APPLIED PHYSICS

FACULTY OF APPLIED SCIENCES

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This report was finalised on 16 September 2021

REPORT ON THE BACHELOR'S PROGRAMME TECHNISCHE NATUURKUNDE AND THE MASTER'S PROGRAMME APPLIED PHYSICS OF DELFT UNIVERSITY OF TECHNOLOGY

This report takes the NVAO's Assessment Framework for the Higher Education Accreditation System of the Netherlands for limited programme assessments as a starting point (September 2018).

ADMINISTRATIVE DATA REGARDING THE PROGRAMMES

Bachelor's programme Technische Natuurkunde

Name of the programme:	Technische Natuurkunde (EN: Applied Physics)
CROHO number:	56962
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Location:	Delft
Mode of study:	full-time
Language of instruction:	Dutch
Submission deadline NVAO:	01-11-2021

Throughout the report, the bachelor's programme Technische Natuurkunde will be referred to by its English name Applied Physics to improve readability of the report.

Master's programme Applied Physics

Name of the programme:	Applied Physics
CROHO number:	60436
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	Physics for Energy Physics for Fluids Engineering Physics for Health and Life Physics for Instrumentation Physics for Quantum Devices and Quantum Computing
Location:	Delft
Mode of study:	full-time
Language of instruction:	English
Submission deadline NVAO:	01-11-2021

The visit of the assessment panel Applied Physics to the Faculty of Applied Sciences of Delft University of Technology took place on 8-9 June 2021. Due to the limitations imposed by the corona pandemic, the site visit was organized online.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

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

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO approved the composition of the panel on 8 April 2021. The panel that assessed the bachelor's programme and the master's programme Applied Physics consisted of:

- Dr. C. (Cees) Terlouw, Senior Researcher and Consultant at Terlouw Consultancy & Advice (chair);
- Prof. P. (Petra) Rudolf, Professor Experimental Solid State Physics and Dean of Graduate Studies, University of Groningen;
- Prof. M.J. (Margriet) Van Bael, Professor Quantum Solid State Physics at KU Leuven;
- Dr. F.J.P. (Frank) Schuurmans, Vice President System Engineering at ASML Netherlands;
- X.M. (Xander) de Wit BSc., master student Applied Physics at Eindhoven University of Technology (student member).

The panel was supported by Peter Hildering MSc., who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The site visit to the bachelor's programme and master's programme Applied Physics at the Faculty of Applied Sciences of Delft University of Technology was part of the cluster assessment Applied Physics. In June 2021 the panel assessed eight programmes at three universities. The following universities participated in this cluster assessment: Delft University of Technology, Eindhoven University of Technology and 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. As of 1 July 2021, Qanu was supported by evaluation bureau Academion. Peter Hildering was project coordinator on behalf of Qanu as well as Academion, and acted as secretary in the cluster assessment for all site visits.

Panel members
The members of the assessment panel were selected based on their expertise, availability and independence. The full panel consisted of the following members:

- Dr. C. (Cees) Terlouw, Senior Researcher and Consultant at Terlouw Consultancy & Advice (chair);
- Prof. P. (Petra) Rudolf, Professor Experimental Solid State Physics and Dean of Graduate Studies, University of Groningen;
- Prof. M.J. (Margriet) Van Bael, Professor Quantum Solid State Physics at KU Leuven;
- Dr. F.J.P. (Frank) Schuurmans, Vice President System Engineering at ASML Netherlands;
- Prof. P.J. (Patrick) French, Professor Biomedical Electronics at TU Delft;
- M.S. (Mare) Dijkstra BSc., master student Applied Physics at University of Groningen (student member).
- X.M. (Xander) de Wit BSc., master student Applied Physics at Eindhoven University of Technology (student member).
- Em. prof. G. (Guido) van Oost, Professor Emeritus Nuclear Fusion at Ghent University (referent);

Preparation
On 29 March 2021, 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 27 May 2021. During this meeting, the panel members received instruction on the use of the assessment framework. 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. The panel's chair and the project coordinator made a selection of theses to be read by the panel. The selection consisted of 15 theses and their assessment forms for the programmes, based on a provided list of graduates between 2018-2020. 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 online visit to Delft University of Technology took place on 8-9 June 2021. Before and 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, professional field and representatives of the Board of Examiners. It also offered students and staff members an opportunity for confidential discussion during a consultation hour. No requests for private consultation were received. 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.

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 report to the Faculty in order to have it 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 the standards:

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

Meets the standard
The programme meets the generic quality standard.

Partially meets the standard
The programme meets the generic quality standard to a significant extent, but improvements are required in order to fully meet the standard.

Does not meet the standard
The programme does not meet the generic quality standard.

The panel used the following definitions for the assessment of the programme as a whole:

Positive
The programme meets all the standards.

Conditionally positive
The programme meets standard 1 and partially meets a maximum of two standards, with the imposition of conditions being recommended by the panel.

Negative
In the following situations:

- The programme fails to meet one or more standards;
- The programme partially meets standard 1;
- The programme partially meets one or two standards, without the imposition of conditions being recommended by the panel;
- The programme partially meets three or more standards.

SUMMARY JUDGEMENT

Bachelor's programme Applied Physics

The profile and aims of the bachelor's programme Applied Physics are fitting for an academic programme within the field, focusing on the broad core of physics. The programme has strengthened the applied character of the curriculum, and maintain an appropriate balance between a fundamental and engineering approach. The panel recommends monitoring this balance with special attention for design and system engineering. The goals of the programme have been well-translated into a coherent set of intended learning outcomes that are aligned with the requirements of the academic and professional field through the Meijer's criteria and a domain-specific framework of reference that is based on international standards. The panel recommends expanding the intended learning outcomes for the programme with skills and competences related to diversity, inclusivity, research integrity and social awareness.

The programme has adequately translated its intended learning outcomes into a coherent curriculum. It offers a broad foundation within applied physics and gives students a thorough training in the knowledge, skills and competences within the field. The learning trajectories provide structure and coherence to the programme. The panel welcomes the addition of a learning trajectory on design engineering in the programme. To further improve the learning trajectories, the panel recommends defining them in more detail to also include elements offered in multiple courses, such as academic and professional skills. The teaching methods in the programme are appropriate. The panel recommends monitoring the balance between mathematical exercises and qualitative understanding of physical phenomena. It also advises to take care of providing sufficient depth when discussing the application of theory in practice. Furthermore, the panel recommends more variety in teaching methods with regard to communication skills, in particular writing. The panel supports the decision to offer the programme in Dutch. To build up English language proficiency in order to prepare students for a master's programme, the programme could consider creating a learning trajectory on this skill. The curriculum is feasible, and helps students get acquainted with studying at the university by dividing the first year into short octals with a focused study schedule. Since feedback on this system is mixed, the panel supports the planned curriculum structure evaluation. The programme aims to improve feasibility by stimulating a timely completion of the thesis project. The panel supports these efforts. With regard to support during the corona pandemic, the programme was generally successful in transitioning towards online education when corona measures demanded this. The panel praises the efforts of the programme in facing this challenge, in particular the attention to cohesion and well-being of first year's students. The teaching staff involved in the programme is competent, well-qualified, motivated and open for feedback.

The programme has a valid, transparent and reliable system of assessment in place. The four-eyes principle used in all exams, individual components in group work, the assessment matrices and the online feedback system are successful tools to achieve this. During the corona pandemic, the programme successfully made the switch to online assessment. The thesis projects for the programme are evaluated through a solid assessment system. The composition of the assessment committees guarantees multiple viewpoints, and the insightful and detailed rubric matrix helps examiners substantiate their assessment, although sometimes the committees could provide more written explanation with regard to the grades. The Board of Examiners fulfils its role in safeguarding the programme's quality of assessment through checks of course assessment and thesis checks. The panel thinks that the Board could be even more successful if it made more use of its authority to realize changes in internal culture, for instance with regard to knowledge and completion of assessment forms and the time management in thesis projects. Finally, the panel recommends safeguarding the assessment of the ILOs on design engineering skills for all students.

The panel concludes that theses of the programme are of a high quality, and convincingly show that the respective intended learning outcomes are achieved. The panel agrees with the grading and praises the programme with the high level attained by the students at the end of the programmes. A point of improvement is the writing skill of students. Graduates of the bachelor's programme continue successfully into a master's programme. They feel well-prepared for their career and are satisfied with the level of the programme.

