APPLIED PHYSICS

FACULTY OF SCIENCE AND TECHNOLOGY

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REPORT ON THE BACHELOR'S AND MASTER'S PROGRAMME APPLIED PHYSICS OF THE UNIVERSITY OF TWENTE

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:	Enschede
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
Location:	Enschede
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 Science and Technology of the University of Twente took place on 21-22 June 2021.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

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

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has 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;
- M.S. (Mare) Dijkstra BSc., master's student Applied Physics at University of Groningen (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 Science and Technology of the University of Twente 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;
- Em. prof. G. (Guido) van Oost, Professor Emeritus Nuclear Fusion at Ghent University (referent);
- Prof. P.J. (Patrick) French, Professor Biomedical Electronics at TU Delft;
- M.S. (Mare) Dijkstra BSc., master's student Applied Physics at University of Groningen (student member). X.M. (Xander) de Wit BSc., master's student Applied Physics at Eindhoven University of Technology (student member).

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 the University of Twente, 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 visit to the University of Twente took place on 20-22 June 2021, and was combined with the site visit to the master's programme Nanotechnology at the same Faculty. 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 management, alumni and the Board of Examiners. It also offered students and staff members an opportunity for confidential discussion during a consultation hour. One request for private consultation was 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. The programme is strongly embedded within the research environment of the Faculty, and has a clear vision with regard to personal development in a safe environment. The panel considers this to be a strong point of the programme. The panel recommends improving communication on the engineering goals of the programme to students, and integrating understanding of what it means to be an applied physicist into the goals and curriculum of the programme. The goals of the programme have been well-translated into a coherent sets of intended learning outcomes that are aligned with the requirements of the academic and professional fields through the Meijer's criteria and a domain-specific framework of reference that is based on international standards. The panel applauds the attention paid to engineering skills and social context within the learning outcomes of the programme. The panel supports the plans to launch a Curriculum Committee with members that assure strong ties of the programme with the professional field.

The *bachelor's programme* has adequately translated its intended learning outcomes into a coherent curriculum. The TOM model aligns very well with the goals of the programme, and provides substantial training in academic, transferable and engineering skills, as well as creative problem-solving. The programme has made sensible adaptations of the TOM model in later modules to allow for more advanced courses. The learning lines provide structure and coherence to the programme, creating a comprehensive overview of knowledge and skills in the curriculum. The teaching methods in the programme are interactive and student-driven, and focus on personal development within a community. The panel supports the decision to offer the programme in Dutch with a gradual increase of the use of English in the curriculum, which makes it easier to create a community and safe environment for students in the first years. The curriculum is feasible although many students take longer to graduate due to extracurricular activities. The panel encourages the programme to reflect on whether sufficient alternative options are explored before students are advised to drop courses. The programme took appropriate actions during the corona pandemic to keep the programme feasible. The close community of students and teaching staff is a very strong characteristic of the programme, and results in a great deal of attention to student well-being and feedback on educational quality. This is further facilitated by the new Homebase facility. The teaching staff is qualified, and very much appreciated by students.

The programme has a valid, transparent and reliable system of assessment in place. The assessment methods are varied and fit the learning goals of the courses. The programme pays sufficient attention to individual performance in group projects. During the corona pandemic, the programme successfully made the switch to online assessment. The procedures and assessment forms for the bachelor's theses are solid, but could be more transparent. The panel recommends introducing grades for the various subcriteria and provide examiners with a rubric to help them substantiate their assessment. It also recommends tightening the procedures and requirements for changes in assessment procedures for the bachelor's assignment. The Board of Examiners fulfils its role in safeguarding the quality of assessment in the programme. The panel recommends more structural checks to determine the quality of course assessment and bachelor's assignments, and a standard training for new members.

The panel concludes that assignments of the programme are generally of a high quality, and show that the intended learning outcomes of the programme are achieved. The panel praises the programme with the high level that students attain at the end of the curriculum. Graduates of the bachelor's programme continue successfully into a master's programme. They felt that the programme provided them with sufficient skills, and are very satisfied with the education they have received.

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. The programme is strongly embedded within the research environment of the Faculty, and has a clear vision with regard to personal development in a safe environment. The panel considers this to be a strong point of the programme. The panel recommends improving communication on the engineering goals of the programme to students, and integrating understanding of what it means to be an applied physicist into the goals and curriculum of the programme. 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 fields through the Meijer's criteria and a domain-specific framework of reference that is based on international standards. The panel applauds the attention paid to engineering skills and social context within the learning outcomes of the programme. The panel supports the plans to launch a Curriculum Committee with members that assure strong ties of the programme with the professional field.

The *master's programme* offers a varied curriculum that covers all elements of the intended learning outcomes. The compulsory courses and the associated learning lines provide a common coherent core to the programme, whereas the electives, internship and master's assignment offer many opportunities for students to shape the programme to their own ambitions. The student-centred approach resembles a master-apprentice relation, and helps students develop. The programme has many opportunities for students to develop their design skills, although the attention paid to engineering in the core curriculum is rather limited. The panel recommends expanding this more explicitly in a learning line. The programme is offered in English, which the panel considers a logical choice in light of the dominance of English in the academic and professional world in which the graduates can be expected to find employment. The new curriculum seems to be feasible, although it is too early to draw conclusions. The panel advises the programme to keep monitoring whether the recent curriculum change has the desired effect, or if additional measures are necessary. The programme took appropriate actions during the corona pandemic to keep the programme feasible. The close community of students and teaching staff is a very strong characteristic of the programme, and results in a great deal of attention to student well-being and feedback on educational quality. This is further facilitated by the new Homebase facility. The teaching staff is qualified, and very much appreciated by students.

