APPLIED PHYSICS

DEPARTMENT OF APPLIED PHYSICS

EINDHOVEN UNIVERSITY OF TECHNOLOGY

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REPORT ON THE BACHELOR'S AND MASTER'S PROGRAMME APPLIED PHYSICS AND THE MASTER'S PROGRAMME SCIENCE AND TECHNOLOGY OF NUCELAR FUSION OF EINDHOVEN 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 Applied Physics

Name of the programme:	Applied Physics
CROHO number:	56962
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Location:	Eindhoven
Mode of study:	full-time
Minor in Education	applicable
Language of instruction:	English
Submission deadline NVAO:	01-11-2021

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:	Fluids, Bio and Soft Matter (FBSM) Nano, Quantum and Photonics (NQP) Plasmas and Beams (PB)
Location:	Eindhoven
Mode of study:	full-time
Educational profile:	applicable
Language of instruction:	English
Submission deadline NVAO:	01-11-2021

Master's programme Science and Technology of Nuclear Fusion

Name of the programme:	Science and Technology of Nuclear Fusion
CROHO number:	66904
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Location:	Eindhoven
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 Department of Applied Physics of Eindhoven University of Technology took place on 16-17 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:	Eindhoven 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 & Advies (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 student Applied Physics at University of Groningen (student member).
- Em. prof. G. (Guido) van Oost, Professor Emeritus Nuclear Fusion at Ghent University (referent Nuclear Fusion);

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 Department of Applied Physics of Eindhoven 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 Department. Prior to the site visit, the Department selected representative partners for the various interviews. See Appendix 4 for the final schedule.

Before the site visit to Eindhoven 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 them amongst all panel members. The referent Nuclear Fusion provided the panel with feedback and questions for the *inpassingsbeoordeling* of the master's programme Science and Technology of Nuclear Fusion.

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 Eindhoven University of Technology took place on 16-17 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 Examination Committee. 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 Department 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 Department 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 APPLIED PHYSICS PROGRAMMES

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 a solid foundation of disciplinary physics knowledge. The programme has a strong educational vision as well as clear long-term goals. The panel supports the programme in implementing these, with attention to the workload of the teaching staff. Furthermore, 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 are translated very well into a coherent set of intended learning outcomes that is 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 Board of Advice further strengthens the connection of the programme's goals to the professional field. The panel recommends expanding the intended learning outcomes for the programme with skills and competences related to diversity and inclusiveness.

The bachelor's programme adequately translated their intended learning outcomes into a coherent curriculum. It offers a broad foundation within applied physics and the knowledge, skills and competences within the field. The Bachelor College courses provide students with modern engineering skills, and the free elective space gives students a lot of opportunities to shape the programme to their own preferences. The number of EC for core physics courses is smaller than in similar programmes: the panel recommends investigating whether there is room for more programme-specific content in the Bachelor College courses, such as the USE courses. The learning trajectories provide structure and coherence to the programme, although they could be more detailed to provide a more comprehensive overview of competences and skills taught in the curriculum. The panel recommends adding more detail to the learning trajectories, in particular with regard to the transferable skills learning trajectory. The panel supports the decision to offer the programme in English and praises the careful process through which this was implemented.

The programme has been working towards the educational principle of challenge-based learning. The panel supports this and was already enthusiastic about the examples it saw during the online site visit. The teaching methods in general are fitting and pay sufficient attention to student-regulated learning. The international classroom could be an interesting addition to the teaching environment, but is currently hampered by the limited number of international students in the programme. The programme is feasible, and students are well-supported during their studies, including the period of the corona pandemic. To further improve student support, the panel recommends improving the mentorship programme based on the suggestions by students, and including professionalization of the staff involved in mentorship. The final projects are sometimes a cause of delay. The programme took several measures to improve this, which the panel supports, in particular the fixed thesis duration. The teaching staff involved in the programme is knowledgeable, approachable, and open for feedback. The Department and the University took measures to increase the teaching capacity and provided extra support during the corona pandemic. This led to a teaching load that is experienced by the staff as manageable, although workload in general is still high. The panel praises the attention the programme pay to professionalization of the staff, and the high priority that is given to educational training.

The programme has a valid, transparent, and reliable system of assessment in place, with explicit attention to formative testing next to summative testing. Assessment could be made more even more insightful by adding an overview of the assessment of transferable skills, both with regard to the programme as a whole and for each individual student. The panel also recommends to structurally include individual elements in the assessment of 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 adequate, and the insightful and detailed rubric helps examiners substantiate their assessment. Qualitative feedback is sometimes limited, but this can be expected to improve now that the form requires a minimum amount of qualitative feedback. The panel recommends to add design skills as a separate criterion on the assessment form, to be used in the assessment of engineering oriented theses. Furthermore, the panel recommends to invest in benchmarking of the thesis grades, for instance by requiring second examiners to come from another group as the supervisor. The Examination Committee strongly fulfils its role in safeguarding the quality of assessment in the programme through checks of course assessment and thesis checks, and is well aware of the strengths and points of improvement of the assessment system of the programme.

The panel concludes that theses of the programme are generally of a high quality and show that the intended learning outcomes are achieved. The panel praises the programme with the high level that students attain when they complete the curricula. Graduates of the bachelor's programme continue successfully into a master's programme. Overall, 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 programmes Applied Physics are fitting for an academic programme within the field. The programme focuses on the theoretical basis and technical, experimental and scientific skills necessary to contribute to high-tech solutions for societal, technical and scientific challenges. It has a strong educational vision as well as clear long-term goals. The panel supports the programme in implementing these, with attention to the workload of the teaching staff. Furthermore, 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 the programme are translated very well into a coherent sets of intended learning outcomes that is 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 Board of Advice further strengthens the connection of the programme's goals to the professional field. The panel recommends expanding the intended learning outcomes for the programmes with skills and competences related to diversity and inclusiveness.

The master's programme offers a varied curriculum that covers all elements of the intended learning outcomes and offers lots of room for individual customization and specialization through the research tracks, electives, internship, and graduation projects. Coherence of the curriculum as well as skills training for individual students could be better monitored. The panel recommends investigating how master's students can be better supported in selecting their path within the curriculum, and monitoring the amount of skills training for each student. 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 programme has been working towards the educational principle of challenge-based learning. The panel supports this and was already enthusiastic about the examples it saw during the online site visit. The teaching methods in general are fitting and pay sufficient attention to student-regulated learning. The international classroom could be an interesting addition to the teaching environment, but is currently hampered by the limited number of international students in the programme. The programme is feasible, and students are well-supported during their studies, including the period of the corona pandemic. To further improve student support, the panel recommends improving the mentorship programme based on the suggestions by students, and including professionalization of the staff involved in mentorship. The external internship and master's thesis are often a cause of delay. The programme took several measures to improve this, which the panel supports, in particular the fixed thesis duration. The teaching staff involved in the programme is knowledgeable, approachable, and open for feedback. The Department and the University took measures to increase the teaching capacity and provided extra support during the corona pandemic. This led to a teaching load that is experienced by the staff as manageable, although workload in general is still high. The panel praises the attention the programme pay to professionalization of the staff, and the high priority that is given to educational training.