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

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Student assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

Master's programme Applied Physics

The profile and aims of the master's programme Applied Physics are fitting for an academic programme within the field. It focuses on the deepening and application of knowledge, skills and competences to a specific field and the related technical challenges. The programme has strengthened the applied character of the curriculum, and maintain an appropriate balance between a fundamental and engineering approach. The panel recommends monitoring this balance with special attention for design and system engineering. The goals of the programme have been well-translated into a coherent set of intended learning outcomes that are aligned with the requirements of the academic and professional field through the Meijer's criteria and a domain-specific framework of reference that is based on international standards. The panel recommends expanding the intended learning outcomes for the programme with skills and competences related to diversity, inclusivity, research integrity, social awareness and entrepreneurship.

The programme offers a varied and attractive curriculum that covers all elements of the intended learning outcomes. The common core and structure of the curriculum provide students in all tracks with a comparable experience and defines the level of the programme, while the track-specific electives, orientation and master thesis project offers many opportunities for individual trajectories. Students are encouraged to develop their own learning path and learn by working with experts in the field. The teaching methods are varied and fit the goals of the programme. The panel recommends a more systematic monitoring of transferable skills and design engineering education throughout the curriculum, for instance by creating learning trajectories. The programme is offered in English, in line with the international field of physics in which graduates of the programme can be expected to work. The panel considers this choice to be well-motivated. The curriculum is feasible in general, although some students experience a full or unbalanced curriculum based on their individual choices. The panel recommends increasing support for students in dealing with planning issues and helping them make choices without keeping their options open for too long. The programme aims to improve feasibility by stimulating a timely completion of the thesis project. The panel supports these efforts. With regard to support during the corona pandemic, the programme was generally successful in transitioning towards online education when corona measures demanded this. The teaching staff involved in the programme is competent, well-qualified, motivated and open for feedback.

The programme has a valid, transparent and reliable system of assessment in place. The four-eyes principle used in all exams, individual components in group work, the assessment matrices and the online feedback system are successful tools to achieve this. During the corona pandemic, the programme successfully made the switch to online assessment. The thesis projects for the programme are evaluated through a solid assessment system. The composition of the assessment committees guarantees multiple viewpoints, and the insightful and detailed rubric matrix helps examiners substantiate their assessment, although sometimes the committees could provide more written explanation with regard to the grades. The Board of Examiners fulfils its role in safeguarding the programme's quality of assessment through checks of course assessment and thesis checks. The panel thinks that the Board could be even more successful if it made more use of its authority to realize changes in internal culture, for instance with regard to knowledge and completion of assessment forms and the time management in thesis projects. Finally, the panel recommends safeguarding the assessment of the ILOs on design engineering skills for all students.

The panel concludes that theses of the programme are of a high quality, and convincingly show that the respective intended learning outcomes are achieved. The panel agrees with the grading and praises the programme with the high level attained by the students at the end of the programmes. A point of improvement is the writing skill of students. Graduates of the programme find suitable positions in academia and industry. They feel well-prepared for their career and are satisfied with the level of the programme.

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

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Student assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

The chair, Cees Terlouw, and the secretary, Peter Hildering, of the panel hereby declare that all panel members have studied this report and that they agree with the judgements laid down in the report. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 16 September 2021

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

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.

Profile and aims
The bachelor's and master's programmes in Applied Physics are organized by the Faculty of Applied Sciences at Delft University of Technology (TU Delft). The programmes aim to train students to occupy key roles in societal challenges for which physics can provide solutions, such as sustainable energy, health care, climate, safe information and a sustainable food supply. Graduates of the programme should be strong problem analysts and solvers, with strong analytic, numerical and experimental skills, as well as generic skills. They learn concepts and methods of physics, as well as the knowledge, skills and competences to design physical solutions for scientific and technical challenges. They should be able to work in a wide range of positions, including scientific research, engineering, management and industry.

The bachelor's programme provides a solid foundation in physics, including the mathematical, experimental, numerical and general academic skills necessary to be able to work within the field. The master's programme builds upon the foundation laid in the bachelor's programme (either at Delft or elsewhere). Next to a common core of mathematical skills, the programme provides the opportunity to specialize in a specific research field in physics, and to deepen the knowledge and skills necessary to solve challenges within the field. The specializations, which are implemented as tracks within the master's programme, are Radiation Science and Technology, Physics for Energy, Physics for Fluids Engineering, Physics for Health and Life, Physics for Instrumentation and Physics for Quantum Devices and Quantum Computing. These fields align with the strength of the Faculty's research fields, and cover areas that are involved in providing solutions for societal challenges.

The panel studied the profile and aims of the bachelor's and master's programme Applied Physics, and concludes that they are fitting for academic Applied Physics programmes. The bachelor's programme focuses on the broad core of physics, whereas the master's specialization covers fields that provide physical solutions to relevant problems.

Compared to other engineering programmes in the Netherlands, the Applied Physics programmes at Delft have a relatively large focus on the fundamentals underlying the phenomena that are studied. During the site visit, the panel discussed with several representatives of the programmes to what extent the Applied Physics programmes can be considered engineering programmes. The programmes consider themselves to be on the more fundamental side of the engineering spectrum. The programme management explained that the bachelor's programme Applied Physics is to a large extent similar to Physics bachelor's programmes at non-technical universities. This is due to the broad core of physics that covers most of the curriculum and is necessary to be able to work within the field. To underline the engineering character of the programme, the programme has included a learning trajectory on design (see Standard 2) as a response to remarks by the previous accreditation committee. The master's programme continues this learning trajectory and offers more opportunities to specialize in the direction of engineering and design, although there are also some research areas that are quite fundamental in nature that students can choose. The panel concludes that the programmes are aware of their position in between fundamental physics and physical engineering, and maintain an appropriate balance between these two aspects. The programmes have convincingly replied to the recommendations of the previous accreditation committee by developing a design learning trajectory that more strongly underlines their engineering character. The panel recommends to the programmes to keep monitoring the balance between fundamental physics and physical engineering within the curricula.

Intended learning outcomes
The bachelor's programme translates its goals into a set of eight intended learning outcomes (ILOs). The master's programme uses a set of nine ILOs that are formulated on a programme level, with the first learning outcome on applied physics knowledge providing differentiation between the research fields underlying the six specialization tracks. These ILOs describe the knowledge, skills and competences that are required of a bachelor's or master's student in Applied Physics. Both sets of ILOs are included in Appendix 2.

To align the ILOs with the international requirements of the field, the Applied Physics programmes in the Netherlands have composed a domain-specific frame of reference (DSFR). This framework is based on the CALOHEE Tuning document for European Physics programmes on the one hand, and the Academic Competences and Quality Assurance (ACQA) framework on the other hand. The ACQA framework (also known as the Meijer's criteria) has been developed by the Dutch technical universities (4TU) as a translation of the Dublin descriptors for higher education in engineering. The programmes have provided the panel with a matrix detailing the relation between the ILOs, the DSFR and Meijer's criteria.

The panel studied the ILOs of both programmes and concluded that they form a convincing and well-structured overview of the main goals of the programme translated into knowledge and skills to be acquired by students. The use of the Meijer's criteria in designing the ILOs guarantees that they meet the respective bachelor's and master's level and academic orientation, as well as their compliance with general engineering skills required by the academic and professional field. The DSFR is strongly grounded in international requirements for physics programmes, making both programmes well aligned with the requirements of the field. The panel noted that the learning outcomes related to the applied character of the programmes have been added since the previous accreditation. It considers these to be solid and well integrated, and compliments the programmes with this.

The panel notes that professional and transferable skills could be more prominent in the ILOs for both programmes. In the self-evaluation, the programmes already conclude that the learning outcomes do need to be updated to include elements from the DSFR regarding diversity, inclusivity and research integrity. The panel supports this, and notes that this update could include additional skills that will be important in the future workplace, such as social awareness and entrepreneurship. This is relevant for the master's programme in particular, as many of the alumni end up working in industry.

Considerations
The profile and aims of the bachelor's and master's programme Applied Physics are fitting for an academic programme within the field. The bachelor's programme focuses on the broad core of physics, and the master's programme on the deepening and application of knowledge, skills and competences to a specific field and the related technical challenges. The programmes have strengthened the applied character of their curricula, and maintain an appropriate balance between a fundamental and engineering approach. The panel recommends monitoring this balance with special attention for design and system engineering.