The programme has a valid, transparent and reliable system of assessment in place. The assessment methods are varied and fit the learning goals of the courses. The programme pays sufficient attention to individual performance in group projects. During the corona pandemic, the programme successfully made the switch to online assessment. The procedures and assessment forms for the master's theses are solid, but could be more transparent. The panel recommends introducing grades for the various subcriteria and provide examiners with a rubric to help them substantiate their assessment. It also recommends tightening the procedures and requirements for changes in assessment procedures for the master's assignment. The Board of Examiners fulfils its role in safeguarding the quality of assessment in the programme. The panel recommends more structural checks to determine the quality of course assessment and master's assignments, and a standard training for new members.

The panel concludes that assignments of the programme are generally of a high quality, and show that the intended learning outcomes of the programme are achieved. The panel praises the programme with the high level that students attain at the end of the curriculum. Graduates of the master's programme end up in various positions in academia and industry. They felt that the programme provided them with sufficient skills, and are very satisfied with the education they have received.

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: 11 October 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.

Findings

Profile and aims
The bachelor's and master's programmes Applied Physics are organized by the Faculty of Science and Technology (TNW) at the University of Twente (UT). The programmes aim to educate academic professionals who can come up with creative solutions for interdisciplinary problems, building on disciplinary knowledge, skills and attitude in the domain of applied physics. The Applied Physics programmes aim for their students to be independent, creative, good at problem solving, authentic, reflective and critical. The programmes strive for a strong sense of community among students, teachers and staff. By assuring an atmosphere of mutual trust, the programmes aim to provide a solid foundation for personal development in a stimulating and safe environment.

The *bachelor's programme* aims to provide students with a solid basis to continue in a technical programme at master's level, starting with basic knowledge and skills towards complex problem solving. The *master's programme* builds upon this basis so students can develop and apply original new ideas, contributing to science, industry and society. The programme does not consist of separate tracks but offers students dedicated study programmes including ample room to pursue personal ambitions. Specialization courses are offered primarily in the fields of Materials, Optics and Fluid & Soft Matter, the research areas of the groups associated with the master's programme.

The panel studied the profile and aims of the bachelor's and master's programme Applied Physics, and concludes that they are fitting for an academic Applied Physics programme. The programmes are strongly embedded within the research environment of the Faculty. In particular the master's programme courses are closely correlated with the research interests of the Faculty, providing students with state-of-the-art experience in applied physics research. The programmes have a clear vision related to a safe environment where students can develop themselves as independent and creative problem solvers. In the interviews throughout the site visit, the panel clearly felt the strong sense of community that was reported by the programmes in the documents. The panel praises the programmes for this.

During the site visit, the panel discussed with several representatives of the programmes to what extent the Applied Physics programme can be considered an engineering programme. According to the programme management, the engineering characteristic is mostly visible in the problem solving and design skills integrated into the curriculum. In particular the TOM (Twente Educational Model) projects in the bachelor's programme (see Standard 2) require students to develop their engineering skills. At the same time, not all students that the panel interviewed identified themselves as an engineer or recognized the engineering character of the programmes as opposed to a general physics bachelor's or master's programme. The panel therefore recommends to better communicate the profile of the programmes to students, and integrate understanding of what it means to be an applied physicist into the goals of the programme, as well as into the curriculum.

Intended learning outcomes
The bachelor's and master's programme have translated their goals into fifteen intended learning outcomes (ILOs), divided into five sets labelled Knowledge, Skills, Personal Development, Communication and Organisation. These ILOs describe the knowledge, skills and competences that are required of a bachelor's or master's student in Applied

Physics. The ILOs for both programmes have a similar structure and content, and differentiate in the level required of the student. Both sets of ILOs are included in Appendix 1.

To align the ILOs of 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 Meijers criteria) was developed by the Dutch technical universities (4TU) as a translation of the Dublin descriptors for higher education in engineering. The programmes provided the panel with a matrix detailing the relation between the ILOs and the DSRK.

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 Meijers criteria in designing the ILOs guarantees that they meet the respective bachelor's and master's level and academic orientation, as well as comply 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 engineering character of the programmes is clearly included in the skills required of the graduates. Furthermore, the ILOs explicitly mention social context, including attention to inclusivity issues, the international orientation of the field, integrity, ethical norms and taking responsibility for one's own performance. The panel considers these aspects to be strong points.

To further align the goals and aims of the programmes with the professional field, the programmes are in the process of composing a Curriculum Board with ties with industry. This Board will be asked to provide the programme management with input on the goals, aims and content of the programme in order to keep these connected to the demands and opportunities of the professional field. The panel supports this initiative, and encourages the programmes to realize these plans.

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 programmes are strongly embedded within the research environment of the Faculty, and have a clear vision with regard to personal development in a safe environment. The panel considers this to be a strong point of the programmes. The panel recommends improving communication on the engineering goals of the programmes to students, and integrating understanding of what it means to be an applied physicist into the goals and curriculum of the programme. 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 fields through the Meijer's criteria and a domain-specific framework of reference that is based on international standards. The panel applauds the attention paid to engineering skills and social context within the learning outcomes of both programmes. The panel supports the plans to launch a Curriculum Committee with members that assure strong ties of the programmes with the professional field.