The programme has a valid, transparent, and reliable system of assessment in place, with explicit attention to formative testing next to summative testing. Assessment could be made more even more insightful by adding an overview of the assessment of transferable skills, both with regard to the programme as a whole and for each individual student. The panel also recommends to structurally include individual elements in the assessment of 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 adequate, and the insightful and detailed rubric helps examiners substantiate their assessment. Qualitative feedback is sometimes limited, but this can be expected to improve now that the form requires a minimum amount of qualitative feedback. The panel recommends to add design skills as a separate criterion on the assessment form, to be used in the assessment of engineering oriented theses. Furthermore, the panel recommends to invest in benchmarking of the thesis grades, for instance by requiring second examiners to come from another group as the supervisor. The Examination Committee strongly fulfils its role in safeguarding the quality of assessment in the programme through checks of course assessment and thesis checks, and is well aware of the strengths and points of improvement of the assessment system of the programme.

The panel concludes that theses of the programme are generally of a high quality and show that the intended learning outcomes are achieved. The panel praises the programme with the high level that students attain when they complete the curricula. Graduates of the programme end up in various positions in academia and industry. In hindsight, they would have welcomed more attention to transferable skills in the curriculum. Overall, 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

STATE OF AFFAIRS MASTER'S PROGRAMME SCIENCE AND TECHNOLOGY OF NUCLEAR FUSION

The master's programme Science and Technology of Nuclear Fusion (often shortened as 'Nuclear Fusion') is offered by the Department of Applied Physics at TU/e. It was accredited based on a stand-alone visitation with submission date 1 November 2019. TU/e expressed the wish to classify the programme in the visitation group WO Applied Physics with the submission date of 1 November 2021, and had this request approved by the NVAO. Since only two years passed since the previous accreditation, TU/e and NVAO agreed upon an 'inpassingsbeoordeling', in which a reflection on the state of affairs with regard to the recommendations of the previous accreditation can serve as basis for accreditation. The panel Applied Physics was asked to study the programme's state of affairs note, and report on its findings. The programme director, teaching staff, students and chair of the Examination Committee of the Nuclear Fusion programme participated in the interviews of the master's programme Applied Physics. The chair of the previous accreditation committee, Prof. Guido Van Oost (Ghent University) was asked to provide feedback on the state of affairs note as referent to the panel.

Nuclear Fusion is an interdisciplinary, goal-oriented programme with the aim of educating scientists and engineers for the development of a nuclear fusion reactor. It is one of the few programmes of its kind in Europe and fulfils a crucial role in the education of nuclear fusion experts according to the previous accreditation committee. In response to the recommendation of that panel, the programme explicitly linked its intended learning outcomes to the Meijer's criteria and made them more detailed with regard to fusion-specific content. It also followed another recommendation by the previous panel, namely to develop learning trajectories, which are formulated in parallel to the three learning trajectories of the Applied Physics programmes: theoretical knowledge, technical proficiency and transferable skills. Furthermore, the programme strengthened the fusion engineering content in the curriculum by adding a new master class on fusion engineering, opening in the department a vacancy for a fusion engineering researcher, who will also have a role in education (hiring is still underway), and expanding its network to include more hosts for an engineering-oriented internship or graduation project.

The panel is very positive on the developments of the programme Nuclear Fusion since the previous accreditation. The updates with regard to the learning outcomes and learning trajectories, as well as the extra fusion engineering content, further improved the coherence and technical character of the programme. The panel also underlines the positive conclusions of the previous accreditation panel that the programme has a unique, interdisciplinary character, offering a small-scale interactive education model with lots of attention for personal coaching. It also noted the strong attention to feasibility and study success in the programme: by using a well-defined thesis trajectory, the large majority of students finish their thesis within the designated time. It was also impressed by the formative assessment of professional skills in the programme through individual development dialogues with students.

With regard to assessment, the programme implemented the previous panel's recommendations regarding the procedures of the Examination Committee. Among other measures, the Committee's composition was changed to better assure independence in a small-scale programme, and quality assurance checks of courses and theses were increased in frequency. Another recommendation of the previous committee with regard to the alignment of assessment plans with the learning trajectories is still under development and the programme expects to complete it in the near future. The panel is positive on the changes implemented based on the previous site visit and considers the procedures with regard to the Examination Committee to be sufficiently improved. It encourages the programme to continue working on the alignment between learning trajectories and assessment plans in order to make a full overview of the knowledge and skills and their assessment in the programme.

Based on the state of affairs note, the discussions during the site visit and the input by the referent, the panel concludes that the master's programme Science and Technology of Nuclear Fusion took the recommendations of the previous accreditation committee to heart and implemented these to the best of its abilities.

Master's programme Science and Technology of Nuclear Fusion

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 of the panel, Peter Hildering, hereby declare that all panel members studied this report and that they agree with the judgements laid down in the report. They confirm that the assessment was conducted in accordance with the demands relating to independence.

Date: 24 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 programme Applied Physics are organized by the Department of Applied Physics at Eindhoven University of Technology (TU/e). The programmes aim to educate the researchers and engineers of the future, whether in high-tech industry, research institutes or in other fields where analytical thinking using mathematics and physics modelling is a key element. To this end, they aim to provide students with modern technical and transferable skills. One of the strategies to achieve this is project-based education (Challenge Based-Learning, or CBL) where theory and open-ended challenges are integrated.

The *bachelor's programme* aims to provide students with a solid foundation of disciplinary physics knowledge, combined with extensive hands-on components, offered by active researchers in the field. The solid foundation in physics is increasingly connected to research as the programme progresses. Students obtain general academic and engineering skills in the university-wide Bachelor College courses and have a relatively large amount (45 EC) of free elective space to either deepen or broaden the programme to fit their own preferences. With the acquired skills and knowledge, bachelor's graduates should be well-equipped to enter a dedicated follow-up master's programme in applied physics or a related field.

The *master's programme* aims to provide students with a solid theoretical basis and technical, experimental and scientific skills, so that they can contribute to high-tech solutions for societal, technical and scientific challenges. The programme allows students to further deepen their fundamental knowledge in applied physics in one of the tracks, and combine this with hands-on, research-driven components. Master's students work with active researchers in the field, using state-of-the art research infrastructure. Students can choose between the tracks Fluids, Bio and Soft Matter (FBSM), Nano, Quantum and Photonics (NQP) or Plasmas and Beams (PB). The structure provided by the university-wide Graduate School offers students many further opportunities to shape the curriculum to individual preferences with options for electives, projects and internship. At the end of the programme they should be well-prepared to enter either the professional field or a PhD programme in academia.