The goals of both programmes have been well-translated into two coherent sets of intended learning outcomes that are aligned with the requirements of the academic and professional field through the Meijer's criteria and a domain-specific framework of reference that is based on international standards. The panel recommends expanding the intended learning outcomes for both programmes with skills and competences related to diversity, inclusivity, research integrity, social awareness and for the master's programme also with entrepreneurship.

Conclusion
Bachelor's programme Applied Physics: the panel assesses Standard 1 as 'meets the standard'.
Master's programme Applied Physics: the panel assesses Standard 1 as 'meets the standard'.

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.

Curriculum: Bachelor's programme
The bachelor's programme Applied Physics consists of a 150 EC core programme and a 30 EC minor. Most courses are either 3 EC or 6 EC, and are offered in a structure of octals, with short, focused four-week periods of education, following by an assessment week (see Feasibility for further discussion). The first two years have a strong focus on fundamental knowledge and skills, with respectively 45 (year 1) and 42 EC (year 2) reserved for core courses in mathematics, general physics (i.e., Mechanics, Electromagnetism, Quantum Physics) and applied physics (i.e., Thermodynamics, Systems & Signals, Computational Science). The remaining 15 and 18 EC are for courses on design, research skills, experimenting and technology management. The third year consists of the minor (30 EC) in the first half of the year, the final general and applied physics courses (15 EC), a philosophy of science course (3 EC) and the bachelor's research project (12 EC). For the minor, students can choose from a wide selection of minor programmes offered by TU Delft to either broaden their view outside physics or follow a bridging programme for a non-physics master's programme. In addition, students can opt for a minor abroad, or the selective deepening minor in physics offered in collaboration with Leiden University. For the bachelor's research project, students perform an individual research project in one of the Faculty's research groups under supervision of a staff member.

The courses in the curriculum are connected through learning trajectories. The learning trajectories consist of interrelated courses that build upon each other over three years. Learning trajectories can be subdisciplines (*i.e.,* Mechanics, Electromagnetism) or skills and methods (Experimenting, Computation, Design). Teaching staff associated with the courses have a constructive alignment meeting once every two years where all content, learning objectives and assessments within a learning trajectory are reviewed and aligned by the teaching staff together with the programme management. The learning trajectory Design was added to the curriculum in response to the request of previous accreditation committee. This learning trajectory consists of two Design Engineering projects in which students get familiar with the design cycle, and work in groups to design experiments and products.

The panel studied the structure and content of the curriculum of the bachelor's programme Applied Physics, as well as the contents of a number of courses, and spoke with programme management, students and teaching staff. It concludes that the programme has translated its intended learning outcomes into a solid and coherent curriculum. It offers a broad foundation within applied physics and gives students a thorough training in the knowledge, skills and competences within the field. The learning trajectories provide structure and coherence to the programme for both students and teaching staff. As the learning trajectories are defined as groups of courses, they exclude general skills such as professional and academic skills, which are offered in a more integrative way rather than in separate courses. But also, even if skills have their own dedicated courses, they exclude skill components offered as part of other courses. The learning trajectory Design is an example of this. Although the panel considers the two design engineering courses that make up this learning trajectory to be good additions to the curriculum that underlines the applied, engineering character of the programme, there is also room for design elements in other courses, such as the practicals or the bachelor's project. During the interviews, the panel learnt that the programme management plans to update the curriculum in the coming years. The panel recommends including a review of the learning trajectories in this update, in particular by allowing for more detail in the description of the learning trajectories' lay-out. Among other things, this will make room for a skills learning trajectory that can provide a more systematic overview of academic and professional skills education in the programme. Furthermore, the panel recommends increasing the frequency of alignment meetings within the learning trajectories, for instance by adding smaller alignment meetings before the start of new courses in order to finetune the coherence between courses.

Curriculum: Master's programme

The curriculum of the master's programme consists of a common core (24 EC), electives (18 EC), an orientation programme related to the career the student wants to pursue after gradation (30 EC), and the master's thesis project (48 EC). The curriculum is structured in the same way for each of the five tracks. The definition of a track is quite broad and in fact defined by the master's thesis and 12 EC of electives labelled for that track; this means that students do not have to choose a track immediately when starting the master's programme.

- The *common core* consists of two compulsory courses: Mathematical Methods for Physics (9 EC) and Ethics (3 EC). In addition, students are required to choose two out of four 6 EC master's courses on fundamental physics topics.
- For the *electives*, students can choose specialized courses related to their track of choice. There are over 50 track-related courses to choose from. As mentioned above, students are required to choose at least 12 EC of courses from within their track. Any remaining EC can be spent on any physics or mathematics course on master's level. Most students choose a course relevant to their master's project.
- In the *orientation*, students can strengthen their skills for one semester (30 EC) with regard to the direction they want to pursue after their graduation. This can be either Research & Development, Education, or Management of Technology. Alternatively, students can opt to study abroad for a half year. The orientations Education and Management of Technology are fixed curricula that students follow at either the master's programme Science Education and Communication or in Management of Technology. In the Orientation Education, students obtain a first- or second-degree teaching qualification (depending on whether or not they followed the educational minor during their bachelor's programme) as a physics teacher. The Research and Development orientation lets students choose between an industrial internship (18 EC) or a group design project and course (15 EC), with the remaining EC to be spent on additional electives. For studying abroad, students can either propose a project of a university of their own choice to their supervisor or take part in the Optics in Jena programme with the Friedrich Schiller Universität. The latter is an extended programme of 60 EC, in which students also pursue their master's thesis as an external project in Jena. An additional special variant of the programme is the Casimir programme offered in collaboration with Leiden University. This programme is offered to a select group of excellent students (grade point average 7.5 EC or higher) that aim to pursue a PhD programme after completion of their master's project. It is focused on conducting a master's thesis project that is developed into a PhD project proposal.
- The *master's thesis project* is an individual research project conducted at one of the research groups associated with the selected track of the student. Students start by doing 6 EC of preparatory work, focusing on general and academic skills necessary for setting up and executing the project. After that they conduct their 42 EC project and finalize it with a report, a presentation for an audience and a closed-door oral defence with the assessment committee.

The panel studied the curriculum of the master's programme and concludes that the programme has successfully translated the ILOs into a coherent and varied curriculum with lots of room for individual customization and specialization. The common core and structure of the curriculum provide students in all tracks with a comparable experience and defines the level of the programme. The Management and Education orientations provide attractive options for students that want to pursue a career in these directions, and the Casimir and Optics in Jena programmes are attractive options for students interested in either studying abroad or pursuing a PhD after completion of their master's degree. The addition of a design project to the orientation is a good response to the previous assessment committee's recommendation to improve the attention to design engineering in the programme. The panel learnt from the interviews that most students in the research & development orientation choose an industrial internship, with only a small group opting for the design project. The panel supports the efforts of the programme to make the design project more popular with students, as it sees this project as one of the distinctive features of an applied physics programme as compared to a general physics master's programme.

The master's programme has not explicitly formulated learning trajectories throughout its curriculum. The panel understands that students to a large extent follow an individualized curriculum, but nevertheless thinks that the programme should at least monitor the training in skills and in design engineering that students receive more systematically. Academic skills are well-covered in the preparatory work for the master thesis project, but transferable skills such as cooperation and working in interdisciplinary teams have a more diffuse presence in the curriculum, spread over multiple electives. The same applies to design engineering in the case of students that do not choose the design project. The alumni survey as well as the alumni interviews mention attention to transferable skills as a point of improvement. The programme could realize a more systematic embedding by integrating a skills and a design learning trajectory into the common elements of the programme, or by monitoring this for each student individually. During the interviews, the panel learnt that the programme management plans to update the curriculum in the coming years. The panel recommends including the implementation of the abovementioned learning trajectories transferable skills and design into this process.

Teaching methods
The *bachelor's programme* focuses in its teaching methods on extensive practicing with the teaching materials to help students get familiar with the mathematical and physical concepts and techniques. In general, first-year students are required to spend 60% of their time on lectures and tutorials, 20% on practical work (lab work, computer assignments and projects) and 20% on self-study. In the second and third year this balance shifts towards more self-study and less lectures and tutorials. In their practical work, students are increasingly challenged to work in a problem-based way and design their own experiments, rather than using a pre-selected set-up.