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.

Findings

Bachelor's programme: curriculum and teaching methods
The curriculum of the bachelor's programme Applied Physics (see Appendix 3) is structured using the principles of the Twente Educational Model (TOM). This model is characterized by the integration of courses in thematic 10-week modules of 15 EC each. Modules are designed alongside overarching themes such as Dynamics and Relativity, Thermodynamics, and Quantum & Geometrical Optics. Within each theme, multiple theoretical, mathematical and lab courses are integrated in a coherent unit, alongside a capstone project. This group project presents students with a specific, open-ended challenge that requires skills and knowledge from each of the courses, supplemented by independently gained knowledge and skills by the students. With TOM, the university aims to teach students to study themes in an integrative manner, and discover the roles of researcher, designer and organizer by practicing these in project groups.

The TOM model is most prominently visible in year 1 and the start of year 2 of the curriculum. Later modules in year 2 have a different set-up. Instead of courses and a capstone project, they consist of a physics course, a mathematics course and an integrative applied physics course combining both aspects. The programme has chosen this to invest in skills training at the start, and focus more on knowledge and theory later in the curriculum. The introductory level of most courses in year 1 makes them more suited to a project-based approach than the more advanced courses in year 2. In year 3, students choose a 30 EC minor programme aimed at broadening students' perspectives. This can be one of the many minor programmes offered by the UT, teacher training, studying abroad or following a bridging programme for a master's programme. The second half of year 3 is devoted to the bachelor's assignment (15 EC + 5 EC preparatory course) and applied physics electives (10 EC). The bachelor's assignment is an individual research or design project conducted in one of the research groups associated with the programme, supervised by a staff member. During the preparatory course, students do a literature study and write a research proposal.

The design of the curriculum in relation to the intended learning outcomes is based on constructive alignment where the realization of the ILOs is the basic design principle of the curriculum and courses. The programme has listed how each module contributes to the attainment of the learning outcomes, and which teaching methods are used in doing this. In a more detailed overview, the programme has formulated twelve learning lines related to knowledge (mathematics, dynamics, thermodynamics, quantum mechanics & materials physics and electromagnetism & optics) and skills (experimental skills, programming skills and project skills, journaling and reporting, problem solving, history and foundations of physics, and job orientation). These learning lines are used in the design of the modules and curriculum to safeguard that all elements are covered sufficiently throughout the courses.

The panel studied the structure and content of the curriculum as well as the content of a selection of modules and courses within the programme, and spoke to the programme management, teaching staff and students. It concludes that the programme's intended learning outcomes are well incorporated into the curriculum in a good balance of mandatory courses, track-related electives, and free electives. The learning lines provide a clear overview of the knowledge and skills trained throughout the curriculum. The TOM model aligns very well with the goals of the programme, and allows students to develop creative problem-solving skills in open-ended challenges. In particular the first half of the curriculum offers substantial skills training through project work, including academic, transferable and design skills. In year 2 this is less prominent, but the panel learned during the site visit that skills are refreshed in the preparatory course for the bachelor's assignment. The panel understands the reasons of the programme not to implement the TOM model with capstone projects in every module of the curriculum. Applied Physics has a relatively large amount of theoretical and mathematics courses compared to other engineering programmes, which

for the more advanced courses requires a different approach. The panel is satisfied with the variety of teaching methods used throughout the courses. The programme focuses on interactive, student-driven teaching methods such as flip-the-classroom and peer learning, encouraging student participation and initiative. The students reported to the panel that they were very satisfied with the interaction between teachers and students, and among students within the courses and projects.

Master's programme: curriculum and teaching methods

The master's programme Applied Physics provides students with the opportunity to deepen their knowledge and competences in a tailor-made programme. The curriculum (see Appendix 3) has 20 EC of compulsory courses in year 1 (Applied Quantum Mechanics, Mathematical and Numerical Physics, Heat & Mass Transfer, Small Signals & Detection and Ethics and Cultural Awareness), covering the core and level of the programme. In addition, students choose 20 EC of specialization electives linked to their research interests, and 20 EC of free electives. The second year is devoted to an internship (20 EC) in either research, engineering or industry, and the master's assignment (40 EC), an individual research or design project in one of the Applied Physics research groups. Up to 2018, the programme consisted of three separate tracks in Material Physics, Optics & Biophysics and Physics of Fluids, the main research areas studied within the Applied Physics group at the Faculty. The programme decided to drop this set-up in favour of a more coherent curriculum with core elements, and a more flexible choice of research topics for students. The specialization courses are still grouped in categories related to the original three tracks, but instead of choosing a full programme, students compose their own coherent curriculum in close consultation with the study adviser and a researcher whose field of expertise is related to the student's research interests. As in the bachelor's programme, the design of the master's curriculum in relation to the intended learning outcomes is based on constructive alignment. The programme has listed how the compulsory elements of the curriculum (compulsory courses, internship and master's assignment) contribute to the attainment of the learning outcomes. The learning outcomes function as learning lines in the curriculum, and show that all students are sufficiently trained in all interned learning outcomes, regardless their choice of electives.