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 have a strong educational vision, work towards a clear professional graduate profile and set long-term goals with regard to flexible curricula, modern technical and transferable skills, and project-based education. The programme expects to implement this long-term vision, called 'Vision 2030' in the coming ten years. The panel sees the seeds of this vision already appearing in the programmes, and supports the programmes in the implementation of this strategy, without losing sight of the workload of the teaching staff (see Standard 2)

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 programme management and teaching staff provided the panel with several examples of courses in both programmes where students work on engineering challenges and design projects. Furthermore, the Bachelor College and the CBL approach provide bachelor's students with engineering and design skills. Nevertheless, some of the students that the panel interviewed seemed less outspoken on the profile of the programme and they did not all recognize the engineering character of the programmes as opposed to a general physics bachelor's or master's programme. The panel therefore recommends better communicating the programmes’ profile to students, and integrating understanding of what it means to be an applied physicist into the goals of the programme, as well as in the curriculum. This could for instance be implemented in a professional skills learning trajectory (see Standard 2).

Intended learning outcomes
The bachelor's programme translates its goals into fourteen intended learning outcomes (ILOs), divided into three sets labelled Cognitive skills, Applied physics competencies and skills, and General competencies and skills. The master's programme uses a set of eighteen ILOs, labelled General cognitive skills, Application of cognitive skills, Interpersonal skills and Personal skills. These are formulated on a programme level, with one of the learning outcomes describing state-of-the-art knowledge in physics research providing differentiation between the research fields underlying the three 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.

In order to align the ILOs with the international requirements of the field, the Applied Physics programmes in the Netherlands composed a domain-specific frame of reference (DSFR, see Appendix 1). 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. The ACQA framework (also known as the Meijer’s 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, 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 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 panel notes that the learning outcomes do not explicitly include elements from the DSFR relating to diversity and inclusiveness. It recommends adapting the learning outcomes in this aspect.

To further align the goals and aims of the programmes with the professional field, the department has its own Board of Advice, which consists of representatives of the national and international job market in both academia and industry. The Board meets with the programme management twice per year to give advice and feedback on the curriculum, the ILOs and on how well the programmes dovetail the job market. The panel considers this a very good initiative that keeps both programmes connected to the demands and opportunities of the professional field.

Considerations
The profile and aims of the bachelor's and master's programmes Applied Physics are fitting for an academic programme within the field, with the bachelor's programme focusing on a solid foundation of disciplinary physics knowledge, and the master's programme on the theoretical basis and technical, experimental and scientific skills necessary to contribute to high-tech solutions for societal, technical and scientific challenges. The programmes have a strong educational vision as well as clear long-term goals. The panel supports the programmes in implementing these, with attention to the workload of the teaching staff. Furthermore, 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 were translated very well 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 Board of Advice further strengthens the connection of the programme's goals to the professional field. The panel recommends expanding the intended learning outcomes for both programmes with skills and competences related to diversity and inclusiveness..

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 is embedded in the framework of the Bachelor College. This means that it follows the same structure as other bachelor's programmes in the university: 95 EC *major courses* (programme-specific), 25 EC *basic courses* in mathematics, physics, ethics and history of technology, engineering design and data analytics, 15 EC courses in the societal *USE learning trajectory* on User, Society and Enterprise, and 45 EC of free elective space.

The *major courses* consist of courses grouped into three main learning trajectories: theoretical knowledge (fundamental physics and mathematics, with a focus on acquiring knowledge and problem-solving skills), technical proficiency (modelling, simulation and experimental physics) and transferable skills. The latter line consists of 5 EC of professional and academic skills embedded in the other courses. The *basic courses* and *USE learning trajectory courses* are followed together with students from other bachelor's programmes at the university and are organized by the Bachelor College. They are organized in the first year of each programme and ensure that all TU/e students have a sufficient basis in engineering as well as a societal and entrepreneurial orientation. The free elective space can be used by students to broaden or deepen their knowledge. The department offers various coherent elective packages such as Advanced Classical Physics, Biological Physics, Modern Physics or Nanophysics and Technology, but it is also possible to choose university-wide packages, such as the educational package leading to a 'tweedegraads' teaching qualification. The capstone of the programme is the 10 EC bachelor end project, which is an individual research project conducted in one of the department's research groups under supervision of an academic staff member. If they aim to continue with a master's programme, this research group often aligns with their future master's track of choice. The project is part of the major courses. Students can choose to expand the size of their bachelor's thesis to 15 EC using free elective space.

The panel studied the structure and content of the curriculum of the programme, as well as the contents of a number of courses, and spoke with programme management, students and teaching staff. It concludes that the programme translated its intended learning outcomes into a solid and coherent curriculum. It offers a broad foundation within applied physics, and the knowledge, skills and competences within the field. The Bachelor College courses provide students with modern engineering skills, and the free elective space gives students a lot of opportunities to shape the programme to their own preferences. The other side of the coin is that the curriculum has less room for core physics courses as compared to similar bachelor's programmes. As such this is a valid choice, that the programme implemented by condensing some of the core courses, and making other topics part of the electives rather than part of the programme core. Nevertheless, the panel got the impression that more efficient use could be made of the Bachelor College courses. Students remarked to the panel that the Bachelor College courses are, while interesting in themselves, often not adapted to the individual programmes. The general mathematics and physics courses for instance are not very well aligned with the needs of an Applied Physics programme, so that the programme needs to devote extra EC to more advanced topics in the major courses. The panel considers this a missed opportunity: by making room for programme-specific adaptations, the Bachelor College courses can become more aligned with the major courses without losing their added value. For instance, the USE courses seem to have room for more applied physics oriented topics. The panel understood that there is a discussion within the university to update the Bachelor College structure with more programme-specific adaptations. The panel supports this discussion and hopes that it will lead to more room in the major courses.

Both students and teaching staff benefit from the fact that the three learning trajectories provide structure and coherence to the programme. The panel is positive on the distinction between theory, practice and skills, making the balance between these elements in the programme clear. It noted from the documents that the learning trajectories could be implemented more structurally in the programme. By adding more detail and including an overview of the assessment (see Standard 3), the programme could create a more comprehensive overview of the various competences and skills within a learning trajectory. This is most prominently the case with the transferable skills learning trajectory. In the student chapter, as well as in the interviews, students and alumni remarked that they would prefer more structural training in professional and academic skills such as written and oral communication, research integrity and cooperation. Some skills training is embedded in elective courses, which results in differences in skills training for individual students. They also noted that there is little room for individual feedback with regard to their skills development. The panel supports the students' wish for more structural professional skills training within the curriculum and recommends expanding the transferable skills training trajectory. This also includes attention to the role of electives in the learning trajectory, so that the programme can be sure that all students receive comparable skills training, regardless of their choice of electives.