The panel appreciates the educational concept and teaching methods in the programme, in particular the shift towards problem-based learning during practical work. Furthermore, the relatively large number of tutorials helps students get acquainted and practice with the sometimes complex and abstract material. The panel understands that this is necessary to reach the level of abstraction required in the field of physics. At the same time, it recommends monitoring the balance between understanding and applying the phenomena studied. The students that the panel interviewed recognized the programme’s strong focus exercises. They reported to sometimes miss attention to the qualitative discussion of the physical phenomena behind the mathematical exercises, as well as the application of course content towards practical challenges. The panel appreciates the comment of the students and adds that the applied part of the courses should have its own level of depth rather than serving as an illustration by a theoretical exercise, as was sometimes the case in the materials that the panel studied. Furthermore, some students mentioned that they would also value more variety in teaching methods with regards to writing reports, giving presentations and project work. The panel supports this, adding its own observation from the bachelor's theses that in particular writing skills within the programme could be improved (see Standard 4).

The *master's programme* uses the educational concept of self-development. Students are encouraged to develop their own learning path, and to learn by doing through working with experts in the field. Especially the electives are often small-scale courses where students work closely together with fellow students and teachers. These courses usually use teaching methods suitable to specialized, small-scale courses, such as discussing homework exercises, and executing projects and presentations based on papers. In the master thesis project, students work on their own research project with researchers within their field. The panel concludes that the educational concept of the programme fits the goals of the programme, and that the curriculum is designed to accommodate this. Students have a lot of room for self-development and for interaction with experts, and the teaching methods applied in this framework are varied.

Over the past two academic years, both programmes were generally successful in transitioning towards online education when corona measures made it hard to organize on-campus meetings. Lectures and tutorials were held online. With additional support from student tutors, tutorials could be held in smaller groups, making it easier to interact with all students. The limited campus time that was available to the programmes was mostly used for cohesion and support for first-year bachelor students and experimental work in small groups. Students and teaching staff reported to the panel that, although there were some teething problems in the start-up period, they were ultimately satisfied with the online education and the variety of online teaching methods. Nevertheless, most were looking forward very much towards a return to normal.

Language and internationalization
The *bachelor's programme* is offered in Dutch. It is one of the few bachelor's programmes at Delft University of Technology that has not made the switch to English. This is an explicit choice of the programme management. The programme attracts a relatively large group of students that have a low proficiency in English at the start of the programme. As the curriculum is already experienced as challenging by first year students, the programme does not want to further complicate the study process by offering courses in English. The use of English is gradually introduced during the bachelor's programme, starting with English-language study materials, and continuing in an increasing number of English-taught courses in the second and third years of the programme. At the end of the bachelor's programme, students usually have sufficient command of English to be able to write their bachelor's thesis in English (although the option to write it in Dutch is present) and continue into an English-language master's programme.

The panel supports the well-motived the decision of the programme management to offer the bachelor's programme in Dutch. The increased use of English throughout the programme prepares students for an English-language master's programme and the international professional field on the one hand, and on the other hand allows for the inclusion of international teaching staff in later courses. The panel recommends continuing to monitor English-language proficiency within the programme. The panel noted from the bachelor's theses that a small portion of the students still struggle with the English language at the end of the curriculum. The programme could consider formalizing the build-up of English-language proficiency as a learning trajectory throughout the programme.

The *master's programme* is offered in English. According to the programme, English is the dominant language in the field, both in academia and in the professional field. This means that the English language is essential in order to be able to participate in the international field of applied physics. As the staff in the Faculty is very international, the use of English means that all staff can participate in education. Due to this international context, all teaching staff works and communicates in English on a day-to-day basis. For new staff members, language proficiency is one of the selection criteria. Additionally, the university offers courses to improve language proficiency of all staff.

The panel considers the choice for the use of English to be very well motivated. The programme is offered in an international environment, with regard to both the field of applied physics and to the staff of the Faculty. An English-language programme prepares students for an internationally oriented field. Students are generally positive on the quality of the education in English, and sufficient attention is paid to the language skills of the teaching staff. The programme itself mentions that the integration between Dutch and non-Dutch students could be improved. The relatively small group of international students (15-20% of students in total) sometimes has trouble integrating into the larger group of students that already know each other very well from the Delft bachelor's programme. The panel supports efforts of the programme to improve this. The programme could for instance consider a joint introduction week or event for all students or moving the common core courses where students meet each other as much as possible to the first semester of the first master year. Furthermore, the panel learnt from the interview with the professional field that international graduates of the programme are not always familiar with Dutch (professional) culture. This can make them less attractive for companies based in the Netherlands. The panel suggests offering international students additional training in working in the Netherlands, either within the curriculum or as an extracurricular activity.

Feasibility

The *bachelor's programme* invests significantly in the feasibility of the programme, particularly during the first year. Prospective students participate in a mandatory matching event in which they can experience whether the programme fits their interests and skills and can opt for a pre-university online course in Physics if they are unsure about their level. Throughout their first year, the programme helps students in the transition from secondary school to university by offering a strict curriculum in which it is clear what is expected from them each week. The curriculum is divided into octals, with short four-week periods in which 3 EC courses are taught, followed by an assessment week. In the second and third year, the curriculum increasingly offers 6 EC courses over periods of eight weeks in order to make room for more in-depth courses, and to give students more responsibility for their own planning.

The panel praises the attention to feasibility in the bachelor's programme, in particular the attention to the shift from secondary school to university that results in a relatively limited drop-out. During the interviews, the panel noted that the octal-based curriculum was regarded with mixed feelings both by students and teaching staff. Some students felt very well-supported through the fixed structure, whereas others felt that the short periods of education followed by assessment allowed them hardly any breathing room, in particular when they also had to integrate resits for tests. The teaching staff experience short periods of high workload due to the octal system; some did not mind but others would prefer to offer a more balanced distribution of teaching load. Furthermore, some teaching staff mentioned that they felt the short duration of courses negatively impacted long-term retention of knowledge in students over later years. The precise causal relation between the curriculum structure and feasibility is up for further evaluation and debate. The bachelor's programme is therefore planning a thorough evaluation of the octal system as part of the earlier-mentioned curriculum review. The panel supports this plan. It recommends to not only an evaluation of the practical implications of the system, but also of the philosophy behind this system using insights from the educational sciences.

The feasibility of the master's programme is mostly dependent on the choices for an individual curriculum that students make. During the interviews, some students mentioned that they had to work very hard to complete the programme within the allocated time. Many students continue working on their courses and projects during the summer holidays to be able to successfully complete the programme. The teaching staff and programme management told the panel during the interviews that they recognize the issue, but that it is not usually the result of the study load itself. Some of the individual curricula are not well balanced over the year or have too many ECs since students try to keep their options open for as long as possible. The panel recommends monitoring the feasibility of the individual curricula of master's students, supporting them in dealing with planning issues and helping them to make choices without keeping their options open for too long.

In *both programmes,* the thesis project is often a source of study delay. Students often keep working on their project beyond the allocated time to realize better results or because the project interests them. In some cases, supervisors even promote this rather than steering towards timely completion. The programmes are actively working to improve this situation. A new rubric for scoring the thesis includes time management as a criterion and includes a summative mid-term assessment on the progress so far. The preparatory work for the master thesis project that was recently included helps students plan their project and set realistic goals. The panel supports these measures and encourages the programme to stimulate both students and supervisors to promote timely completion of thesis projects. It understood from discussions with the programme management and Board of Examiners that the programmes sometimes still struggle to convince all supervisors to include time management in the thesis assessment. The panel considers that the programme management and the Board of Examiners could play a role in more strongly enforcing this rule (see also Standard 3).

Student support

The students that the panel interviewed feel well supported throughout the programme. The programme coordinator is available for programme-related questions, and two academic counsellors for issues related to personal circumstances. The study association provides an important informal network for support of students, in particular when they first start at the university. For talented students, both programmes provide additional opportunities, such as a double bachelor's programme with Applied Mathematics, a university-wide honours programme and the Casimir programme for prospective PhD students or a double master during the master's programme. In the past year, when corona measures made it impossible to organize on-campus meetings for most of the year, the programme especially invested in cohesion and student support for first-year bachelor's students. Each student was assigned a mentor responsible for monitoring his or her well-being and study success. Extra student tutors (third-year bachelor's students or master's students) were hired to allow for more personal education in smaller groups. When the opportunity arose to organize physical meetings on a small scale, the programme used this time mainly to improve social cohesion for first-year students. Students reported to the panel that they valued the efforts of the programme and felt that the measures taken kept the programme feasible, also during distance education. Bachelor's students in later years as well as master's students regret that they had less opportunities to meet, but understand and support the decision of the programme management to give preference to first-year students' tutorials.