The panel studied the curriculum of the master's programme and concludes that the programme successfully translated the ILOs into a coherent and varied curriculum with lots of room for individual customization and specialization. The compulsory courses and the associated learning lines provide a common coherent core to the programme, whereas the electives, internship and master's assignment offer many opportunities for students to shape the programme to their own ambitions. Integrity and inclusiveness is covered in the course 'Ethical and cultural awareness', which the panel considers to be a valuable addition to the curriculum. As the panel understood from the interviews, the programme thinks in possibilities rather than limitations, which is very much appreciated by students. The small-scale and interactive nature of the master's programme results in a teaching environment resembling a master-apprentice relationship, where students have frequent interaction with researchers, who help them grow with regard to research and personal skills. Courses are typically very interactive with a lot of room for student input. The panel appreciates this student-centred approach in the curriculum as well as the teaching methods.

The panel is very positive on the possibilities for students that want to develop themselves as an engineer. They can follow engineering electives, pursue an internship in an engineering group or in industry, and do a design project for their master's assignment. At the same time, students that are less interested in engineering can choose a curriculum with little training in designing skills. Although the core course Small Signals & Detection covers the minimum requirements of the associated learning outcomes, the panel thinks that attention to engineering and design skills in the learning line could be strengthened. Providing creative solutions to interdisciplinary problems is a main goal of both the bachelor's and master's programme, a goal that is very well addressed by an engineering approach. The panel advises the programme to increase attention to this aspect in a more explicit learning line in the core curriculum.

Language and internationalization

The *bachelor's programme* is offered in Dutch. It is one of the few programmes at the University of Twente that has not made the switch to English. This is an explicit choice of the programme management. Following discussion with students and teaching staff, the programme management concluded that enabling students to communicate in their mother tongue is highly beneficial for their understanding and performance in the early years of the programme, both with regard to the courses as to community forming and personal development. A considerable fraction of the students have low proficiency in English at the start of the programme. In practice, the programme develops into a hybrid Dutch-English programme later in the curriculum. The use of English is gradually introduced, starting with English language study materials, and continuing to an increasing amount of English-taught courses, often by international staff members, in the second and third year 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 assignment 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 decision of the programme management to offer the bachelor's programme in Dutch, with a gradual increase of the use of English in the curriculum. It thinks that this fits the personalized and student-centred approach of the programme. From the bachelor's assignments, the panel concluded that bachelor's students generally have sufficient command of English at the end of their studies to be able to enter an English-language master's 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 where graduates of the programme can be expected to work. As the staff in the Faculty is very international, the use of English means that the curriculum can be closely aligned with the research groups of the Faculty. Due to the 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 optional courses to improve language proficiency of all staff. The panel considers the choice for the use of English to be well motivated. The programme is closely related to the research and staff of the Applied Physics groups, which are fully embedded in an international environment. An English language programme prepares students for an internationally oriented field. Students are positive on the quality of the education in English, and there is sufficient attention to the language skills of the teaching staff.

The panel notes, however, that the current intake of international students is very small in the master's programme (approximately 2-5 out of 45-50 students annually). The panel thinks that an international classroom could be a valuable addition to the programme with regard to its learning outcomes related to the international orientation of the discipline. It recommends the programme investigating whether there are more opportunities to recruit international students.

Feasibility

In the *bachelor's programme*, approximately 30% of the students graduate nominally in three years, and 60% in four years. These numbers are comparable with other physics programmes in the Netherlands. According to the programme, delays are often caused by extracurricular activities. This was confirmed by the students, who also mentioned that the programme supports and facilitates students in undertaking extracurricular activities, even if this leads to study delays. The panel fully understands the reasons of the programme to facilitate this to enable the pursuit of personal ambitions and extracurricular competence development'. Yet it also wonders whether dropping courses is not too often used as the default option when students are starting to feel overwhelmed. The panel encourages the programme management to reflect on this, and to make sure that other options, such as helping students to make choices, are sufficiently explored. Other causes for delay mentioned in the bachelor's programme were the TOM system and the duration of the bachelor's assignment. In the previous iteration of TOM, entire 15 EC modules were either pass or fail, which could cause considerable delay when students had to redo an entire module. The new version of TOM allows resits for individual parts of modules to remedy this. The panel supports this change. The programme management has started encouraging the students and supervisors to keep the duration of the bachelor's assignment limited to at most 10 weeks, which is effective in that most students now complete their

project in time. The corona pandemic had some effect on the feasibility of the bachelor's programme, in particular for students who were conducting experiments as part of their bachelor's assignment. For all students, an appropriate solution could be found. The other courses could be transformed into online courses. For the experimental work in the bachelor's programme, the programme redesigned experiments so they could be controlled remotely or performed at home using common household items.

For the master's programme, 15-20% of the students graduate nominally, and 60-70% in three years. Students and staff mentioned to the panel that these delays are mostly related to the pre-2018 curriculum which had some scheduling issues. The programme hopes to see the new curriculum's first effects on feasibility in the near future. Furthermore, the corona pandemic caused delays for many students due to the inaccessibility of laboratories or difficulties with internships abroad. The programme was able to address some of these by offering alternatives and giving students priority access to labs when corona restrictions were loosened, but delays could not fully be prevented. The panel encourages the programme to keep investing in the feasibility of the master's programme, and to also make sure that the internship and master's assignment do not take longer than scheduled for students. Furthermore, the panel understood from students during the site visit that there are scheduling issues associated with the KiesOpMaat (KOM) pre-master's programme for *hbo*-students. It recommends the programme investigating this, and to make sure that this pre-master is feasible and coherent for all students.