Curriculum: master's programme
The curriculum of the master's programme consists of a common curriculum structure, in which students choose one of the three research tracks. *Plasmas and Beams* focuses on the behaviour of plasmas, and related applications in for instance light sources, solar cells and medical research. *Fluids, Bio and Soft Matter* addresses the physics of fluids and soft solids, often in the context of biological, medical and industrial applications such as biosensors, inkjet printing, self-healing materials, lab-on-a-chip devices and energy storage. In the *Nano, Quantum and Photonics* track, students study novel materials at the nanometer scale, including quantum devices and technology and photonic structures and materials. Applications include emerging technologies in optical communication, quantum computing and data storage.

All students follow a mandatory common course in Computational and Mathematical Physics (5 EC), the mandatory core course(s) of their track and track electives (20 EC), free electives (20 EC), an external internship (15 EC) and a graduation project (45 EC). The remaining 15 EC can be added to the free elective space, the external internship or the graduation project. In the *track* and *free electives* students choose from a list of track electives to deepen their knowledge within their subfield of choice, often related to the graduation project. The free electives can be any master's level course relevant to the student's individual curriculum, including an educational profile followed at the Eindhoven School of Education (ESoE). This profile leads to an educational profile certificate, or an 'eerstegraads' teaching qualification if combined with sufficient extra educational courses obtained next to this master's programme. A mentor advises students on their choice of electives, and the Examination Committee checks each curriculum to see whether all learning outcome of the programme are met. In the *external internship,* students develop their academic skills in either an academic or industrial setting outside TU/e, within the Netherlands or abroad. Students are relatively free in choosing content and location of the internship. They discuss their ambition and the skills they want to develop with their internal supervisor, and choose a fitting subject and location accordingly. The graduation project is the capstone of the master's programme. It consists of an individual research project in a research group related to the chosen track. With permission and under responsibility of the supervisor, students can also do their research project outside of the department.

The panel studied the curriculum of the master's programme and concludes that the programme successfully translated the ILOs in a coherent and varied curriculum with lots of room for individual customization and specialization. The three tracks fit the research expertise of the Department of Applied Physics, providing students with hands-on, state-of-the-art education and research training. 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 electives, the external internship and the graduation projects provide lots of freedom and opportunities for students to broaden or deepen their programme as they see fit, and pre-sort for a career in either research, industry or education. The extra 15 EC to spend on courses, research or the internship gives students an extra opportunity to focus their curriculum, and allows for longer projects abroad or in industry.

With regard to the freedom in the curriculum, the panel recommends paying attention to the coherence of the programme for individual students. The panel noted from the student chapter and the interviews that not all students were satisfied with the support they received from their mentor in composing a coherent curriculum. Furthermore, as in the bachelor's programme, students and alumni reported that they would prefer additional skills training in the master's programme to better prepare them for their future career. Students themselves suggest that having a mentor from within their own track would help with this issue. The panel recommends investigating whether this can be realized. In the interviews with the teaching staff and programme management, the participants pointed out that skills training is primarily done in the bachelor's programme, and that this is further developed in the internship and the graduation project. The panel understands this line of reasoning but notes that this is primarily the case for graduates from their own applied physics bachelor's programme, and does not necessarily include intake from other academic and professional bachelor's programmes. To improve the programme’s coherence, the panel recommends introducing learning trajectories in the master's programme, or using another method to monitor that all students receive equal training in all skills, regardless of their choice of track and electives.

Teaching methods

Both programmes recently adopted Challenge-Based Learning (CBL) as their educational principle. This consists of integrating theory and open-ended challenges that students explore in teams, where possible in interdisciplinary teams with students from multiple programmes. This approach is under development: most courses still use the lecture-tutorial approach, supplemented with practical, hands-on work in experiments, computer simulations and projects. In addition to these teacher-regulated activities, the programme also includes student-regulated activities in the form of the Studio Classroom, a guided self-study activity where teachers are available for students' requests.

In 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, and experimental and project work was, wherever possible, organized on campus with the limited contact available. Students and teaching staff reported to the panel that they were ultimately satisfied with the online education and the variety of online teaching methods. Teaching staff took the opportunity to experiment with new teaching methods during this period, such as using pre-recorded and edited video lectures and inviting online guest lecturers from abroad.

The panel was positive on teaching methods, both in the regular set-up (Studio Classroom, working in small groups) and during the corona pandemic, as well as on the planned switch towards CBL. This approach is fitting for a modern engineering programme, and provides good opportunities for students to develop their transferable skills. One particularly interesting case of a new CBL course that the panel encountered during the site visit was the master's course Physics of Engineering Problems, where students worked directly with international companies on their actual challenges. Industrial partners from Asia participated in online lectures to provide direct context and feedback to students. The panel considers this an innovative approach with regard to CBL as well as online education. The programmes expect to introduce several more of such challenge-based courses in the coming year.

Language and internationalization

Both programmes are offered in English, with the bachelor's programme making the switch from Dutch to English in 2017. According to the programme, English is the dominant language 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 physics. As the staff in the Department is very international, the use of English means that all staff can participate in education. 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 courses to improve language proficiency of all staff.

The bachelor's programme worked closely together with the programme committee to ensure a smooth transition from Dutch to English. Measures included providing video lectures in Dutch in the start-up phase, and offering extracurricular English language courses to both students and teaching staff. A survey conducted by the programme at the end of the academic year showed that the switch to English did not hinder understanding of the subjects for almost all students. This was backed up by the interviews the panel held with students, where both students that experienced the switch and students from recent years stated that they were satisfied with the process as well as with the current situation.

The panel considers the choice for the use of English to be well motivated. The programme is offered in an international environment, with regard to both the field of applied physics and the staff of the Department. An English language programme prepares students for an internationally oriented field. Students are positive about the quality of the education in English, and about the process of the recent switch to English in the bachelor's programme. There is sufficient attention to the language skills of the teaching staff.

The panel notes that the current intake of international students is limited in both programmes, even though the programmes aim to offer students an international environment. The international intake is roughly 10-15% in the bachelor's programme and 2-5% in the master's programme. The programme management aims towards a student population of which about one-third of the students has an international background. This will further strengthen an international classroom. The programmes expect that with the English language bachelor programme and the end of the corona pandemic, the number of international students will grow. The panel supports this goal and the efforts of the programme to achieve it. According to the panel, the current low number of international students also requires careful monitoring of the integration of this group within the student population. The panel received no signals that this is an issue, but it should remain on the agenda.

Feasibility

The average study duration in the bachelor's programme is slightly over 3.5 years, and around 3 years for the master's programmes. The bachelor's programme invests in the feasibility of the programme in several ways. Prospective bachelor's students are required to participate in a 'study choice check' event in which they can experience whether the programme fits their interests and skills. Furthermore, basic courses, Bachelor College courses and electives all have the same study load (5 EC) and are scheduled in specific timeslots during the week throughout the university to allow each student a feasible individual planning. The panel considers the success rates and feasibility of the bachelor's programme to be acceptable. Students mentioned to the panel that they found the curriculum challenging, especially in the first year, but that it is generally feasible in three years. From the documentation and the interviews, the panel learned that the main factor for delay is an extended duration of the bachelor end project, which is discussed below.

