. It also approves the assessment policy in general and the position of the educational advisor in particular. Teaching staff can count on ample support in improving the quality of their assessments.

Assessment methods
In the bachelor's programme every course or project unit contains at least one summative test at the end of the module period. For the theory courses, testing is rather uniformly conducted by 'written exams'; the majority on paper (containing mixtures of open questions, multiple-choice questions and 'short answer' questions), but some tests are taken on computer screens in prepared digital examination halls. To cope with open-question exams with the large number of students in the first year, some exams are graded using 'grading factories': a setting in which a group of selected older student assistants grade individual questions supported by the responsible teacher.

In the projects, a variety of assessment forms is used, including written research reports (desktop design projects or TCDs – Technical Construction Dossiers; as of last year called MDE, Mechanical Design Engineering reports), essays (ethics) and oral presentations (various) that are all commonly graded via a rubric. The BEP is graded with a rubric by the supervisor and during an exam session by a graduation committee of three staff members. There is also a group-wise grading for presentation of the work by a departmental colloquium committee and a grading for the individual research and design methodology exam.

Within the master's programme several ways of formative and summative testing are used: written exams, oral exams, individual project work, group project work and homework assignments. The graduation project is split up into three parts: a literature survey, an internship or research assignment, and a thesis project. The student writes a report about the literature survey, which is graded separately and provides an indication for the final grade for the thesis project. The internship is evaluated in detail on a dedicated form by the daily supervisor of the company, institution or external organisation involved, while the final decision to award credit is made by the academic staff member with a check mark; the student does not receive a grade.

The thesis is assessed by a graduation committee, which consists of at least two scientific staff members and one postdoc or PhD. One staff member should be from another section or preferably department. The chair must be a full professor or an associate professor who is authorised by the Board of Examiners to sign the master certificate. The thesis is assessed with a uniform master thesis grading rubric.

The panel appreciates that a variety of assessment methods are used in both the bachelor's as well as the master's programme, which are aligned, with the help of the matrices, with the intended learning outcomes and the curriculum. The main assessment form used in the bachelor's programme is still the written test, which is appropriate. During the site visit it was mentioned that multiple-choice questions are being used steadily less, due to less successful experiences. The panel wants to emphasise that it is possible to construct high-quality multiple-choice exams, testing higher level

learning outcomes and competences. It likes the creative solution that has been found to grade large numbers of exams by means of the 'grading factory'. It demonstrates that the academic staff and the management of the bachelor's programme are putting a lot of effort into efficiently assessing the exams whilst taking care that the assessments are reliable.

Board of Examiners
The Board of Examiners (BoE) of 3mE consists of a chairman, a secretary, one member of each research department and an external member from another Faculty. The BoE performs its duties independently. The chairman and the secretary of the BoE hold regular meetings with the Dean, the Director of Education, and other TU Delft Boards of Examiners to discuss common concerns and improve assessment.

The BoE monitors the quality of assessment and the correct application of the Teaching and Examination Regulations. Additionally, it deals with students with special personal circumstances and with appeal cases. The BoE has regular meetings in which it decides on cases brought in by students and staff members. The outcomes of the decisions are communicated in writing. In order to promote the equal treatment of students and to preserve the ability to act decisively, wherever possible, decisions are transformed into policy and recorded in internal policy documents.

The BoE has set strict rules for the composition of graduation committees and for graduating with distinction. It has a fraud and a complaints committee, each consisting of three members. These committees advise the BoE, which comes to a joint decision. There is a protocol for the procedure to be followed in cases of fraud. The BoE maintains close contact with the educational advisor about the quality of the exams. The semester evaluation by the educational advisor is regularly discussed in a meeting of the BoE. In specific cases, the BoE can request the educational advisor to provide feedback or an analysis of an exam that was not assessed that year.
Every year, the BoE writes an annual report on the performance of its statutory duties.

The BoE inspects the thesis work and accompanying assessment forms twice a year for a number of randomly chosen master students and assesses whether the graduation committees made fair judgements leading to the final grades.

According to the panel, the BoE has put adequate procedures in place to check the quality of assessment in the programme. The panel is very positive about the way the BoE is performing its tasks.

Considerations
The Faculty's assessment system and policy are well developed and implemented. All teachers are aware of the policies and measures implemented to assure the validity and reliability of the assessments. The Faculty has ensured that the teachers are supported in their tasks by the appointment of an educational advisor.

The courses in the bachelor's as well as in the master's programmes use a variety of assessment methods, which are very well aligned, with the help of the matrices, with the learning outcomes and the curriculum. The assessment procedures for the BEP and the master's thesis are well developed and documented. The procedures are transparent for teachers and students.

The panel is very positive about the way the Board of Examiners is performing its tasks and concluded that the examinations, tests and the thesis assessment are transparent, valid and reliable.

Conclusion
Bachelor's programme Mechanical Engineering: the panel assesses Standard 3 as good.

Master's programme Mechanical Engineering: the panel assesses Standard 3 as good.

Standard 4: Achieved learning outcomes
The programme demonstrates that the intended learning outcomes are achieved.