Student support

Both programmes heavily invest in student support and in forming a close community of students. Students, staff and management all indicated in the interviews that they consider this a very strong aspect of the Applied Physics programmes in Twente. There is frequent personal contact between students and staff, and students find support with fellow students, study association Arago, and staff members when they struggle with their studies or well-being. The study advisors do not only provide counselling, but also curriculum advice and skills training. The close community also translates into the quality culture within the programmes: students can easily provide feedback and actively cooperate with teaching staff to improve the quality of the courses. For formal feedback, the programmes have an education quality committee, in which bachelor's and master's students provide the programme director with student feedback on the courses.

The panel praises the sense of community in the programmes and the positive effects this has on their quality as well as on the well-being of students. The study advisors have a very broad supportive and advisory role compared to other programmes, and can help students on all levels during their studies. The panel did learn during the interviews that in the master's programme, in contrast to the bachelor's programme, support is usually provided on request rather than through a counselling programme for all students. The master's programme could consider setting this up. The panel noted from discussions during the site visit that there are several students in the programme with special needs, such as autism or dyslexia. The panel is positive on the attention paid to this in student support. It also recommends paying attention to this in terms of visibility of the support possibilities and in teacher professionalization, so that the needs of this group have the attention of teaching staff during the courses. Considering the importance of the programmes' community, both the programmes and students feel that the lack of face-to-face interaction during the corona pandemic affected education negatively. All groups were looking forward to a return to normal with on-campus education.

For talented students, both programmes provide additional opportunities. The bachelor's programme offers double diploma curricula of 220 EC with the bachelor's programmes Applied Mathematics. The master's programme offers double diploma trajectories upon request. Furthermore, excellent students from both programmes can participate in a programme-specific plus programme where they take additional courses into other research fields, such as Nanotechnology, Biophysics or Computer Science, or in a university-wide honours programme. The panel judges that both programmes offer sufficient opportunities for talented students.

With regard to professional orientation, the programmes offer multiple job orientation events in cooperation with study association Arago, such as excursions to companies in the region. In the curriculum, the bachelor assignment preparatory course explicitly focuses on job orientation. This includes presentations from alumni and an optional career test for students. The programmes currently explore how they can better present options for bachelor's and master's assignments in industry. Based on the documents studied and the discussions during the site visits, the panel is positive on the attention paid to professional orientation in both programmes.

During the site visit, the panel discussed the relatively low intake of female students and teaching staff members in the programmes. According to the panel, the programmes are aware of the situation, but could pursue a more proactive strategy to try to attract more female students to the programme. It recommends reflecting on this.

Teaching staff

The programmes are taught by the scientific staff of the Applied Physics research groups within the Faculty. Almost all lecturers have a PhD and are active researchers. They are often supported by PhD students that function as tutors and as daily supervisor for bachelor's and master's assignments. Senior students are often employed as teaching assistants under supervision of tenured staff, primarily for lab courses, tutorials and projects in the bachelor's programme. The programmes consider teaching assistants to be a crucial aspect of education, both for the quality of education and for the personal development of the teaching assistants themselves, and therefore encourage senior students to consider these positions. The involvement of students in courses further adds to the strong community within the programme. With regard to professionalization of teachers, the programmes require all new teaching staff to have obtained or follow the UTQ course. Current staff members have either followed or are following the UTQ course, or received an exemption based on a dossier proving acquired teaching competences. At the moment, 75% of the teaching staff has obtained an UTQ or is in the process of obtaining it, and 15% has an exemption based on previous education.

The documents and in particular the interviews with students and teaching staff gave the panel a very positive impression of the teaching staff of both programmes. Students praise the expertise, didactic qualities, accessibility and coaching skills of their teachers. They are very involved in the programme, and participate in social events organized by student association Arago. The teaching staff appreciates working within the programme. The workload associated with the personal approach advocated by the programme can be high, especially in the past year with the extraordinary circumstances of remote education, but is not felt to be problematic. The programmes aim to relieve some of this teaching workload by defining several staff positions with a greater emphasis on teaching. The panel is assured that the issue of workload has the attention of the programme management, and it encourages the management to keep this on the agenda. The programme pays sufficient attention towards professionalization of the staff. The panel understood with appreciation from the interviews that the UTQ trajectory allows for a personalized programme that takes into account the personal development goals of the teacher. With regard to gender balance, the panel encourages the programme to involve female staff in education as much as possible to improve diversity and provide (prospective) female students with potential role models.

Facilities

The programmes use lab facilities and a self-service workshop for practical work, as well as the new Homebase area that houses a communal study area, project rooms and the study associations of the programmes Applied Physics, Chemical Science & Engineering and Advanced Technology. Bachelor's and master's assignments are conducted within the research groups. The panel had the opportunity to visit the student lab facilities as well as the Homebase, and praises the programme-specific facilities of both programmes. The Homebase is an excellent new facility designed for and with students, which is very much appreciated by students.

Considerations

The *bachelor's programme* has adequately translated its intended learning outcomes into a coherent curriculum. The TOM model aligns very well with the goals of the programme, and provides substantial training in academic,

transferable and engineering skills, as well as creative problem-solving. The programme has made sensible adaptations of the TOM model in later modules to allow for more advanced courses. The learning lines provide structure and coherence to the programme, creating a comprehensive overview of knowledge and skills in the curriculum. The teaching methods in the programme are interactive and student-driven, and focus on personal development within a community. The panel supports the decision to offer the programme in Dutch with a gradual increase of the use of English in the curriculum, which makes it easier to create a community and safe environment for students in the first years. The curriculum is feasible although many students take longer to graduate due to extracurricular activities. The panel encourages the programme to reflect on whether sufficient alternative options are explored before students are advised to drop courses. The programme took appropriate actions during the corona pandemic to keep the programme feasible. The close community of students and teaching staff is a very strong characteristic of the programme, and results in a great deal of attention to student well-being and feedback on educational quality. This is further facilitated by the new Homebase facility. The teaching staff is qualified, and very much appreciated by students.