For the master's programme, the average study duration is slightly less than 3 years. As mentioned by the programme in the documents and the interviews, the main factor for delay is the duration of the external internship and the graduation project. The programme took several measures to improve this. Students have an extra 15 EC that they can spend on a longer internship or thesis if they have the ambition to do a larger project. Furthermore, the core courses and electives are scheduled such that they can all be followed in the first year, leaving the second year completely free to pursue the internship and thesis. The panel supports these measures and agrees that average study duration of the master's programme could be improved.

Both programmes recently introduced a fixed-length thesis trajectory, with clear deadlines for students to deliver their report and presentation. The master's programme recently implemented this, and the bachelor's programme will implement this from 2021-2022. The fixed-length trajectories for the internship and the thesis are a promising method to remedy the delay associated with the thesis trajectories, and were already successfully implemented by the master's programme Science and Technology of Nuclear Fusion within the Department. From the interviews, the panel got the impression that there is a culture of implicitly or explicitly encouraging students to spend longer time on their projects than they are supposed to in order to get better results. Such cultural habits might be hard to break, so the panel recommends the programme management to monitor the implementation of the fixed thesis and internship length policy, to assure its success.

Student support

The programmes offer various study-related support and guidance to students. The programmes' academic advisor is available for issues with regard to planning, procedures, study progress and advice. The academic advisor can also refer students to services at the university level when they are dealing with personal circumstances and issues. All first year bachelor's students are assigned a student mentor: senior students that help them getting acquainted with life at the university and making the first choices with regard to the individual curriculum and electives. In addition, all bachelor's students have a teacher coach, a member of the staff that coaches small groups of students in their curriculum choices. In the master's programme, students have a mentor, an academic staff member who helps them with their choices and ambitions during the programme. Students that also did the bachelor's programme Applied Physics at the TU/e keep their teacher coach, until the graduation project, where the supervisor takes over.

The panel is positive on the student support in both programmes in general. Bachelor's students reported to the panel that they were very satisfied with the role of the student mentor, especially in making the transition from secondary school to university. The student association Van der Waals and the student education organization STOOR play an important role in providing a safe and welcoming environment for new students. With regard to the quality of support from teacher coaches and mentors, student opinions differed. Some bachelor's students would welcome more input from their teacher coach with regard to choosing electives at the end of the first year, as well as feedback on the development of their professional skills throughout the curriculum. Master's students were not unanimously satisfied with the role of their mentor: as discussed under Curriculum, they would prefer a mentor from within their track. The panel recommends investigating how to improve mentorship. It understood that the programmes are in the process of implementing changes to the mentoring system, based on student feedback. The panel supports this. It suggests paying attention in this processs to professionalization of the teacher coaches and mentors. It might be advisable to select a number of mentors and coaches, and specifically train them for their role, rather than including all academic staff. This could also reduce workload for the academic staff if these mentors and coaches are assigned extra time for this role. 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 for this in student support, but also recommends paying attention to special needs in teacher professionalization, in order that the needs of this group actively have the attention of teaching staff during the courses.

For talented students, both programmes provide additional opportunities. The programme offers double diploma curricula of 225 EC with the bachelor's programmes Applied Mathematics, Chemical Engineering and Chemistry, but combinations with other bachelor's programmes are also possible on an individual basis. The master's programme offers double diploma trajectories with the master's programmes Science and Technology of Nuclear Fusion as well as Science Education and Communication, and other master's programmes upon request. Furthermore, excellent students from both programmes can participate in a university-wide honours programme for bachelor's or master's students. The panel judges that both programmes offer sufficient opportunities for talented students.

With regard to professional orientation, the programmes have various connections with the professional field within the curriculum, for instance in engineering projects and the external internship in the master's programme. There are also various extracurricular activities such as open company days and guest speakers from industry. These activities are mostly organized by the study association Van der Waals. Most students were satisfied with this, although some would prefer more career development activities and individual feedback on career options organized by the programmes itself. The panel encourages the programmes to continue their efforts and investigate whether there is more room for career orientation in the programmes. With the planned further internationalization of the programme, the panel recommends also considering training for international students on Dutch professional culture, as to prepared them well for a career in the Netherlands.

Impact of the corona pandemic
In the past year, when corona measures made it impossible to organize on-campus meetings for most of the year, the Department immediately launched an Education Crisis Team aimed at making the transition to online education and examination as transparent as possible for students. The binding study advice (BSA) was postponed for first year students, resulting in no negative recommendations for 2019-2020, in order to account for the extraordinary circumstances. The main impact of the corona measures with regard to the curriculum was felt in the experimental physics courses of the bachelor's programme and the master's external internship and graduation project. The programme management and Examination Committee decided to adapt the bachelor's curriculum to relocate the experimental courses and allowed master's students to do an internal internship at TU/e if necessary. Also, students could reduce the length of their projects in EC in exchange for extra courses. The same applied to the bachelor's theses for students who opted for the 15 EC project. The panel is positive on the way that the programmes dealt with the circumstances caused by the corona pandemic. The students interviewed by the panel felt well supported during the corona pandemic. They reported that they valued the efforts of the programmes, and thought that the measures taken by the programme kept the programme feasible, also during distance education.

Teaching staff
The programmes are taught by the scientific staff associated with the Department of Applied Physics, with the exception of the courses in the Bachelor College, which are organized on a central university level. The programmes aim for a strong connection between research and education: the policy is that all lecturers are involved in the research activities of the Department. Most academic staff members therefore participate in educational activities in one of the programmes or both, with each staff member typically involved in three or four courses as responsible lecturer or co-lecturer. As the number of students in the Department almost doubled over the past six years (from 580 to 1068), the Department invested in attracting new staff members. This included new research positions as well as student assistants and PhD candidates with a five-year PhD contract and a teaching load of 25%. With regard to professionalization, the programmes require all new teaching staff to have obtained or follow the UTQ course. Current staff members either followed or are following the UTQ course, or received an exemption based on a dossier proving acquired teaching competences. At the moment, 73% of the teaching staff received educational training, a number, which is expected to grow to 100% in the near future.