Findings
The panel studied a selection of 15 bachelor final projects and 15 master's theses to assess whether the graduates had achieved the intended learning outcomes. It concluded that the bachelor graduates did indeed achieve the level that can be expected of them. It found both the BEPs and the master's theses to be of a high level overall. The BEP reports showed that the bachelor students are qualified in the domain of engineering science and technology and are able to conduct research and design under supervision. They demonstrated a scientific approach to problems and ideas, based on current knowledge. The bachelor's programme prepares the students for continuing their studies in a master's programme. The alumni of the bachelor's programme felt well prepared for the master's programme. Almost no bachelor enters the job market after graduation.

The panel also concluded that the master graduates did indeed achieve the level that can be expected of them. It studied a selection of theses with a mix of high grades and low grades and found them to be of a high level overall. It would have tended in general to grade the theses higher than the graduation committee. The theses showed that the graduates are able to conduct research and design independently, have a scientific approach to complex problems and ideas, and have the ability to seek new potential applications, taking the social context into consideration. The theses showed an advanced level of knowledge in a specialised field, systematic understanding of the key aspects and concepts in mechanical engineering, and the ability to integrate theory and practice.

The self-evaluation described that the ME programme is relevant for the manufacturing industry from nano devices to mega plants, power companies, developers of medical devices, car (component) companies, transhipment and logistics companies in the Netherlands and abroad. Graduates easily find a job, the unemployment rate after graduation is virtually nil. The faculty has an active Industrial Advisory Board which meets twice a year and is involved in curriculum changes, research reviews and the profile of the graduates. A recent survey of employers showed that the professional field perceives the graduates as competent. This is confirmed by the alumni in a national survey in 2017.

Considerations
The panel concludes that graduates of the bachelor's programme Mechanical Engineering have achieved the intended learning outcomes. It found the level of the BEP reports to be good. The graduates of the bachelor's programme are well prepared for continuing their study in a master's programme.

The panel concludes that graduates of the master's programme Mechanical Engineering have achieved the intended learning outcomes. It found the level of the master's theses to be very good and would have graded most theses higher than the graduation committee. The graduates are well prepared for continuing in a PhD trajectory or a job in industry.

Conclusion
Bachelor's programme Mechanical Engineering: the panel assesses Standard 4 as good.

Master's programme Mechanical Engineering: the panel assesses Standard 4 as good.

GENERAL CONCLUSION

The panel assesses standards 1, 3 and 4 of the bachelor's programme as good and standard 2 as satisfactory. It was positive about the detailed formulation of the intended learning outcomes, the assessment system and the level achieved by the graduates. Following the NVAO decision rules, the panel's general conclusion is that the programme is assessed as good.

The panel assesses standards 1, 3 and 4 of the master's programme as good and standard 2 as satisfactory. It was positive about the detailed formulation of the intended learning outcomes, the assessment system and the level achieved by the graduates. Following the NVAO decision rules, the panel's general conclusion is that the programme is assessed as good.

Conclusion
The panel assesses the *bachelor's programme Mechanical Engineering* as good.

The panel assesses the *master's programme Mechanical Engineering* as good.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

Introduction
Mechanical Engineering studies the analysis and synthesis of structures, machines, devices, systems and processes that accomplish a desired objective in a safe, ethical and sustainable fashion. Mechanical engineers therefore improve quality of life, address societal challenges, and improve industrial competitiveness. No profession unleashes the spirit of innovation like engineering. From research to real-world applications, engineers constantly discover how to improve our lives by creating bold new solutions that connect science to life in unexpected, forward-thinking ways. There is great variety in fields of application, ranging from small to large scale, static to dynamic, and deep-sea to space, to name a few. Modern mechanical engineering is characterized by increasing multidisciplinarity, i.e. overlap with life sciences, electrical and chemical engineering etc. This necessitates a systemic approach in which the various fields of expertise reinforce one another, giving rise to world leading mechatronics, nano-manufacturing, robotics, precision agriculture, shipbuilding and more. The Netherlands' strength in this respect, along with its strong entrepreneurial spirit, partly explains its innovative power.

Curriculum
Active collaboration and exchange of students and staff takes place between the technical universities. The three curricula in Mechanical Engineering (BSc and MSc) in the Netherlands at TU Delft, TU Eindhoven and University of Twente comply with the definitions in ABET2, OECD3 and ASME3. The curriculum is based on a solid scientific foundation, deep engineering knowledge and agile engineering design skills.
Courses, projects and other modalities are designed to be mutually stimulating. For example, knowledge from courses is applied in projects and, conversely, in their design projects students experience the need for and utility of basic knowledge and engineering methodology. Overall learning goals cover science (mathematics, physics and thermodynamics), engineering (materials, solid and fluid mechanics, dynamics) and design (specifications, synthesis, modelling and optimisation, manufacturing, evaluation).

The bachelor curriculum is composed of three key components:
1. Basic science (mathematics, physics, thermodynamics)
2. Engineering courses (solid and fluid mechanics, dynamics, control)
3. Design projects (integration of the above analysis tools in a synthesis-oriented group effort, along with dedicated knowledge acquisition and soft skill training). Projects are structured accordingly, with integration of design specification, synthesis, modelling and optimisation, manufacturing, evaluation and presentation techniques.

The bachelor includes a one-semester minor of choice or elective program ME plus a project in the final year, i.e. a research or design project done in small teams.

The MSc curriculum is composed of one year of courses in an MSc track, plus a second year of an internship (optional in some cases) and a graduation project including a literature study, in which students mature to independent engineers or researchers. In some cases (part of) a graduation study is done in a company or another lab, possibly abroad. In several cases a graduation study results in a scientific publication.