The panel is positive about the student support in both programmes. It praises the attention to the well-being of first-year students who enrolled during the corona pandemic, as well as the many opportunities that the programmes offer for talented students. Furthermore, the panel is positive about the important role that the study association has in student support, especially for first year students. Based on the discussions during the site visit, the panel noted that not all students with special needs, such as autism or dyslexia, seem to find their way towards additional support. It recommends improving communication in order that all students are aware of the support that is available at the university. From the alumni survey mentioned under Standard 4, the panel concluded that 5% of master's students struggle to find a job after graduation: experiences from other programmes leads the panel to believe that these could be special needs students who could maybe profit from additional support from the university. Furthermore, the panel thinks that attention towards inclusivity and diversity could be improved. Both programmes acknowledge that the number of female students as well as female teachers is relatively low in the programmes, even when compared to national averages. The panel recommends continuing to look for the causes for this discrepancy and to formulate concrete actions to address this gender gap.

With regard to professional orientation, the programmes offer various extracurricular activities such as lunch meetings with speakers from industry and open company days as well as opportunities for industrial internships in the master's programme. Most students were satisfied with this, although some bachelor's students would prefer more contacts with industry. The panel encourages the programme to continue their efforts and to investigate whether there is more room for career orientation in the bachelor's programme.

Teaching staff

The programmes are taught by the scientific staff associated with the Faculty of Applied Sciences, with a small number of courses being taught by lecturers form the Faculties of Electrical Engineering, Mathematics and Computer Science or Technology, Policy and Management. Some of the teaching staff of the master's programme are associated with the QuTech institute for quantum computing: they can act as lecturers provided they obtained a University Teaching Qualification (UTQ). Courses are generally taught by two staff members, who are both responsible for the quality of education, and review each other's contributions based on the four-eyes principle. Nearly all teaching staff (98%) of the bachelor's programme and all of the teaching staff of the master's programme hold a PhD. All new teaching staff are required to have obtained or follow the UTQ course. Current staff members have either followed the UTQ course, or received an exemption based on a dossier proving acquired teaching competences.

The documents as well as interviews with students and teaching staff gave the panel a very positive view of the teaching staff of both programmes. Students are satisfied with the quality of the education, and experience their teachers as very competent and approachable, even though the number of students in the courses can be high. The panel praises the attention towards professionalization of the staff, both with regard to UTQ requirements and in the four-eyes principle used by the pairs that teach the courses. As in most university departments, workload can be high at times, but in general the staff report that their teaching load is manageable. The panel gained the impression that teaching staff cooperate well as a team, and appear motivated, proactive and open for feedback from students and colleagues. Regarding student feedback, the panel noticed during the interviews that students do not always see the results of their feedback on courses, although the programme usually follows up on this feedback. It recommends sending information on course improvements based on student feedback to the students that originally provided the feedback.

Programme-specific facilities
The bachelor's programme uses ten student laboratories for practical work, as well as a Maker Space that students can use to construct prototypes and instruments as part of design projects. The laboratories are mostly used by first year students: for most second and third year bachelor's courses, as well as all master's courses, students do their experimental work within the Faculty's research groups, allowing students to become familiar with state-of-the-art equipment. As the site visit took place online, the panel did not visit the laboratories, but based on the documents and the students' remarks, the panel is positive on the programme-specific facilities of both programmes.

Considerations

The *bachelor's programme* has adequately translated their intended learning outcomes into a coherent curriculum. It offers a broad foundation within applied physics and gives students a thorough training in the knowledge, skills and competences within the field. The learning trajectories provide structure and coherence to the programme. The panel welcomes the addition of a learning trajectory on design engineering in the programme. To further improve the learning trajectories, the panel recommends defining them in more detail to also include elements offered in multiple courses, such as academic and professional skills. The teaching methods in the bachelor's programme are appropriate. The panel recommends monitoring the balance between mathematical exercises and qualitative understanding of physical phenomena. It also advises to take care of providing sufficient depth when discussing the application of theory in practice. Furthermore, the panel recommends more variety in teaching methods with regard to communication skills, in particular writing. The panel supports the decision to offer the programme in Dutch. To build up English language proficiency in order to prepare students for a master's programme, the programme could consider creating a learning trajectory on this skill. The curriculum is feasible, and helps students get acquainted with studying at the university by dividing the first year into short octals with a focused study schedule. Since feedback on this system is mixed, the panel supports the planned curriculum structure evaluation.

The *master's programme* offers a varied and attractive curriculum that covers all elements of the intended learning outcomes. The common core and structure of the curriculum provide students in all tracks with a comparable experience and defines the level of the programme, while the track-specific electives, orientation and master thesis project offers many opportunities for individual trajectories. Students are encouraged to develop their own learning path and learn by working with experts in the field. The teaching methods are varied and fit the goals of the programme. The panel recommends a more systematic monitoring of transferable skills and design engineering education throughout the curriculum, for instance by creating learning trajectories. The programme is offered in English, in line with the international field of physics in which graduates of the programme can be expected to work. The panel considers this choice to be well-motivated. The curriculum is feasible in general, although some students experience a full or unbalanced curriculum based on their individual choices. The panel recommends increasing support for students in dealing with planning issues and helping them make choices without keeping their options open for too long.

Both programmes aim to improve feasibility by stimulating a timely completion of the thesis project. The panel supports these efforts. With regard to support during the corona pandemic, the programmes were generally successful in transitioning towards online education when corona measures demanded this. The panel praises the efforts of the programmes in facing this challenge, in particular the attention to cohesion and well-being of first year's bachelor students. The teaching staff involved in the programmes is competent, well-qualified, motivated and open for feedback.

Conclusion

Bachelor's programme Applied Physics: the panel assesses Standard 2 as 'meets the standard'.
Master's programme Applied Physics: the panel assesses Standard 2 as 'meets the standard'.

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

Assessment system

Both programmes adhere to the faculty-wide assessment system. This system is based on constructive alignment and aims to use assessment methods that align with the course objectives and the teaching methods used in the courses. Each course has an assessment matrix, in which students can find the form, requirements and goals of each test. Each exam is checked by two examiners: usually the two teachers associated with a course. In the case of project work, such as the design engineering projects, there is always an individual component next to the group assessment to guarantee that each student meets the intended learning outcomes. The faculty recently introduced an online correction system called 'Zesje' that provides students with detailed feedback on each question in written exams.

Over the past two years, the programmes were forced to shift towards online assessment for most courses. This initially sparked a debate among programme management, teaching staff, Board of Examiners and students on the rules and guidelines of online assessment. The result was an increased use of open book exams, which are more fraud-resistant than the closed-book exams in an online setting. In some courses for which open book exams were not suitable, limited exceptions for on-campus exams were possible. Various groups that the panel interviewed reported this debate to be a time-consuming and sometimes frustrating process, but in the end, most were satisfied with the result. For a small number of courses (10-15%) exams had to be postponed due to the lack of an online alternative, but for each course ultimately a solution was found.

The panel is very positive about the system of assessment in both programmes. The four-eyes principle used in all exams, as well as the attention to individual components when evaluating group work, add to the reliability and validity of the assessment. The assessment matrices that the panel studied were insightful and provided a coherent overview of the goals and forms of assessment in relation to the course goals. 'Zesje' is a very good feedback tool that is valued by both students and teaching staff and makes assessment an integrated part of the student learning process. Online assessment was handled adequately by both programmes, even though not without friction, and the resulting rules and guidelines for online assessment sufficiently guarantee the quality of assessment. If the programmes want to implement online closed-book exams, the panel suggests investigating the use of online tools that are designed to prevent fraud, for instance through randomizing the order of exam questions and of variables used in them.