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. The measures taken by the department and the university to increase teaching capacity led to a teaching load that staff experience as manageable, and by students as favourable. The teaching staff of both programmes that the panel interviewed were very positive on the support from the Department and the central Education and Student Affairs (ESA) department they received to accommodate the growth in student numbers. This includes support for distance education during the corona pandemic, where technical support was available to facilitate online lectures and tutorials. Some teachers mentioned that they took this as an opportunity to experiment with new teaching methods (see Teaching Methods), further proving that there is time available for innovation. Nevertheless, the panel noted that the workload resulting from the non-educational responsibilities is still high, so staff workload should remain on the agenda of the Department, in particular in implementing the new educational vision discussed in Standard 1. The panel praises the attention towards professionalization of the staff, and the high priority that is given to educational training through the UTQ. This recommendation of the previous accreditation committee was fully addressed by the programmes and turned into a strength.

The students interviewed by the panel find their teachers to be knowledgeable, approachable, and open for feedback. With regard to student feedback, the panel noted from the interviews that students do not always see the results of their feedback on courses, although it is usually followed up. It recommends sending information on course improvements based on student feedback to the students that originally provided the feedback.

Programme-specific facilities
The programmes use laboratory facilities for practical work, as well as project rooms that students can book for project meetings. The laboratories are mostly used by bachelor's students: master's students as well as bachelor's students in the second half of the curriculum perform most research projects within the Department'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* adequately translated their intended learning outcomes into a coherent curriculum. It offers a broad foundation within applied physics and the knowledge, skills and competences within the field. The Bachelor College courses provide students with modern engineering skills, and the free elective space gives students a lot of opportunities to shape the programme to their own preferences. The number of EC for core physics courses is smaller than in similar programmes: the panel recommends investigating whether there is room for more programme-specific content in the Bachelor College courses, such as the USE courses. The learning trajectories provide structure and coherence to the programme, although they could be more detailed to provide a more comprehensive overview of competences and skills taught in the curriculum. The panel recommends adding more detail to the learning trajectories, in particular with regard to the transferable skills learning trajectory. The panel supports the decision to offer the programme in English and praises the careful process through which this was implemented.

The *master's programme* offers a varied curriculum that covers all elements of the intended learning outcomes and offers lots of room for individual customization and specialization through the research tracks, electives, internship, and graduation projects. Coherence of the curriculum as well as skills training for individual students could be better monitored. The panel recommends investigating how master's students can be better supported in selecting their path within the curriculum, and monitoring the amount of skills training for each student. 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.

Both programmes have been working towards the educational principle of challenge-based learning. The panel supports this and was already enthusiastic about the examples it saw during the online site visit. The teaching methods in general are fitting and pay sufficient attention to student-regulated learning. The international classroom could be an interesting addition to the teaching environment, but is currently hampered by the limited number of international students in both programmes. The programmes are feasible, and students are well-supported during their studies, including the period of the corona pandemic. To further improve student support, the panel recommends improving the mentorship programme based on the suggestions by students, and including professionalization of the staff involved in mentorship. The final projects are often a cause of delay in both programmes. This is most prominently the case for the external internship and master's thesis. The programmes took several measures to improve this, which the panel supports, in particular the fixed thesis duration. The teaching staff involved in the programmes is knowledgeable, approachable, and open for feedback. The Department and the University took measures to increase the teaching capacity and provided extra support during the corona pandemic. This led to a teaching load that is experienced by the staff as manageable, although workload in general is still high. The panel praises the attention the programmes pay to professionalization of the staff, and the high priority that is given to educational training.

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 department-wide assessment system, as well as the respective Bachelor College and Graduate School assessment guidelines. This system and guidelines make frequent use of formative testing next to summative testing, to allow students and teachers to monitor progression throughout the courses. The specific form of testing depends on the learning goals of the courses, and includes written tests, reports and assignments. The 'traditional' physics and mathematics courses are often assessed using written tests, whereas reports and presentations are frequently used in courses associated with the technical proficiency and transferable skills learning trajectories. Tests are developed by at least two teachers involved in the course who check each other's contributions. The goals, grading and associated learning outcomes of each test are communicated to students beforehand through the student information system. External projects such as the internship in the master's programme are always assessed by an internal examiner from within the programme, with input provided by the external supervisor. Since the outbreak of the corona pandemic, the programmes were forced to shift towards online assessment for most courses. The programmes took this opportunity to structurally implement digitized and online examinations in the programme, mainly for formative purposes. In the period where all exams were held online, all courses developed online alternatives for their test, and had these checked by the Examination Committee. When deemed necessary, online proctoring was used to prevent fraud.

The panel is positive on the system of assessment in both programmes. The four-eyes principle used in all exams adds to the reliability and validity of the assessment, and the use of formative testing adds to the student learning process. The assessment methods fit the learning goals of the courses. The shift towards online assessment was made carefully and resulted in the structural addition of online testing within the programmes. In addition to the discussion on the transferable skills learning trajectory in Standard 2, the panel recommends paying attention to the assessment of skills throughout both programmes. By including assessment in the further development of this learning trajectory and making sure that each individual curriculum has comparable skills training, the programmes can create a comprehensive overview of all skills training and assessment. During the site visit, the panel discussed the assessment of group projects in the interviews. Group projects provide individual components in their assessment through peer feedback and the possibility to drop free-riding group members from the team. According to the panel, there could be a more structural embedding of individual assessment within group projects, for instance by asking students to provide a recognizable part of the report. The panel recommends developing an assessment policy for group work that takes these considerations into account.

Thesis assessment

The bachelor's and master's thesis have similar assessment procedures. In the current situation, bachelor students are assessed by their supervisor and a second examiner. Master students are assessed by a graduation committee consisting of at least three examiners. The assessment is based on the performance during the research project, the final report and a presentation. The master's thesis also includes a defence before the graduation committee as a fourth aspect. The committee members individually grade each aspect at the closed meeting after the student presentation and defence. The committee members then compare and discuss their grades and jointly reach a consensus on the grades for each of the aspects, using a rubric with subcriteria and textual descriptions for each grade to transparently determine the quality of the work. The assessment form encourages giving feedback on each of the four aspects through fields for comments. The final grade is a weighted average of the subgrades.

As part of its preparation of the site visits, the panel studied 15 bachelor's and 15 master's thesis projects with the accompanying assessment forms. It concludes that the forms used to evaluate the theses are useful, and detailed. The panel felt that grades were sometimes inconsistent between theses, with theses that the panel considered to be generally of the same quality being graded differently. Based on this and on the resulting discussion with the programme management and teaching staff, the panel got the impression that grading cultures between research groups or examiners could differ. It recommends both programmes to better benchmark their grading. This could for instance be achieved by imposing a rule that a second examiner should come from a different research group: something that is currently often not the case, especially with the bachelor end project. The new rubric that is in the process of implementation could also provide a new stimulation for benchmarking. The panel had the opportunity to study this rubric and found this to be well-defined and insightful. An important new addition with regard to feasibility of the programme is a check for timely completion: if the thesis is handed in after the deadline, it results in an unsatisfactory score.