Criteria for a Mechanical Engineering programme
The engineering field requires an understanding of core concepts including solid and fluid mechanics, kinematics, thermodynamics, control, materials science and structural analysis. Mechanical engineers use these core principles along with tools like computer-aided engineering and product lifecycle management to design and analyse manufacturing plants, industrial equipment and machinery, heating and cooling systems, transport systems, aircraft, watercraft, robotics, medical devices and more. The field has continually evolved to incorporate advancements in technology and mechanical

engineers today are pursuing developments in fields such as composites, mechatronics, additive and intelligent manufacturing and nanotechnology. The fundamental subjects of mechanical engineering include:

- Statics and dynamics
- Solid mechanics and mechanics of materials
- Materials engineering
- Mathematics including calculus, differential equations and linear algebra
- Thermodynamics, heat transfer, energy conversion
- Fluid mechanics and dynamics
- Mechanism design (including kinematics and dynamics)
- Manufacturing engineering (technology and processes)
- Design engineering (including CAD/CAM)

Mechanical engineers are also expected to understand and be able to apply basic concepts from chemistry, physics, chemical engineering, civil engineering and electrical engineering.
Most mechanical engineering programmes include multiple semesters of calculus, as well as advanced mathematical concepts including differential equations, partial differential equations, linear algebra, abstract algebra and differential geometry, among others.

A benchmark comparison with five European BSc-ME programmes was completed in 2013. In 2016 a comparative study for the theory learning lines was made between the three Dutch BSc-ME programmes. The main findings of these two studies are presented in Appendix A (of the Self-evaluation).

APPENDIX 2: INTENDED LEARNING OUTCOMES

Bachelor's programme Mechanical Engineering

1. Competent in the scientific discipline mechanical engineering

A graduate in Wb is able to...

1A. solve intermediate problems in the fundamental engineering sciences that form the basis of mechanical engineering: solid mechanics, thermodynamics, transport phenomena, materials science, control engineering & mechatronics and mathematics, especially analysis & algebra.
1B. solve elementary problems in related fields: electricity and magnetism, electronics, information technology and chemistry.
1C. solve intermediate problems in the most important mechanical engineering disciplines: mechanical systems, production technology, process & energy technology and robotics.

2. Competent in doing research

A graduate in Wb is able to...

2A. apply knowledge and skills in the scientific discipline mechanical engineering to research mechanical systems.
2B. apply commonly used methods and tools to model, simulate and research mechanical systems.
2C. document research approach and outcomes in a scientific report or paper.

3. Competent in designing

A graduate in Wb is able to...

3A. apply knowledge and skills in the scientific discipline mechanical engineering to design mechanical systems.
3B. develop complex mechanical systems based on the Conceive-Design-Implement-Operate – process (CDIO).
3C. generate innovative contributions to the discipline of mechanical engineering following various creative techniques, such as the Abstract & Categorize, Reflect, Reformulate & Extend – strategy (ACRREx).

4. A scientific approach

A graduate in Wb is able to...

4A. define and analyse problems, in the range from academic-fundamental to industrial-applied.
4B. develop innovative solutions to problems and evaluate the feasibility and limitations of these solutions.

5. Basic intellectual skills

A graduate in Wb is able to...

5A. systematically gather the relevant information to solve problems.
5B. maintain and extend own knowledge and skills through self-study.
5C. critically reflect on own knowledge, skills and attitude.
5D take a rational standpoint with regard to a scientific or technical argument within the area of research and/or design.

6.Competent in co-operating and communicating

A graduate in Wb is able to...

6A. work individually with a high level of autonomy.
6B. work in teams and divide subtasks within a team.
6C. explain and defend outcomes from the research area to specialists and peers from university and industry.
6D. present and report work in Dutch according to the common standards for style and structure and neatness.

7. Considering the temporal and social context

A graduate in Wb is able to...

7A. evaluate and assess the technological, ethical and societal impact of own work.
7B. act responsibly with regard to sustainability, economy and social welfare.

Master's programme Mechanical Engineering

1. Competent in the scientific discipline Mechanical

A graduate in Mechanical Engineering is able to…

1A. …apply advanced physics and measurement methods in mechanical systems.
1B. …design, carry out and evaluate experiments.
1C. …design, identify and control mechanical systems in an interactive and noisy environment.
1D. …relate scientific knowledge to mechanical systems considering their interaction with the environment.

2. Competent in doing research

A gradauate in Mechanical Engineering is able to…

2A. …study a topic by critically selecting relevant scientific literature.
2B. …write a scientific report about own research.
2C. …analyse mechanical systems at various levels of abstraction, including a reflective understanding of their structure and relations to other fields.
2D. …generate knowledge within the discipline of Mechanical Engineering.

3. Competent in designing

A graduate in Mechanical Engineering is able to…

3A. …systematically design complex mechanical systems.
3B. …generate innovative contributions to the discipline of Mechanical Engineering.

4. A scientific approach

A graduate in Mechanical Engineering is able to…

4A. …apply paradigms, methods and tools to design a mechanical system.
4B. …analyse problems and use modelling, simulation, design and integration towards solutions.
4C. …manage own scientific research independently.