The *master's programme* offers a varied curriculum that covers all elements of the intended learning outcomes. The compulsory courses and the associated learning lines provide a common coherent core to the programme, whereas the electives, internship and master's assignment offer many opportunities for students to shape the programme to their own ambitions. The student-centred approach resembles a master-apprentice relation, and helps students develop. The programme has many opportunities for students to develop their design skills, although the attention paid to engineering in the core curriculum is rather limited. The panel recommends expanding this more explicitly in a learning line. The programme is offered in English, which the panel considers a logical choice in light of the dominance of English in the academic and professional world in which the graduates can be expected to find employment. The new curriculum seems to be feasible, although it is too early to draw conclusions. The panel advises the programme to keep monitoring whether the recent curriculum change has the desired effect, or if additional measures are necessary. The programme took appropriate actions during the corona pandemic to keep the programme feasible. The close community of students and teaching staff is a very strong characteristic of the programme, and results in a great deal of attention to student well-being and feedback on educational quality. This is further facilitated by the new Homebase facility. The teaching staff is qualified, and very much appreciated by students.

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.

Findings

Assessment system
The programmes have defined an assessment system that aims to assure that assessments are transparent, valid and reliable. The design of assessment in courses is based on constructive alignment, where the intended learning outcomes are the basic design principle for the course and its assessment. The TOM modules in the bachelor's programme are considered as a single assessment unit. The module team, consisting of the teaching staff involved in the associated courses, designs the assessment of the module. The programmes aim for a balanced mix of assessment methods. Theoretical courses are often assessed with written exams, and practical courses and projects with reports, presentations, videos or demonstrations. From March to September 2020, all assessments were conducted remotely. Written exams were adapted into either open book exams or online oral exams, and presentations and demonstrations were held online.

Due to the small-scale nature of most master's courses, the assessment methods are often interactive, such as presentations, assignments and projects. The internship is assessed on performance during the project and a report. The academic supervisor functions as examiner, and the external supervisor provides input for the assessment. Both programmes pay extra attention to teamwork, which the programmes deem to be an important engineering skill. Teamwork is explicitly pursued in the projects of the TOM modules in the bachelor's programme, and in the lab courses and group presentations and projects in the master's programme. The programmes take care to include individual components in the assessment of group work, such as peer assessment, self-assessment, or individual assignments, which the panel considers an adequate response to the recommendations of the previous accreditation committee.

The panel is positive on the system of assessment in both programmes. The assessment methods fit the learning goals of the courses and are sufficiently varied. The students that the panel interviewed were satisfied with the assessment within the programmes, both in the regular curriculum and during the online assessments in 2020.

Assessment of bachelor's and master's assignments

The bachelor's and master's assignments are assessed by a graduation committee that looks at student performance, a report, and an oral presentation and defence. For the bachelor's assignment, the graduation committee consists of the responsible supervisor, who is a tenured or tenure track scientific staff member, and an external member from another group. The daily supervisor can be added as a third member. The master's assignment is assessed by a graduation committee consisting of at least three members: the chair of the group where the assignment was carried out, an external member (full professor) from another group and a third member of choice. Students receive two grades: one for general aspects of their work and one for physics aspects. If both grades are a 6 or higher, the student can graduate. The graduation committee jointly completes an assessment form on which it substantiates the grade on various criteria, as well as feedback to the students. The panel considers the assessment procedures to be well designed. The consistent use of an external member from another research group adds to the validity of the assessment. It also noted that the bachelor's programme changed from a duo project to an individual project based on the recommendations of the previous accreditation committee.

As part of its preparation of the site visits, the panel studied 15 bachelor's and 15 master's assignment projects with the accompanying assessment forms. It concludes that the form has useful subcriteria to evaluate the thesis, and assessors usually provide sufficient feedback. The panel noted, however, that the subcriteria are only assessed qualitatively and are not graded. When discussed during the site visit, the programme management and Board of Examiners explained that they don't want the assessors to feel restricted in how they weigh the various criteria. They felt that using subgrades and rubrics would reduce the spontaneity of the assessment. The panel understands the wish for a qualitative assessment, but also notes that the current grading system becomes less transparent with this approach. It thinks that a good rubric is not restrictive but can help assessors express their qualitative assessment in a grade. As such, it is the final step in a qualitative process aimed at making the justification for the final grade more transparent. It therefore recommends introducing subgrades and rubrics into the assessment procedures of the bachelor's and master's assignments to make these more transparent.

One of the bachelor's assignments that the panel studied consisted of a short article rather than a report. The programme management explained that supervisors sometimes allow students to write a journal article rather than a report as assignment. In this case, the research project turned out to be less suited for a publication than expected, but the supervisor felt that it was too late to request the student to write a report instead. The panel concludes that in this case, the departure from regular assessment procedures was made on a too informal basis. It recommends the programme management and Board of Examiners to tighten procedures and requirements for changes in assessment procedures to prevent similar cases in the future.