The assessment form provides sufficient room for textual feedback. Most of the time, the forms 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. During the interview, the Examination Committee mentioned that it recently came to the same conclusion and asked the programme management to better enforce the complete compilation of the forms. To promote this the form, was recently adapted to require a minimum of 5 lines of qualitative feedback from the supervisor. The panel supports these improvements. Furthermore, the panel noted that design skills are not part of the rubric for both the bachelor and master theses. It understands that these skills are not necessarily part of every thesis project, but if this aspect is present, it should be graded separately, according to the panel. It recommends adding this to the assessment form.

Examination Committee
The bachelor's and master's programme Applied Physics have their own shared Examination Committee, that covers the quality of assessment for both programmes. The committee consists of three lecturers from within the programmes, chosen from research groups involved in the three different master's research tracks, as well as an external member. It is assisted by an assessment committee that monitors the quality of testing in the programmes through analysis of courses, a study programme committee (not to be confused with the Program Committee) that makes decisions regarding the composition and coherence of individual curricula, and a BaMa committee that monitors the quality of bachelor and master thesis and their assessment through sampling on an annual basis. All committees work under the responsibility of the Examination Committee.

Based on the documents, as well as the interview with the Examination Committee Applied Physics, the panel concludes that the Examination Committee strongly fulfils its role by safeguarding the quality of assessment in the programmes. The course assessment checks and the recently adopted thesis sampling procedure are adequate tools for this purpose. The Examination Committee was well aware of the strengths and points of improvement in the assessment system in the programmes, and took appropriate actions towards improvement, such as notifying the programme management on the inconsistent amount of feedback on thesis assessment forms and the need for individual components in group assessment.

Considerations
Both programmes have a valid, transparent, and reliable system of assessment in place, with explicit attention to formative testing next to summative testing. Assessment could be made more even more insightful by adding an overview of the assessment of transferable skills, both with regard to the programme as a whole and for each individual student. The panel also recommends to structurally include individual elements in the assessment of group projects. During the corona pandemic, the programme successfully made the switch to online assessment.

The procedures and assessment forms for the bachelor and master theses are adequate, and the insightful and detailed rubric helps examiners substantiate their assessment. Qualitative feedback is sometimes limited, but this can be expected to improve now that the form requires a minimum amount of qualitative feedback. The panel recommends to add design skills as a separate criterion on the assessment form, to be used in the assessment of engineering oriented theses. Furthermore, the panel recommends to invest in benchmarking of the thesis grades, for instance by requiring second examiners to come from another group as the supervisor. The Examination Committee strongly fulfils its role in safeguarding the quality of assessment in the programmes through checks of course assessment and thesis checks, and is well aware of the strengths and points of improvement of the assessment systems of 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.

Thesis quality

Prior to the site visit, the panel studied 15 bachelor's theses and 15 master's theses Applied Physics. For the master's programme, an equal number of theses was selected for each of the three 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 learning outcomes. One bachelor's thesis was considered by the panel to be of insufficient quality. The student did not follow regular procedures and handed in a report that did not meet the criteria, resulting in a minimum passing grade. According to the programme there were personal circumstances at play, but they agreed with the panel that in hindsight, the thesis should not have been accepted. The panel considers this an incident that is not representative for the overall exit level of the bachelor's programme. The high quality is reflected in the high scores: approximately 60% of the bachelor's student and 65% of the master's students receive an 8.0 or higher for their thesis. Notwithstanding the inconsistencies in grading mentioned in Standard 3, the panel considers these high scores to be generally justified, and praises both programmes for the high level of their graduates.

Alumni of the bachelor's programme generally continue with a master's programme, usually at TU/e. Roughly 75% of students enrol in the master's programme Applied Physics at TU/e, 10% in another master's programme at TU/e, and 15% continue elsewhere. A recent alumni survey shows that master's students Applied Physics feel well prepared for their master's programme. Of the master's programme graduates, 46% continue in a PhD or PDEng programme, 8% continue in another master's programme (roughly half in the Science Education and Communication programme), and 46% enter the professional field. Over the last several years, two-thirds of the programme's graduates work in high-tech industry, and the other third in other positions such as research or consultancy. In alumni surveys as well as in interviews during the site visit, alumni from both programmes mentioned that they were very satisfied with the content and level of their education and felt well-prepared for their career. A point for improvement that was often mentioned is the attention to transferable skills, such as interdisciplinary cooperation and communication. The panel took up this recommendation, as discussed under the other standards in this report. The panel concludes that the bachelor's programme prepares students well for a master's programme, and graduates of the master's programme find fitting positions in industry and academia.

Considerations

The panel concludes that theses 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 when they complete the curricula. 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. In hindsight, they would have welcomed more attention to transferable skills in the curriculum, which was discussed earlier. Overall, 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*

Intended Learning Outcomes of BSc AP program		
1 Cognitive skills	**a**	Graduates have acquired fundamental knowledge in the physical concepts, laws and theories at a bachelor's level and can interpret corresponding phenomena, observations and real-life situations. The physics domains in the Bachelor's include mechanics, electromagnetism, optics, quantum physics, mathematical physics, thermodynamics and statistical physics, condensed matter physics and physics of transport phenomena.
	b	Graduates possess standard mathematical knowledge and general analytic skills insofar as is relevant in applied physics at a bachelor's level.
	c	In at least the fields listed in 1a, graduates are able to understand fundamental physics concepts at a bachelor's level. They have acquired a way of thinking that will enable them to analyze and solve physics-related problems using basic strategies.
	d	In at least the fields listed in 1a, graduates are able to recognize, describe and apply the (fundamental) physical theories behind physical phenomena. Based on these theories, they are able to analyze and model these phenomena, which enables them to carry out predictions and calculations of physical behavior.

2 Applied physics competencies and skills	**a**	Graduates are able to utilize their fundamental knowledge of physical concepts, laws and theories in a professional academic environment and hands-on (open-ended) projects.
	b	Graduates are able to describe, design and perform simple experimental and/or theoretical scientific investigations, to systematically experiment, investigate and adequately interpret the research results and to formulate a conclusion.
	c	Graduates are able to state and apply standard computational tools and methods to solve physics-related problems, model systems and perform data analysis.
	d	Graduates are able to gather and understand scientific articles at the level of scientific literature related to the field of applied physics and are able to integrate this with the knowledge they already possess.
	e	Graduates are able to contribute to the process of design by applying their knowledge of physical concepts, laws and theories in at least the fields listed in 1a while considering predefined design requirements.
3 Generic competencies and skills	**a**	Graduates are able to communicate appropriately for the intended audience both orally and in writing (in English), at least at a fundamental physics level in the fields listed in 1a.
	b	Graduates are able to effectively work together in monodisciplinary and/or interdisciplinary teams and are introduced to the role of an applied physicist in projects in which they recognize and exploit the strengths and limitations of themselves and others.
	c	Graduates are able to plan and organize a project and adjoined activities. When intermediate outcomes indicate to do so, they are able to adjust the project planning accordingly.
	d	Students are able to reflect on the outcomes of projects and are able to draw well-founded conclusions based on results and corresponding analysis. They are able to develop by understanding how their own actions and choices influence the outcomes.
	e	Graduates are aware of the societal impact of engineering and can apply general ethical aspects and rules of scientific conduct on assigned tasks.