5. Basic intellectual skills

A graduate in Mechanical Engineering is able to…

5A. …analyse and solve technological problems in a systematic way.
5B. …identify and acquire lacking expertise.
5C. …critically reflect on own knowledge, skills and attitude.
5D. …plan and execute research in changing circumstances.
5E. …integrate new knowledge in an R&D project, considering ambiguity, incompleteness and limitations.
5F. …remain professionally competent.
5G. …take a standpoint with regard to a scientific argument within the research area.

6. Competent in operating and communicating

A graduate in Mechanical Engineering is able to…

6A. …work both independently and in multidisciplinary teams.
6B. …explain and defend outcomes from the research area to academia and industry, to specialists and laymen.
6C. …present and report in good English.

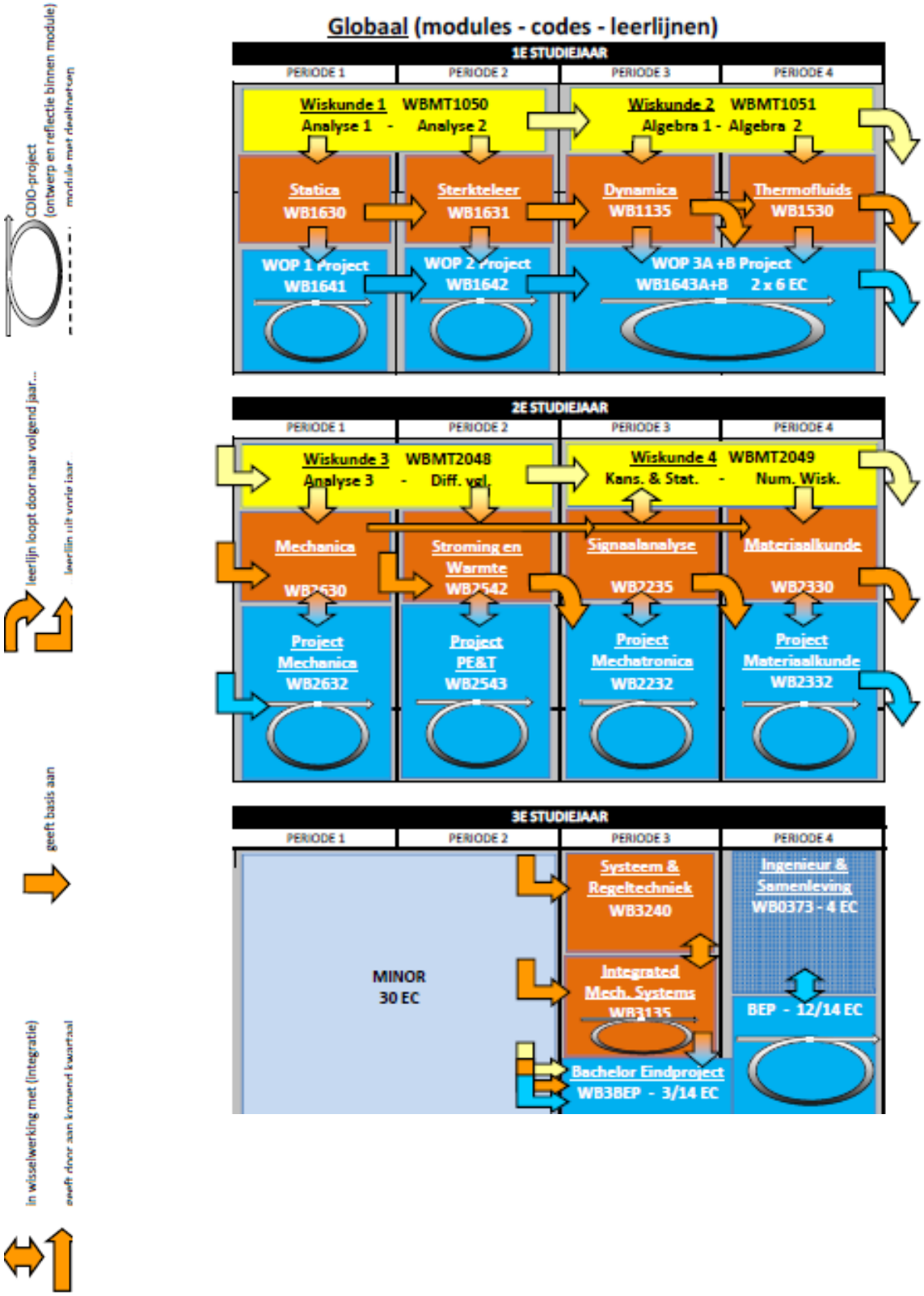
7. Considering the temporal and social context

A graduate in Mechanical Engineering is able to…

7A. …evaluate and assess the technological, ethical and societal impact of own work.
7B. …act responsibly with regard to sustainability, economy and social welfare.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Bachelor's programme Mechanical Engineering