Thesis assessment

The bachelor and master thesis project have similar assessment procedures. Students are assessed by an assessment committee consisting of a minimum of two (bachelor) or three (master) examiners. The committee should at least include the thesis supervisor and a second researcher associated with the Faculty, and at least one of them should be a lecturer within the programme. The master assessment committees have as additional rule that one of the members should be a full or associate professor with *ius promovendi*, and that one of the committee members should belong to a research group independent of the group in which the student performed his or her project. The programmes keep track of the variation in pairing in assessment committees to prevent the forming of preferred assessment partners among staff members. In addition, each report is subject to a plagiarism check. Students in a double bachelor's or master's programme can opt for two separate thesis projects or a larger integrated project covering the ILOs of both programmes. In the latter case, the assessment committee consists of at least four examiners (two per programme). The assessment committee assesses the student based on his or her report, final presentation and oral defence. The committee jointly completes the assessment form after the presentation and defence, using a detailed rubric matrix based on the relevant ILOs provided by the Faculty. This rubric matrix does not only include the report and presentation, but also competencies such as time management, ability to self-reflect and creativity. Students get six grades on subcategories, each with a textual motivation. The final grade is an average of the subgrades, which the committee has the freedom to deviate from for a maximum 0.5 points, provided that they motivate this on the form.

The panel is positive on the assessment procedure of the thesis projects. The assessment committees and the rules for composition guarantee multiple viewpoints on the student's work. As part of its preparation of the site visits, the panel studied 15 bachelor and 15 master theses with the accompanying assessment forms. It concludes that the forms used to evaluate the theses are useful, detailed and have a well-defined rubric. The form provides sufficient room for textual feedback. Most of the time, the rubric matrices were completed by the assessment committee in an insightful way. In a limited number of cases, the panel found the textual motivation somewhat lacking in explaining why a certain (sub)grade was given in relation to the rubric. When discussing this issue with the Board of Examiners, the Board pointed out that it drew similar conclusions from its theses reviews and is working on enforcing the rules for thesis assessment (see below). Furthermore, the panel noticed that design skills are not part of the rubrics list for both the bachelor and master theses. It understands that these skills are not necessarily part of every thesis project but recommends the programmes to make sure that each student is sufficiently assessed on this learning outcome over the course of the programme. This could be part of the further development of the learning trajectory on design engineering discussed under Standard 2. Finally, the panel noted a minor discrepancy in the form for the bachelor thesis project: a grade 10 is defined in the rubric as the student having reached master's level. The panel recommends rephrasing this, as this could imply that students can be entitled to a master's degree based on their bachelor thesis.

Board of Examiners

The Faculty of Applied Sciences has a central Board of Examiners, with a subcommittee for each respective programme within the Faculty. The chairs of each subcommittee, together with a separate general chair, form the central Board of Examiners. Each subcommittee consists of three lecturers from within the programme, and deals with the quality assurance of assessment within the programme, as well as handling individual requests by students. The subcommittees monitor the quality of assessment by analysing exam results and investigating outliers, and systematically review the assessment of the courses and theses. The committees select a number of courses each year, and review and discuss the assessment methods with the responsible lecturers. Furthermore, the committees annually select a sample of theses to evaluate the quality of the work and of the assessment. This sample typically includes several high- and several low-scoring theses, as well as a number of random theses.

Based on the documents as well as on the interviews with the subcommittees for both Applied Physics programmes and the chair of the Faculty Board of Examiners, the panel concludes that the Board of Examiners fulfils its role by safeguarding the quality of assessment in the programmes. The course assessment checks and thesis sampling are adequate tools for this purpose. The panel considers that the committee could make more use of its authority to realize changes in internal culture. For instance, when exerting its soft powers is not successful, the committee could consider rejecting incomplete assessment forms, and request the programme management to better inform the examiner's knowledge of the regulations, and to hold supervisors accountable that are not motivated to steer students towards timely completion of the thesis (see also Standard 2).

Considerations

Both programmes have a valid, transparent and reliable system of assessment in place. The four-eyes principle used in all exams, individual components in group work, the assessment matrices and the online feedback system are successful tools to achieve this. During the corona pandemic, the programmes successfully made the switch to online assessment. The thesis projects for both programmes are evaluated through a solid assessment system. The composition of the assessment committees guarantees multiple viewpoints, and the insightful and detailed rubric matrix helps examiners substantiate their assessment, although sometimes the committees could provide more written explanation with regard to the grades. The Board of Examiners fulfils its role in safeguarding the programmes' quality of assessment through checks of course assessment and thesis checks. The panel thinks that the Board could be even more successful if it made more use of its authority to realize changes in internal culture, for instance with regard to knowledge and completion of assessment forms and the time management in thesis projects. Finally, the panel recommends safeguarding the assessment of the ILOs on design engineering skills for all students in both programmes.

Conclusion

Bachelor's programme Applied Physics: the panel assesses Standard 3 as 'meets the standard'.
Master's programme Applied Physics: the panel assesses Standard 3 as 'meets the standard'.

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

Findings

Thesis quality

Prior to the site visit, the panel studied 15 bachelor theses and 15 master theses in Applied Physics. For the master's programme, the theses were evenly divided over the tracks of the programme. The panel concludes that the theses are generally of high quality, and show that the students in both programmes realize the programmes' learning outcomes. It generally agreed with the grades awarded by the programmes. The high average thesis grades (around 8) in both the bachelor's and the master's programme were found by the panel to be justified by the quality of the reported work. The panel praises the programmes for the high level that their students achieve at the end of the curriculum. For both programmes, the panel found that the quality of the written texts could be better in several cases. The texts were sometimes long-winded and in the case of the bachelor thesis projects sometimes showed limited proficiency in academic English. This was discussed under Standard 2. The English language proficiency was significantly better for the master's programme, but also in the master thesis projects the texts could be more condensed.

Alumni of the bachelor's programme generally continue with a master's programme. Although no exact exit numbers are available, the most popular option is to continue in the master's programme Applied Physics in Delft: roughly 70% of the intake of the master's programme comes from the bachelor's programme Applied Physics. Some bachelor's students remarked that following a master's programme in (Applied) Physics after graduation is sometimes viewed as the default option by the programme and fellow students, and they would prefer more orientation towards other master's programmes or career opportunities throughout the curriculum. The panel recommends paying attention to this aspect. A recent alumni survey shows that graduates from the master's programme easily find a job after graduation, often in industry but also in academia for a PhD project. 5% of students struggle to find a job after graduation. The panel, as mentioned earlier, suspects these could be special needs students, and recommends investigating if this is the case and if the programme is in the position to help this group while still at the university (see Standard 2). In both the survey and in the interviews, alumni reported to be satisfied with the programme. They had some points of improvement, in particular with regard to the attention to transferable skills (see also Standard 1). Overall, they were satisfied with the level of the programme, as well as the preparation for their current job.

Considerations

The panel concludes that theses of both programmes are of a high quality, and convincingly show that the respective intended learning outcomes are achieved. The panel agrees with the grading and praises the programme with the high level attained by the students at the end of the programmes. A point of improvement is the writing skill of students. Graduates of the bachelor's programme continue successfully into a master's programme, and graduates of the master's programme find suitable positions in academia and industry. They feel well-prepared for their career and are satisfied with the level of the programme.

Conclusion
Bachelor's programme Applied Physics: the panel assesses Standard 4 as 'meets the standard'.
Master's programme Applied Physics: the panel assesses Standard 4 as 'meets the standard'.

GENERAL CONCLUSION

The panel assesses all four standards for both programmes as 'meets the standard'.

Conclusion
The panel assesses the *bachelor's programme Applied Physics* as 'positive'.
The panel assesses the *master's programme Applied Physics* as 'positive'.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

Actual framework see: https://surfdrive.surf.nl/files/index.php/s/harvJqndiFvst2B

Introduction Domain-specific Framework of Reference (DSFR) Accreditation Physics and Astronomy

This framework defines the knowledge, skills and competences of the graduates from the Applied Physics programmes of the universities of Delft, Eindhoven and Twente. It is formulated for the teaching assessment exercise ('visitatie') round of 2021. The framework is based on the Tuning document from 2018i, containing criteria for both Bachelor and Master of Physics degrees, with additions to emphasise the skills typical for an *applied* physicist.

Graduates from an Applied Physics Master programme must have a solid knowledge of physics and they must be capable of applying this knowledge and physicist's skills to make useful contributions at possibly high-level positions in society. A number of alumni will enter further education, which is mostly at the PhD level. The graduates should be competitive on the academic and non-academic job market. The Bachelor level should allow students to smoothly enter a Master programme in Applied Physics, but also in General Physics, or other technical programmes at a Master level. These Bachelor programs, together with dedicated follow-up Master programs, are therefore essential in making them strong competitors on the national and international job market.

Applied physicists distinguish themselves from physicists from non-technical universities by their awareness of, and sensitivity to applications, and the technical skills to realize those applications. What sets Applied Physics apart from other technical disciplines is the higher level of fundamental knowledge, which enables graduates to develop novel techniques and new understanding.