Board of Examiners
The programmes have a shared Board of Examiners, specific for the Applied Physics programmes. It consists of a chair, secretary, three internal and one external staff members. The Board monitors the quality of assessment in the programme through investigation of exams and theses when there are anomalies in grading, or in case of negative student feedback. After recommendations of the previous accreditation committee, the Board has taken on a more proactive role by putting issues on the agenda, for instance by setting up an assessment procedure for group work, as well as checking course and module assessment plans and the quality assurance of online exams during the corona pandemic.

Based on the documents as well as the interview with the Board of Examiners for Applied Physics, the panel concludes that the Board of Examiners fulfils its role by safeguarding the quality of assessment in the programmes. The panel recognizes that the Board has taken up a more proactive role in recent years. Whereas this is clearly visible with regard to the assessment policies, the panel thinks that the quality assurance of assessment is still rather reactive. It recommends introducing a more structural approach with regular a posteriori checks of course assessment and quality of the bachelor's and master's assignment, rather than only responding to emerging issues and outliers. Furthermore, the panel noted from the interviews that there is no standard training for new members; it recommends the Board of Examiners to provide this.

Considerations
Both programmes have a valid, transparent and reliable system of assessment in place. The assessment methods are varied and fit the learning goals of the courses. The programmes pay sufficient attention to individual performance in group projects. During the corona pandemic, the programmes successfully made the switch to online assessment. The procedures and assessment forms for the bachelor's and master's theses are solid, but could be more transparent. The panel recommends introducing grades for the various subcriteria and provide examiners with a rubric to help them substantiate their assessment. It also recommends tightening the procedures and requirements for changes in assessment procedures for the bachelor's and master's assignment. The Board of Examiners fulfils its role in safeguarding the quality of assessment in the programmes. The panel recommends more structural checks to determine the quality of course assessment and bachelor's and master's assignments, and a standard training for new members.

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

Bachelor's and master's assignment quality
Prior to the site visit, the panel studied 15 bachelor's and 15 master's assignments Applied Physics. For the master's programme, the former three tracks were evenly covered in the selection. The panel concludes that the assignments are generally of high quality and show that the students in both programmes realize the learning outcomes of the programme. The high quality is reflected in the high scores: approximately 78% of the bachelor's students and 73% of the master's students receive an 8.0 or higher for their assignment. The panel considers these high scores to be generally justified, and praises both programmes with the high level of their graduates.

Alumni

Alumni of the bachelor's programme generally continue with a master's programme. Roughly 70% enrol in the master's programme Applied Physics at the UT, 10-25% in another master's programme at the UT and 5-20% leave the UT, mostly to pursue a master's programme elsewhere. Of the alumni of the master's programme, 45% pursue a PhD and 49% start working in industry, with the remaining 6% unknown. A recent alumni survey shows that alumni of both programmes have a very high appreciation of the education they received. 100% of the respondents was satisfied with the programme in general, and the large majority felt that the programme provided them with sufficient academic (97%) and general (88%) skills. The panel concludes that the programmes prepare students well for a future career. It praises the programmes with the high satisfaction of their alumni, and sees this as a further proof that the programmes deliver on their goals.

Considerations

The panel concludes that assignments of both programmes are generally of a high quality, and show that the intended learning outcomes of both programmes are achieved. The panel praises the programmes with the high level that students attain at the end of the curriculum. Graduates of the bachelor's programme continue successfully into a master's programme, and graduates of the master's programme end up in various positions in academia and industry. They felt that the programme provided them with sufficient skills, and are very satisfied with the education they have received.

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	Master	DSFR
Knowledge – The Applied Physics graduate:		
has comprehensive technical and scientific knowledge of the relevant fields in (applied) physics in combination with relevant mathematics and computer science	has thorough technical and scientific knowledge of essential theories in the domain of (applied) physics and mathematics, and can relate to other disciplines in a multidisciplinary environment	1
has an overview of the various specialisations in the domain of (applied) physics, and their relevance in industry and academia	has advanced knowledge and understanding and the ability to apply this knowledge to design and research within one or more sub-areas of the (applied) physics domain	1
Skills – The Applied Physics graduate:		
can apply basic mathematical, experimental and computational tools and methods to solve problems in physics	can apply advanced mathematical, experimental and computational tools and methods to solve complex physical problems in a broad context	2
is familiar with scientific research methods within the physics domain and can identify basic physics problems in a limited context	can apply the scientific research method and identify advanced physics problems in their full context	3
can contribute to the solution of research or design problems in the field of engineering physics using a systematic approach	can identify, formulate and solve research or design problems in the field of (engineering) physics using a systematic approach.	4
is aware of the scientific design method and can use physics to contribute to innovative solutions and verify their validity	can apply the scientific design method, divide a design problem into different sub-problems, and can apply physics expertise to realise complex innovative solutions	5,6
Personal development – The Applied Physics graduate:		
is critical, self-thinking, and able to reflect on their own performance and personal responsibilities		7
is aware of the role of applied physics in science and society, and of the international orientation of the discipline		7
is aware of the possibilities on the labour market or to continue studying with an academic master's after completing the bachelor's programme	has experience with the possibilities on the labour market and in academia after completing the master's programme	7
can decide based on integrity and take responsibility for their own performance	can decide based on integrity and ethical norms in research and industrial environments and take responsibility in a local, national and international setting	8
can select, process and evaluate information from different sources		9
Communication – The Applied Physics graduate:		
can effectively communicate on technical-scientific topics orally and in writing in a professional manner	can effectively communicate with a variety of audiences to inform, influence and discuss using various techniques and language appropriate for the audience	9
Organisation – The Applied Physics graduate:		
can organise and complete a simple project individually or as part of a team by collaborating, taking initiative and being sensitive to inclusivity issues	can organise, contribute to and complete a complex project, either individually or as part of a team by collaborating, taking the lead and being sensitive to inclusivity issues	10
has the attitude to learn and is able to maintain, improve and integrate new knowledge and academic skills into existing competences		11
can identify relevant competences for further development after completing the academic programme, and can link strengths and weaknesses to personal and professional development goals (life long learning)		11