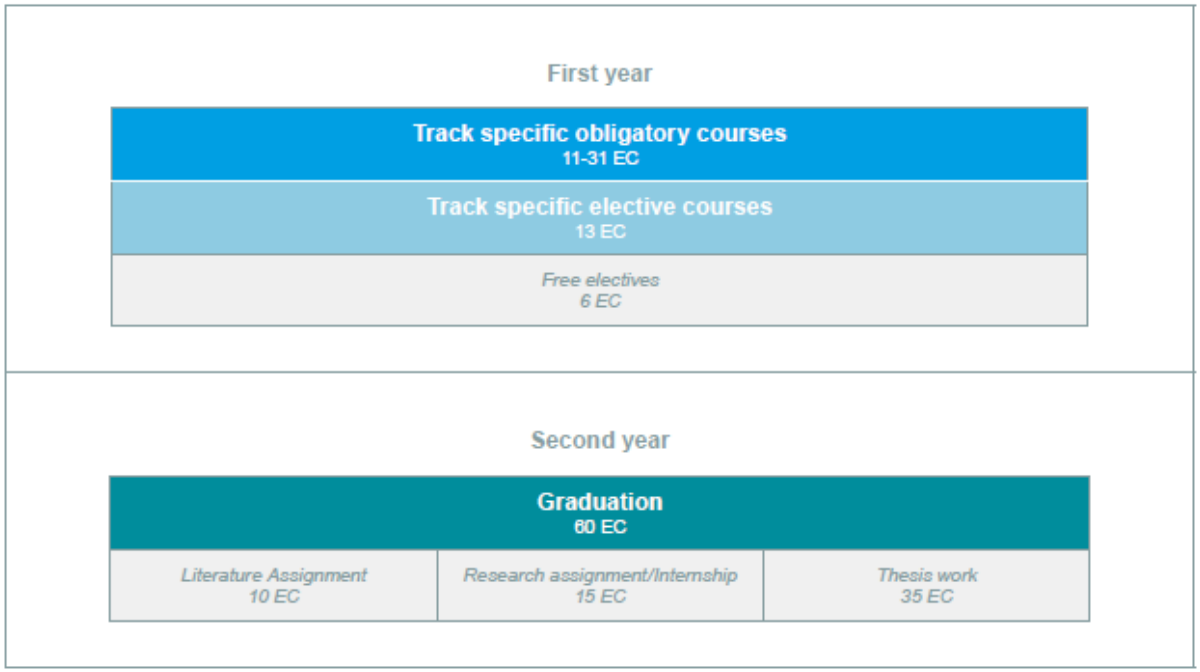


VAKCODE	TOETS	MODULENAAM	ECTS	WEGING	TOETSVORM
WISKUNDEBLOK			**12**		
WBMT1050		**WISKUNDE 1**	**6**		
	T1	Analyse 1 - deeltentamen	3	30	schriftelijk
	T2	Analyse 2 - deeltentamen	3	30	schriftelijk
WBMT1051		**WISKUNDE 2**	**6**		
	T1	Lineaire Algebra 1 - deeltentamen	3	30	schriftelijk
	T2	Lineaire Algebra 2 - deeltentamen	3	30	schriftelijk
WERKTUIGBOUWKUNDE THEORIEBLOK			**24**		
WB1630-16		**STATICA**	**6**		
	T1	Theorietentamen	6	60	schriftelijk
WB1631-15		**STERKTELEER**	**6**		
	T1	Theorietentamen	6	60	schriftelijk
WB1135		**DYNAMICA**	**6**		
	T1	Theorietentamen + Python programmeren	6	60	schriftelijk + software
WB1530-14		**THERMOFLUIDS**	**6**		
	T1	Theorietentamen	6	60	schriftelijk
WERKTUIGBOUWKUNDE PROJECTBLOK			**24**		
WB1641		**WERKTUIGKUNDIG ONTWERPPROJECT 1**	**6**		
	T1	Projecttentamen	3	30	schriftelijk + huiswerk
	T2	Groepswerk, waaronder:	3	30	project
		3 x 2 uur 2D, 3 x 2 uur Programmeren, 1 midd. WP Veiligh.instr.			
WB1642		**WERKTUIGKUNDIG ONTWERPPROJECT 2**	**6**		
	T1	Projecttentamen	3	30	schriftelijk
	T2	Groepswerk, waaronder:	3	30	project
		7 midd. 3D en Programmeren, 1/2 midd. MK, 1 midd. WPI			
WB1643A		**WERKTUIGKUNDIG ONTWERPPROJECT 3A**	**6**		
	T1	Projecttentamen	3	30	schriftelijk
	T2	Groepswerk, waaronder:	3	30	rapport
		6 midd. SR, 1/2 midd. MK, 1 midd. WPI, 1 midd. Lassen			
WB1643B		**WERKTUIGKUNDIG ONTWERPPROJECT 3B**	**6**		
	T1	Projecttentamen	3	30	schriftelijk
	T2	Groepswerk, waaronder:	3	30	project
		6 midd. MP, 2 midd. Ethiek & Werkplaatsgedrag			