The criteria in the following tables are divided into categories (corresponding to the cells in the third column) and each of these categories is in turn divided into three aspects which are summarized as 'knowledge', 'skills' and 'Autonomy and Responsibility'. The first row gives more elaborate descriptions of these aspects (from the Tuning 2018 document). The criteria 'Design' and 'Technical problem solving and innovation' have been added to better represent the Applied Physics degrees (items 5 and 6 in the tables for BSc and MSc).

The criteria are furthermore placed into categories from the so-called 'Meijer's Criteria' (ii), which are tailored to degrees at technical rather than general universities and from the 'Framework for Qualifications of the European Higher Education Area' (iii).

i) https://www.calohee.eu/wp-content/uploads/2018/12/WP-4-Del.-1.5-Guidelines-and-Reference-Points-for-the-Design-and-Delivery-of-Degree-Programmes-in-Physics-FINAL-17DEC2018.pdf
ii) 'Criteria for Academic Bachelor's and Master's curricula' of 'Academic Competences and Quality Assurance criteria' https://www.tue.nl/en/research/research-groups/philosophyethics/acqahttps://research.tue.nl/files/2008910/591930E.pdf
iii) http://ecahe.eu/w/index.php/Framework_for_Qualifications_of_the_European_Higher_Education_Area

APPENDIX 2: INTENDED LEARNING OUTCOMES

Bachelor's programme *Applied Physics*

Een afgestudeerde van de bacheloropleiding Technische Natuurkunde:

A. beheerst de basiskennis van de natuurkunde, met inbegrip van de noodzakelijke wiskunde en aanverwante technische vakken, op het niveau dat vereist is om een internationaal geaccrediteerde masteropleiding (Technische) Natuurkunde te kunnen volgen;
B. kan standaardproblemen binnen de (technische) natuurkunde oplossen, gebruikmakend van theoretisch analytische of numerieke methoden, experimenten en/of simulatie- en modelleringstechnieken;
C. beschikt over brede kennis op het gebied van de natuurwetenschappen;
D. is in staat om problemen, ook buiten de bestudeerde gebieden, te analyseren en te abstraheren. Hij/zij kan de technieken bedoeld in punt toepassen om oplossingen voor deze problemen aan te dragen en te realiseren, met oog voor praktische toepassing;
E. is in staat om zich zelfstandig effectief en efficiënt nieuwe kennis eigen te maken, met behulp van moderne communicatiemiddelen;
F. kan alleen of in teamverband bijdragen aan (technisch) fysisch onderzoek en aan technische ontwerpen en heeft ervaring met een projectmatige aanpak;
G. kan zowel in het Nederlands als in het Engels en zowel mondeling als schriftelijk communiceren over het vakgebied en over zijn of haar werk, gebruikmakend van geëigende presentatietechnieken;
H. heeft kennis van techniek-gerelateerde ontwikkelingen in maatschappelijke context en is in staat om op dit gebied standpunten te formuleren en te verdedigen.

Master's programme *Applied Physics*

The attainment levels of the programme are specific for the Applied Physics degree; they read:

1 Applied physics knowledge

Mastery of Applied Physics at an advanced academic level. This means mastery of a choice of advanced general Physics subjects (such as Quantum Mechanics, Statistical Physics, Electrodynamics, Continuum Physics) and the necessary mathematics, in addition to a choice of applied physics subjects (such as Quantum Electronics, Optics and Lasers, Fluid Dynamics, Reactor Physics) and optionally other advanced technical subjects (such as Computer Science, Materials Science, Chemistry, Life Sciences), as well as skills in the field of experimental techniques, data analysis, simulation and modelling. This knowledge and these skills should be mastered at a level comparable to that of Applied Physics programmes at international, top-quality, educational institutions.

2 In-depth knowledge

In-depth knowledge of at least one area within Applied Physics, so that international research literature can be understood.

3 Research experience

Thorough experience of research in (Applied) Physics and complete awareness of the applicability of research in technological developments.

4 From abstraction to solution

Capable of understanding a wide variety of different problems and being able to formulate these at an abstract level, whilst being able to see the relation between diverse problems at this abstract level and to contribute creatively to their solution, focusing on practical applications.

5 Design

Capable of creating innovative technical designs, taking feasibility issues into account.

6 Collaboration/communication.

Capable of working in a (possibly interdisciplinary) team of experts, performing the aforementioned activities and communicating easily in both written and spoken English.

7 Working independently

Capable of carrying out a (research) project, including planning and time management. Working independently and taking initiatives where necessary.

8 Presentation skills

Capable of making English language presentations of personal research activities to varied audiences. Capable of adapting to the background and interest of the audience.

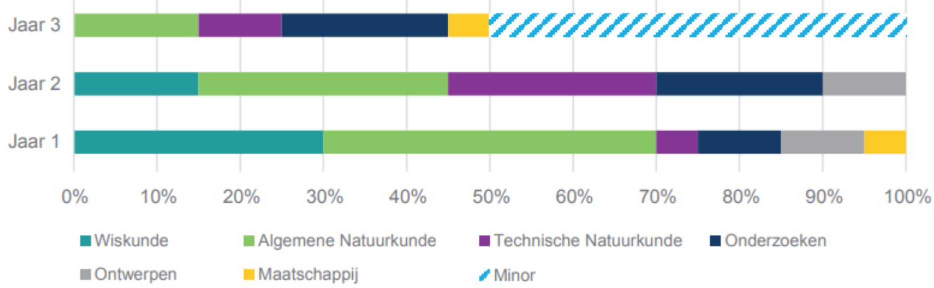
9 Societal awareness

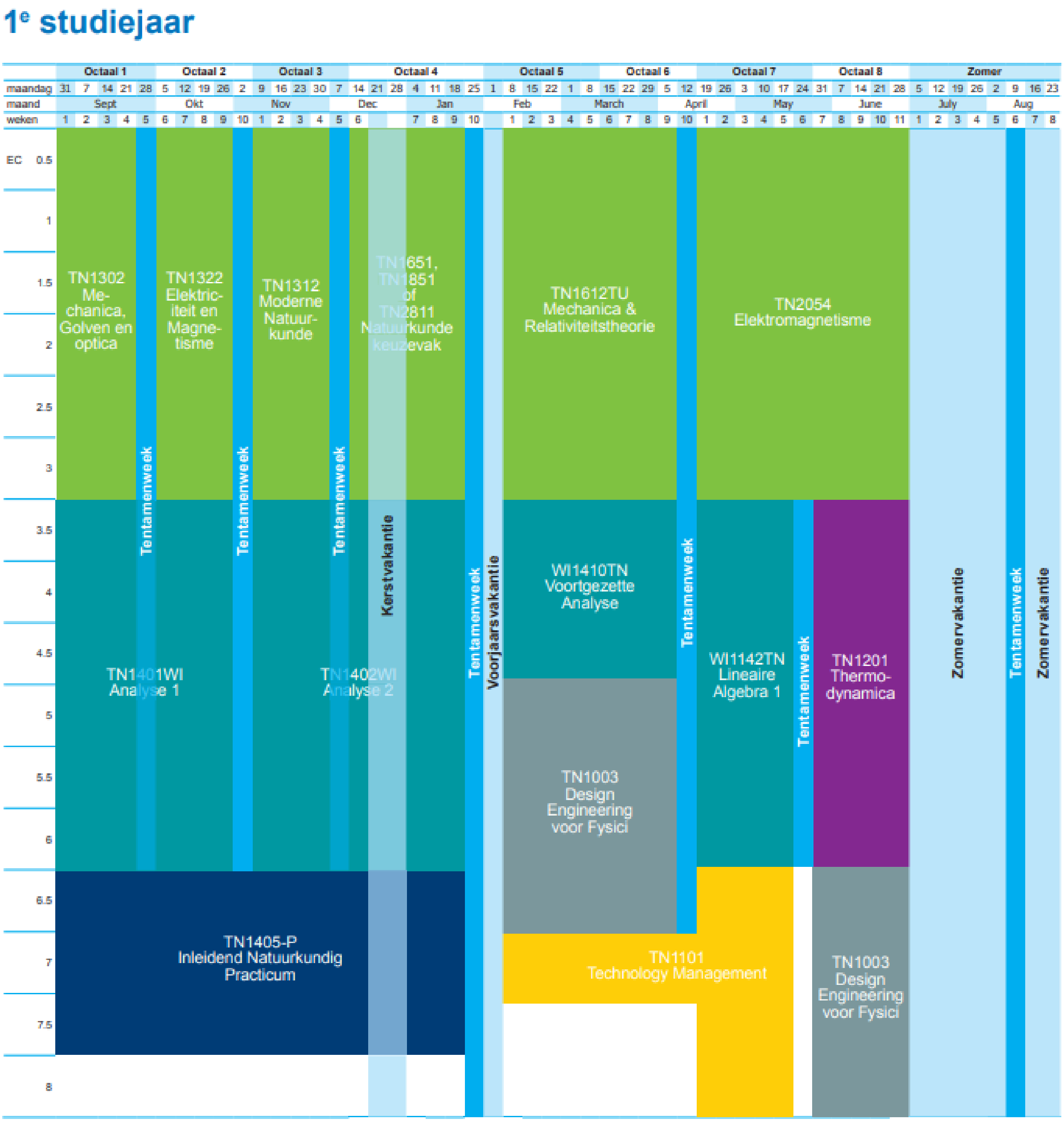
Knowledge of technology-related developments in society, such as sustainability issues. Capable of developing and defending opinions in this area.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Bachelor's programme *Applied Physics*