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Bachelor's programme *Applied Physics*

APPLIED PHYSICS				
Year 1	Dynamics and Relativity	Thermodynamics	Electromagnetism and Measurements	Quantum and Geometrical Optics
	5.0 Dynamics and Relativity 4.0 Calculus 1 1.5 Laboratory practice 1 2.0 Progr. and data anal. 1 2.5 Project	4.0 Thermodynamics 4.0 Calculus 2 2.0 Laboratory practice 2 1.0 Progr. and data anal. 2 4.0 Project	5.0 Electromagnetism 2.0 Vector Calculus 4.0 Instrumentation 1.0 Analytical Programming 3.0 Project	5.0 Quantum Matter 3.0 Linear Algebra 2.5 Geometrical Optics 4.5 Engineering Systems
Year 2	Signals, Models and Systems	Waves, Interferences and Probability	Condensed Matter Physics	Continuum Dynamics
	4.0 Signals 4.0 Models 3.0 Project 4.0 Elective (1 of 2): Classical Mechanics Engineering Solid Mech.	6.0 Quantum Mechanics 7.0 Optics 2.0 Hilbert Space	6.0 Statistical Physics 7.0 Intro Solid State Physics 2.0 Partial Differentials Eqs.	6.0 Electrodynamics 7.0 Physics of Fluids 2.0 Num. methods PDEs
Year 3	Minor		Orientation	Bachelor assignment
	Many possibilities (2 x 15 = 30 EC): High Tech Human Touch (HTHT) minors Regular UT minors[3] Teacher training ('leren lesgeven'), crossing borders Study abroad Study at another educational institution Transfer minor (transfer to another master degree progr.)		5.0 Preparation Bach. Assign. Electives (10 EC): Computational Physics Machine Learning Materials Science Remote Control Exper. Soft Matter Physics Technical Optics	Project (15 EC) General Aspects (50%) Physical Aspects (50%)

Master's programme *Applied Physics*

APPLIED PHYSICS				
Year 1	Quarter 1	Quarter 2	Quarter 3	Quarter 4
	5.0 Applied Quantum Mech. 10.0 Specialisation/Elective	5.0 Math. & Num. Physics 10.0 Specialisation/Elective	5.0 Heat and Mass Transfer 10.0 Specialisation/Elective	4.0 Small Signals & Detect. 1.0 Eth. & Cult. Awareness 10.0 Specialisation/Elective
Year 2	Internship		Master assignment	
	20.0 Internship - Research or corporate - Netherlands or Abroad Optional: 30 EC (using 10EC electives)		40.0 Final assignment - in one of the Applied Physics research groups - optionally also externally (company, research inst.), but under supervision	

APPENDIX 4: PROGRAMME OF THE SITE VISIT

B Technische Natuurkunde (TN)
M Applied Physics (AP)
M Nanotechnolgy (Nano)

SUNDAY 20 JUNE

16.00	17.30	Preliminary Discussion
17.30	18.15	**Interview Programme Management Nano**
18.30	19.00	Consultation hour

MONDAY 21 JUNE

8.30	9.00	Arrival & Welcome
9.00	9.45	**Interview Student & Alumni Panel Nano**
10.00	10.45	**Interview Teacher Panel Nano**
11.00	11.30	**Interview Board of Examiners Nano**
11.30	12.00	**Tour Nanolab**
12.00	13.15	Internal panel consultation (incl. lunch)
13:15	13.45	**Interview with Faculty Board and Programme Management Nano**
13.45	15:00	Panel Preliminary Findings Nano
15.00	15.30	**Oral report & Wrap up Nano**
16.15	17.00	**Interview Programme Management TN/AP**
17.15	17.45	**Interview Alumni Panel AP**

TUESDAY 22 JUNE

8.30	9.15	**Interview Bachelor Panel TN**
9.30	10.15	**Interview Master Panel AP**
10.30	11.15	**Interview Teacher Panel TN/AP**
11.30	12.00	**Interview Board of Examiners TN/AP**
12.00	12.30	**Tour Homebase**
12.30	13.30	Lunch
13.30	14.00	**Interview Programme Committee TN/AP**
14.00	14.30	Internal panel discussion
14.30	15.00	**Interview Faculty Board + Director of Education TN/AP**
15.00	16.30	Panel preliminary findings TN/AP
16.30	17.00	**Oral report & wrap up**

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 15 bachelor's assignments of the bachelor's programme Applied Physics and 15 master's assignments 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:

- Self-evaluation report 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
- Document Adaptation to the Covid-19 crisis
- Annual reports and minutes of the Board of Examiners 2018-2020
- Annual reports of the Programme Committee 2018-2020
- Educational and assessment materials and course evaluations of a selection of courses for both programmes
- Examples of assessment plans
- Summary alumni survey 2020
- Overview contacts with the professional field
- Overview of Meijer's criteria, domain-specific framework of reference and the intended learning outcomes of both programmes