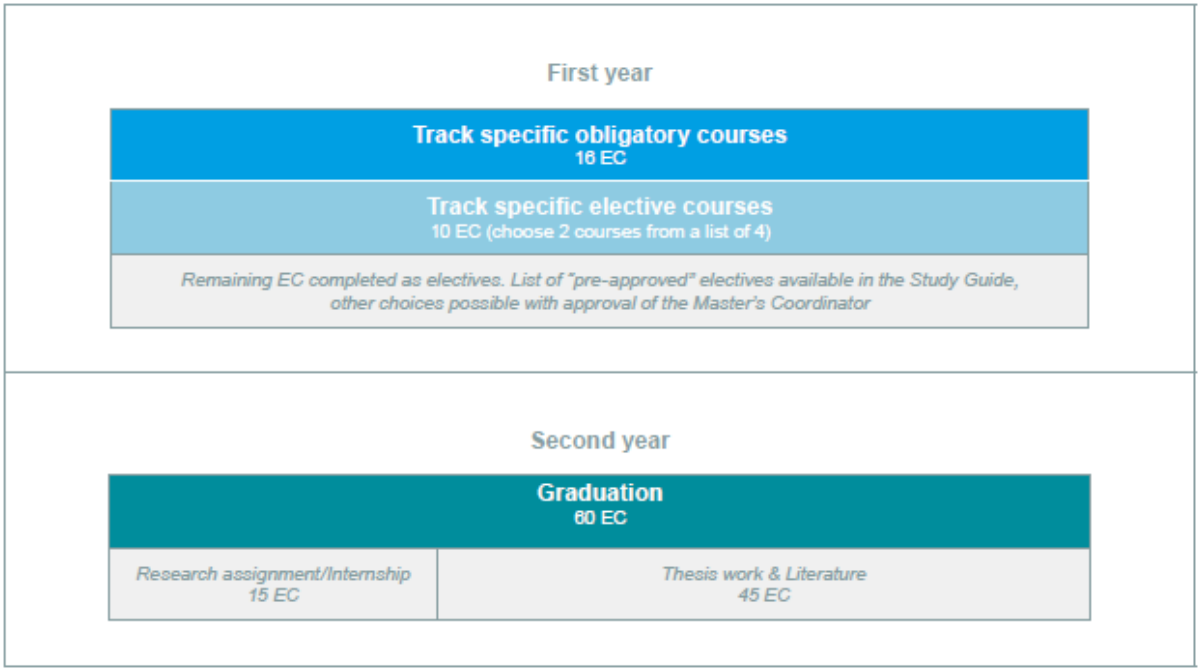
WISKUNDEBLOK			**12**		
WBMT2048		**WISKUNDE 3**	**6**		
	T1	Analyse - deeltentamen	3	30	schriftelijk
	T2	Differentiaalvergelijkingen - deeltentamen	3	30	schriftelijk
WBMT2049		**WISKUNDE 4**	**6**		
	T1	Kansrekening en Statistiek - deeltentamen	3	30	schriftelijk
	T2	Numerieke Wiskunde - deeltentamen	3	30	schriftelijk
	T3	Numerieke Wiskunde - practicum	0	0	practicum; software
WERKTUIGBOUWKUNDE THEORIE BLOK			**24**		
WB2630		**ADVANCED MECHANICS**	**6**		
	T1	Advanced Dynamics	3	30	schriftelijk + tt
	T2	Continuum Mechanics	3	30	schriftelijk + tt
WB2542		**STROMING EN WARMTE**	**6**		
	T1	Stromingsleer	3	30	schriftelijk
	T2	Warmte-overdracht	3	30	schriftelijk
WB2235		**SIGNAALANALYSE**	**6**		
	T1	Signaalanalyse	6	60	schriftelijk
WB2330		**MATERIAALKUNDE**	**6**		
	T1	Materiaalkunde	6	60	schriftelijk
WERKTUIGBOUWKUNDE PROJECTBLOK			**24**		
WB2632		**PROJECT MECHANICA**	**6**		
	T1	Projecttentamen (AED) + FEM opdracht	3	30	schr.+ practicum
	T2	Groepswerk	3	30	project
WB2543		**PROCESS ENGINEERING & THERMODYNAMICS**	**6**		
	T1	Projecttentamen	3	30	schriftelijk
	T2	Groepswerk + practicum	3	30	rapport + practicum
WB2232		**PROJECT MECHATRONICA**	**6**		
	T1	Projecttentamen	3	20	schriftelijk
	T2	Groepswerk + practicum	3	40	project + practicum
WB2332		**PROJECT MATERIAALKUNDE**	**6**		
	T1	Practicum + Projecttentamen	3	45	practicum + schriftelijk
	T2	Groepswerk	3	55	rapport + presentatie
MINORBLOK			**30**		
WERKTUIGBOUWKUNDE BLOK			**12**		
WB3240		**SYSTEEM- EN REGELTECHNIEK**	**6**		
	T1	Systeem en Regeltechniek	6	60	schriftelijk + software
WB3135		**INTEGRATED MECHANICAL SYSTEMS**	**6**		
	T1	IMS - groepsopdracht	3	30	rapportage
	T2	IMS - tentamen	3	30	schriftelijk
EINDPROJECT BLOK			**18**		
WB3073		**INGENIEUR & SAMENLEVING**	**4**		
	T1	Theorie	2	20	schriftelijk
	T2	Opdracht	2	20	essay
WB3BEP-16		**BACHELOR EINDPROJECT**	**14**		
	T1	Bachelor Eindproject	14	140	project