Overview of the courses





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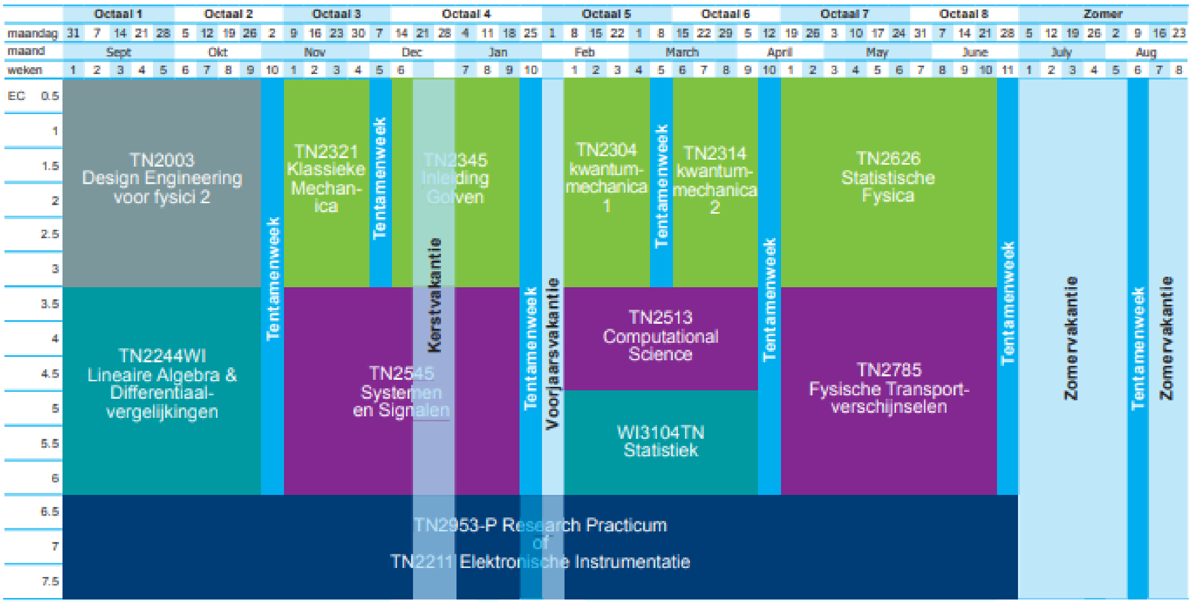

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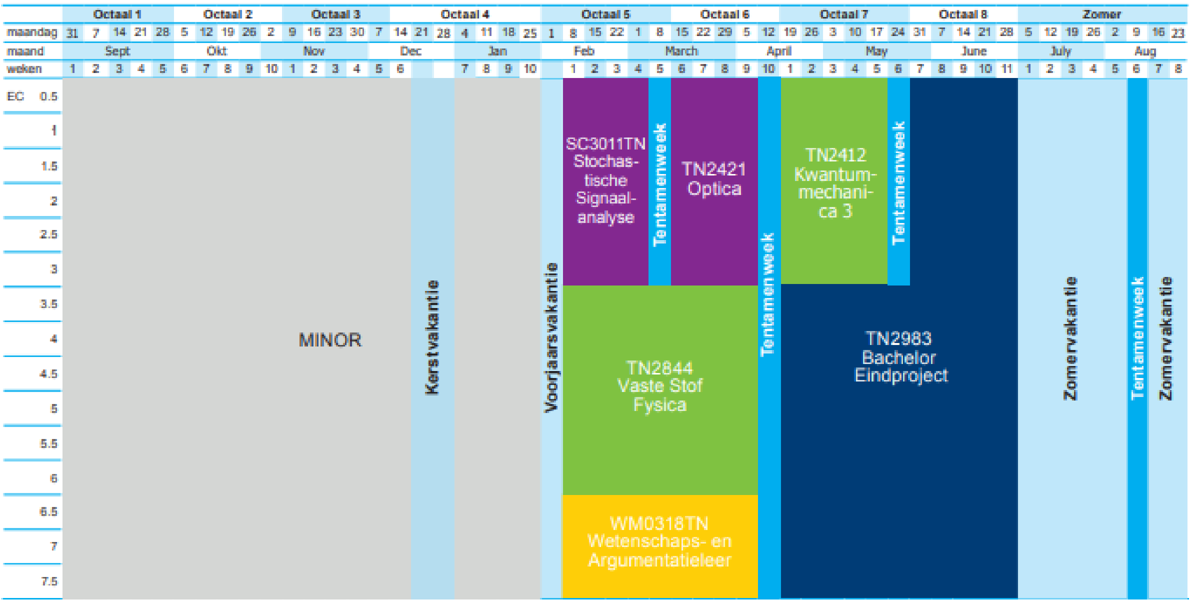

Master's programme *Applied Physics*

APPENDIX 4: PROGRAMME OF THE SITE VISIT

Dinsdag 8 juni 2021 – BSc Technische Natuurkunde

Tijd	Onderdeel
09.00u – 09.15u	Ontvangst
09.15u – 09.30u	*korte pauze*
09.30u – 10.00u	Besloten voorbespreking panel, bekijken leestafelstukken
10.00u – 10.30u	*korte pauze*
10.30u – 11.00u	Programmanagement BSc
11.00u – 11.30u	*korte pauze*
11.30u – 12.15u	Studenten BSc
12.15u – 13.15u	*Lunch*
13.15u – 14.00u	Docenten BSc
14.00u – 14.30u	*korte pauze*
14.30u – 15.00u	Examencommissie BSc
15.00u – 15.30u	*korte pauze*
15.30u – 16.15u	Vertegenwoordiging uit het werkveld
16.15u	*Einde dag 1*

Woensdag 9 juni 2021 – MSc Applied Physics

Tijd	Onderdeel
09.00u – 09.05u	Ontvangst
09.05u – 09.50u	Programmanagement MSc
09.50u – 10.15u	*Korte pauze*
10.15u – 11.00u	Studenten en alumni MSc
11.00u – 11.30u	*Korte pauze*
11.30u – 12.15u	Docenten MSc
12.15u – 13.15u	*Lunch (besloten)*
13.15u – 13.45u	Examencommissie MSc
13.45u – 14.15u	*Korte pauze*
14.15u – 14.45u	Eindgesprek management
14.45u – 15.15u	*Korte pauze*
15.15u – 16.45u	Intern overleg panel
16.45u – 17.00u	*Korte pauze*
17.00u – 17.30u	Mondelinge rapportage voorlopig oordeel publiek

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

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

During the site visit, the panel studied, among other things, the following documents:

- Zelfevaluatierapport BSc Technische Natuurkunde
- Self-evaluation report MSc Applied Physics
- Domain-specific framework of reference Applied Physics
- Education and Examination Regulations
- Overview of the curricula
- Overview of the quality assurance policies at the faculty
- Annual reports of the Board of Examiners 2017-2020
- Annual reports of the Programme Committee 2017-2020
- Educational and assessment materials and course evaluations of a selection of courses for both progammes
- Results of alumni survey 2021
- Overview of Meijer's criteria, domain-specific framework of reference and the intended learning outcomes of both programmes