Master's programme *Applied Physics*

Intended Learning Outcomes of the MSc AP		
1 **General cognitive skills**	**a**	Graduates understand advanced concepts of physics at a master's level. They have acquired a way of thinking that will enable them to analyze and solve complex problems while maintaining a critical attitude towards established scientific insight.
	b	Graduates possess mathematical knowledge, computing and computer science skills and general analytic skills relevant to applied physics at a master's level.
	c	Graduates have acquired state-of-the-art knowledge in (at least) the physics research topic in which they specialize during the graduation project i.e., (1) Fluids, Bio and Soft Matter, (2) Nano, Quantum and Photonics or (3) Plasmas and Beams.
2 **Application of cognitive skills**	**a**	Graduates have experience in utilizing their cognitive skills in a professional academic, applied sciences and/or engineering environment or at a university, research institute and/or company.
	b	Graduates are able to set up and perform experimental and/or theoretical scientific research, to systematically experiment, investigate and critically interpret the research results and to formulate conclusions.
	c	Graduates are able to formulate and analyze scientific problems at an abstract level by dividing them into testable sub-problems, differentiating between major and minor aspects and finding relevant scientific sources.
	d	Graduates are able to recognize and explain the relevance of their research outcomes to the wider context of the research field.
	e	Graduates are able to select the appropriate pathways and research tools/methods for solving new questions and hypotheses within the constraints imposed by the research environment. Graduates can do this in at least one of the three research disciplines of applied physics as defined by the Department of Applied Physics of TU/e.
	f	Graduates are able to gather and understand scientific articles and to follow the developments in the chosen research discipline at the level of scientific literature.
	g	Graduates are able to assimilate newly acquired knowledge of applied physics and integrate this with the knowledge they already possess, including outside of the area of their graduation project.
3 **Interpersonal skills**	**a**	Graduates are able to communicate in English with experts and non-experts both orally and in writing on scientific knowledge and relevant applications at both a basic and specialist level.
	b	Graduates have experienced work in monodisciplinary and/or interdisciplinary research teams in a professional academic, applied sciences and/or engineering environment, including outside of TU/e.
	c	Graduates are able to communicate and disseminate (applied) physics knowledge and insights with other disciplines at a basic level.
4 **Personal skills**	**a**	Graduates are able to formulate and oversee the limitations and/or shortcomings of projects/research they conducted.
	b	Graduates are aware of the importance of the replication and reproducibility of the research/project.
	c	Graduates are aware of the societal and ethical aspects related to their work.
	d	Graduates are aware of scientific integrity and act with integrity in their work.
	e	Graduates have developed the learning skills that are necessary for them to continue undertaking further study and/or a future professional career with a high degree of autonomy.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Bachelor's programme *Applied Physics*

	QUARTER 1	QUARTER 2	QUARTER 3	QUARTER 4
	Calculus	Applied Natural Sciences	Data Analytics for Engineers	Ethics and History of Technology
YEAR 1	Experimental Physics 1	Experimental Physics 2	Linear Algebra	Electromagnetism
	Variables, dimensions, and dynamics	Elective	Mechanics	Elective
	Engineering Design	Optics	Introduction to Quantum Physics	Thermal Physics
YEAR 2	Advanced Calculus	Elements of Mathematical Physics	Signals and Systems	Experimental Physics 3
	Elective/USE	Elective/USE	Elective/USE	Elective/USE
	Physics of Transport Phenomena	Condensed Matter	Elective	Bachelor Final Project
YEAR 3	Applied Quantum Physics	Physics in Perspective	Elective	Bachelor Final Project
	Elective/USE	Elective/USE	Elective/USE	Bachelor Final Project Elective/USE

Master's programme *Applied Physics*

<table>
<tr><th></th><th>QUARTER 1</th><th>QUARTER 2</th><th>QUARTER 3</th><th>QUARTER 4</th></tr>
<tr><td rowspan="8">YEAR 1</td><td>Computational and Mathematical Physics</td><td>(track) Elective</td><td>(track) Elective</td><td>(track) Electives
or</td></tr>
<tr><td rowspan="2">track FBSM
Advanced
Fluid Dynamics</td><td rowspan="3">track FBSM
Soft Matter Physics</td><td rowspan="6">(track) Elective</td><td rowspan="7">External internship

(15 credits in year 1
or
15 credits in year 2
or
30 credits divided
over year 1 and year 2)</td></tr>
<tr></tr>
<tr><td rowspan="2">track NQP
Condensed Matter
at the Nanoscale</td></tr>
<tr><td rowspan="3">track NQP/PB
(track) Elective</td></tr>
<tr><td rowspan="2">track PB
Physics of Plasma
and Radiation</td></tr>
<tr></tr>
<tr><td>(track) Elective</td><td>(track) Elective</td><td>(track) Elective</td></tr>
<tr><td rowspan="2">YEAR 2</td><td colspan="4">Graduation project (60 credits)</td></tr>
<tr><td>External internship</td><td colspan="3">Graduation project (45 credits)</td></tr>
</table>

APPENDIX 4: PROGRAMME OF THE SITE VISIT

Day 1 Wednesday June 16, 2021

09.00	10.15	Internal consultation of panel
10.15	11.15	Interview management
11.45	12.30	Interview BSc AP students
12.30	13.30	Lunch break
13.30	14.15	Interview BSc AP teachers
14.45	15.15	Interview alumni
15.45	16.15	Recap of main findings & Closure
17.00	17.30	Open consultation hour

Day 2 Thursday June 17, 2021

09.00	09.45	Interview MSc AP students *
10.15	11.00	Interview MSc AP teachers *
11.30	12.15	Interview Examination Committee *
12.15	12.45	Internal consultation of panel
12.45	13.30	Lunch break
13.30	14.15	Second interview management
14.30	16.30	Drafting decisions
16.30	17.00	Feedback regarding decisions

* including representatives from the master's programme Science and Technology of Nuclear Fusion

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:

- Self-evaluation report BSc Applied Physics
- Self-evaluation report MSc Applied Physics
- Domain-specific framework of reference Applied Physics
- Education and Examination Regulations
- Overview of Meijer's criteria, domain-specific framework of reference and the intended learning outcomes of both programmes
- Overview of the curricula
- Overview of the quality assurance policies at the department
- Annual reports of the Examination Committees 2019-2020
- Annual reports of the Programme Committee 2019-2020
- Educational and assessment materials and course evaluations of a selection of courses for both programmes
- Education vision 2030
- New rubrics bachelor and master end projects
- Alumni survey 2019