Master's programme Mechanical Engineering

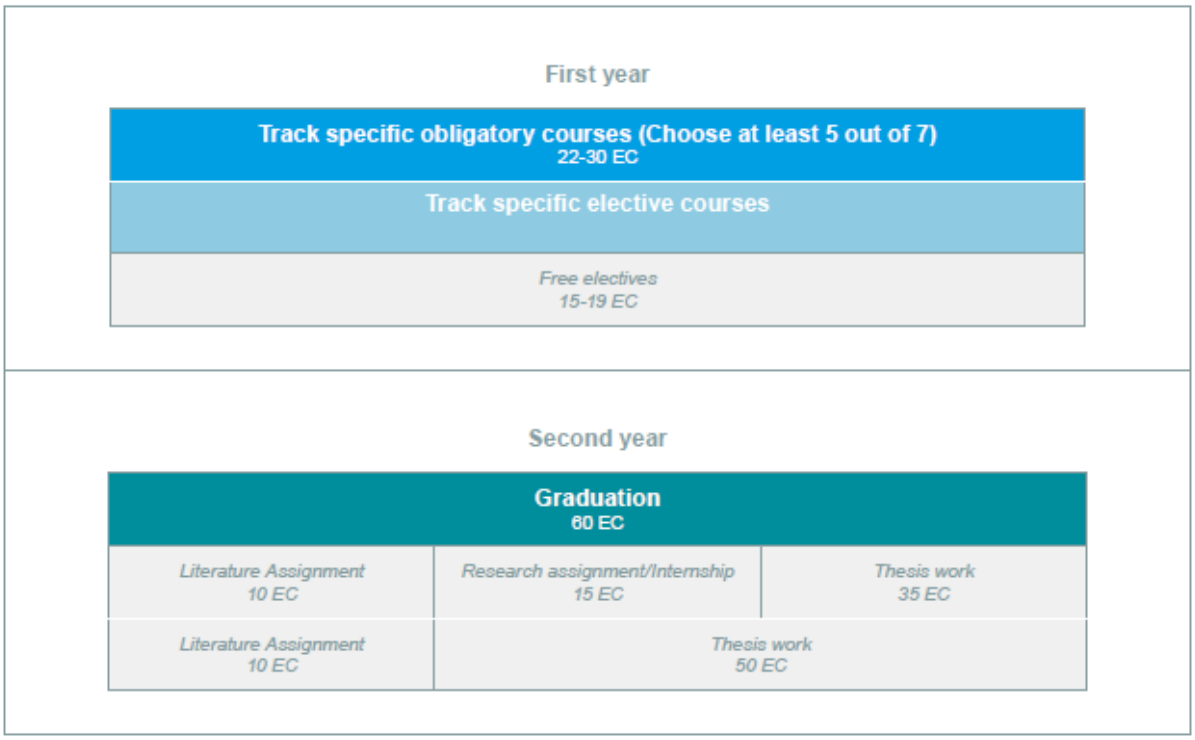
BMD



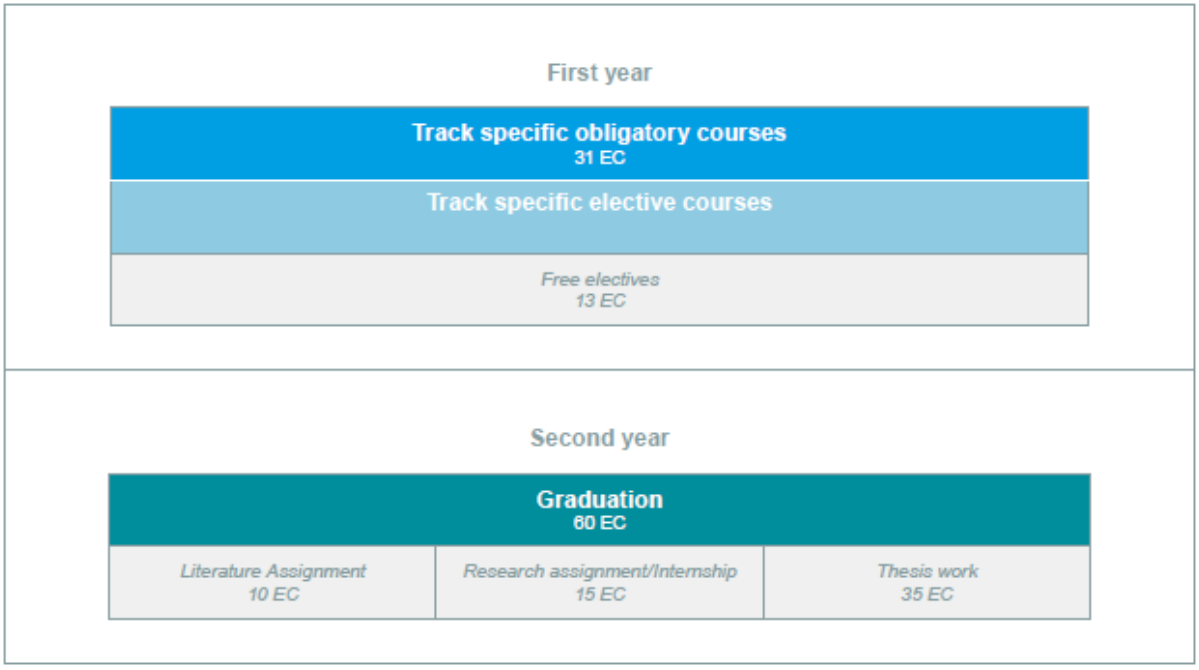
EPT



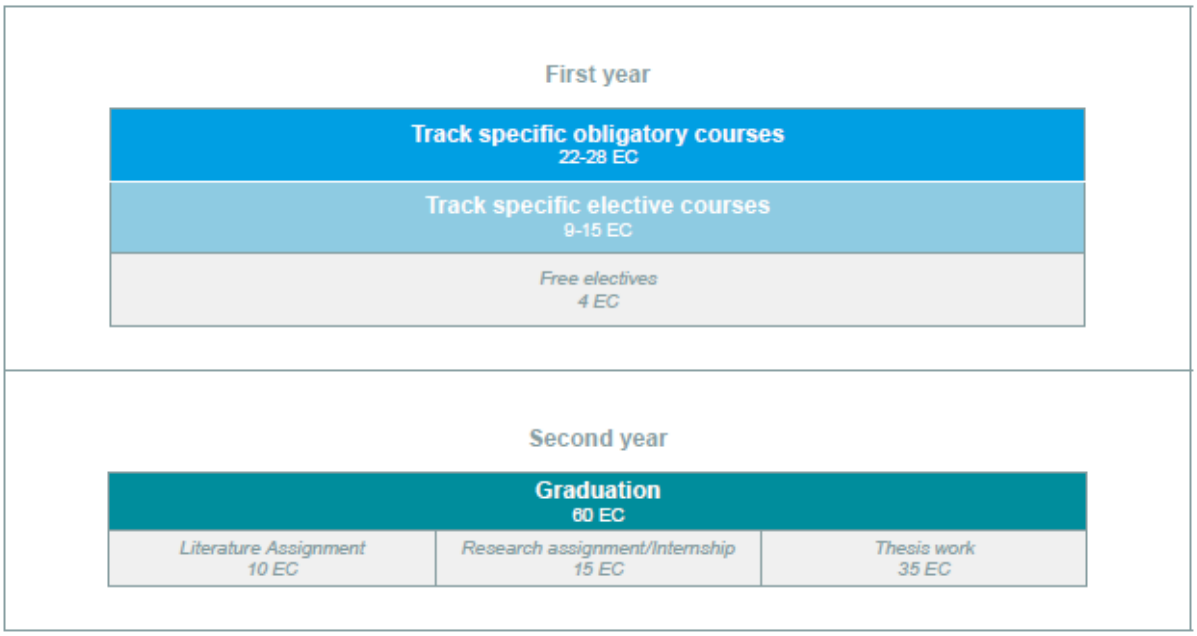
HTE


First year
Track specific obligatory courses (Choose at least 5 out of 7)
22-30 EC
Track specific elective courses
Free electives
15-19 EC
Second year
Graduation
60 EC
Literature Assignment
10 EC
Research assignment/Internship
15 EC
Thesis work
35 EC
Literature Assignment
10 EC
Thesis work
50 EC

TEL


First year
Track specific obligatory courses
31 EC
Track specific elective courses
Free electives
13 EC
Second year
Graduation
60 EC
Literature Assignment
10 EC
Research assignment/Internship
15 EC
Thesis work
35 EC

VE


First year
Track specific obligatory courses
22-28 EC
Track specific elective courses
9-15 EC
Free electives
4 EC
Second year
Graduation
60 EC
Literature Assignment
10 EC
Research assignment/Internship
15 EC
Thesis work
35 EC

APPENDIX 4: PROGRAMME OF THE SITE VISIT

Time 13 December	Activity
08.30 – 08.45 h	**Welcome** Director of Education 3mE
08.45 – 09.45 h	**Programme Management**
09.45 – 10.00 h	*Break*
10.00 – 10.45 h	**Bachelor Students Mechanical Engineering**
10.45 – 11.00 h	*Break*
11.00 – 11.45 h	**Master Students Mechanical Engineering & Materials Science & Engineering**
11.45 – 12.15 h	*Lunch*
12.15 – 12.45 h	**Roundtour**
12.45 – 13.30 h	**Staff Mechanical Engineering**
13.30 – 13.45 h	*Break*
13.45 – 14.30 h	**Staff Materials Science & Engineering**
14.30 – 14.45 h	*Break*
14.45 – 15.15 h	**Board of Examiners**
15.15 – 15.30 h	*Break*

15.30 – 16.30 h	**Professional Field & Alumni**
16.30 – 18.00 h	*Drafting preliminary conclusions*
18.00 – 21.00 h	*Dinner*

Time 14 December	Activity
08.30 – 08.45 h	Arrival
08.45 – 09.45 h	**Programme Management Marine Technology & Offshore and Dredging**
09.45 – 10.00 h	*Break*
10.00 – 10.45 h	**Students Marine Technology**
10.45 – 11.00 h	*Break*
11.00 – 11.45 h	**Staff Marine Technology & Offshore and Dredging Engineering**
11.45 – 12.30 h	*Lunch*
12.30 – 13.00 h	**Students Offshore & Dredging Engineering**
13.00 – 13.45 h	**Programme Management Representatives**
13.45 – 16.00 h	*Drafting preliminary conclusions*
16.00 – 17.15 h	**Feedback meeting & drinks**

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 15 theses of the bachelor's programme Mechanical Engineering and 15 theses of the master's programme Mechanical Engineering. Information on the selected theses is available from QANU upon request.

During the site visit, the panel studied, among other things, the following documents (partly as hard copies, partly via the institute's electronic learning environment):

3mE Vision on Education
Criteria for Academic Bachelor's and Master's Curricula
Film Lab Facilities
Toetsing bij 3mE
Teaching and Examination Regulations Mechanical Engineering 2018-2019
Masters 3mE Graduation Procedure
Results of Employers Survey
Jaarrapportage Bacheloropleiding Werktuigbouwkunde 2016-2017
Year report Master degree programme Mechanical Engineering 2016-2017
3mE Annual Report, MSc Mechanical Engineering 2016-2017
Minutes Board of Examiners 2017-2018
Minutes Board of Studies 2017-2018