Applied Physics

Faculty of Applied Sciences,
Delft University of Technology

Quality Assurance Netherlands Universities (QANU)
Catharijnesingel 56
PO Box 8035
3503 RA Utrecht
The Netherlands

Phone: +31 (0) 30 230 3100
Telefax: +31 (0) 30 230 3129
E-mail: info@qanu.nl
Internet: www.qanu.nl

Project number: Q436

CONTENTS

This report was finalized on 30 April 2014.

Report on the master's programme Applied Physics of Delft University of Technology

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

Administrative data regarding the programme

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:	- Bionanoscience - Fluid Flow and Transport Phenomena - Imaging Physics - Quantum Nanoscience - Radiation Science and Technology
Location(s):	Delft
Mode(s) of study:	full time
Expiration of accreditation:	31-12-2014

The visit of the assessment committee Physics and Astronomy to the Faculty of Applied Sciences of Delft University of Technology took place on 28 and 29 January 2014.

Administrative data regarding the institution

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

Quantitative data regarding the programme

The required quantitative data regarding the programme are included in Appendix 5.

Composition of the assessment committee

The committee that assessed the master's programme Applied Physics consisted of:

- Dr. Henk Blok, retired associate professor at the Faculty of Sciences of VU University Amsterdam (chair);
- Prof. dr. Wim de Boer, professor of Physics at the University of Karlsruhe (DE);

- Dr. ir. Jaap Flokstra, retired asssociate professor Nanotechnology at University of Twente;
- Christianne Vink MSc, didactic coach, educational advisor/trainer and partner of Academic Factory;
- Dr. Jan Hoogenraad, owner of Spoorgloren BV for change management en quantitative service in public transport;
- Carmen van Schoubroeck, student bachelor Mathematics and bachelor Physics and Astronomy, Radboud University Nijmegen.

The committee was supported by Kees-Jan van Klaveren MA, who acted as secretary.

Appendix 1 contains the curricula vitae of the members of the committee.

Working method of the assessment committee

The assessment of the master's programme Applied Physics of Delft University of Technology is part of a cluster assessment. In the context of this cluster visitation, in the time period between November 2013 and April 2014, twenty eight programmes at nine different institutions were assessed.

Appendix 2 contains the framework of reference.

The committee Physics and Astronomy is composed of in total sixteen members:

- Prof. dr. Daan Lenstra, professor emeritus of Electrical Engineering at Delft University of Technology and fellow at Eindhoven University of Technology (chair);
- Prof. dr. Wim de Boer, professor of Physics at the University of Karlsruhe (DE);
- Prof. dr. Elias Brinks, professor of Astrophysics at the University of Hertfordshire (UK);
- Prof. dr. Tom Theuns, reader in Astrophysics at Durham University (UK) and part time professor of Astrophysics at University of Antwerp (BE);
- Prof. dr. Gustaaf Borghs, professor emeritus of Physics at KU Leuven (BE) and senior fellow at the Interuniversity MicroElectronics Centre (IMEC);
- Dr. ir. Jaap Flokstra, retired associate professor Nanotechnology at University of Twente;
- Prof. dr. ir. Guido van Oost, full professor Plasma Physics at the Department of Applied Physics of Ghent University (BE);
- Dr. Henk Blok, retired associate professor at the Faculty of Sciences of VU University Amsterdam;
- Prof. dr. Martin Goedhart, professor Didactics of Mathematics and Natural Sciences at University of Groningen;
- Christianne Vink MSc, didactic coach, educational advisor/trainer and partner of Academic Factory;
- Dr. Jan Hoogenraad, owner of Spoorgloren BV for change management and quantitative service in public transport;
- Dr. ir. Harald Tepper, chief strategy officer at the Dutch Forensic Institute;
- Sander Breur MSc, PhD candidate at Nikhef, University of Amsterdam;
- Lisanne Coenen BSc, master student Applied Physics at Delft University of Technology;
- Carmen van Schoubroeck, bachelor student Mathematics and bachelor student Physics and Astronomy, Radboud University Nijmegen;
- Jelmer Wagenaar MSc, PhD candidate in Physics at Leiden University.

Preparation
The committee held a preliminary meeting on October 8, 2013. During this meeting the committee was instructed about the accreditation framework and the programme of the upcoming assessments. A vice chair for each visit was appointed and the Domain Specific Framework for Physics and Astronomy was set.

To prepare the contents of the site visits, the coordinator first checked the quality and completeness of the critical reflections prepared by the programmes. After establishing that the reports met the demands, they were forwarded to the participating committee members. The committee members read the reports and formulated questions on their contents.

Apart from the critical reflections, the committee members read a selection of fifteen master theses. The theses were randomly chosen from a list of graduates of the last two completed academic years within a range of grades.

Site visit
A preliminary programme of the site visit was made by the coordinator and adapted after consultation of the coordinator of Delft University of Technology. The time table for the visit in Delft is included as Appendix 6.

Prior to the site visit, the committee asked the programmes to select representative interview partners. During the site visit, meetings were held with panels representing the faculty management, the programme management, alumni, the educational committee and the Board of Examiners. Meetings were also held with representatives of the students and teaching staff.

During the site visit, the committee examined material it had requested; an overview of this material is given in Appendix 7. The committee gave students and lecturers the opportunity – outside the set interviews – to speak informally to the committee during a consultation hour. No requests were received for this option.

The committee used the final part of the visit for an internal meeting to discuss the findings. The visit was concluded with a public oral presentation of the preliminary impressions and general observations by the chair of the committee.

Report
Based on the committee's findings, the secretary prepared a draft report. This report was presented to the committee members involved in the site visit. After receiving approval, the draft report was sent to the Faculty with the request to check it for factual inaccuracies. The comments received from the Faculty were discussed with the committee chairman. Subsequently, the definitive report was approved and sent to Delft University of Technology.

Decision rules
In accordance with the NVAO's Assessment Framework for Limited Programme Assessments (as of 22 November 2011), the committee used the following definitions for the assessment of both the standards and the programme as a whole.

Generic quality
The quality that can reasonably be expected in an international perspective from a higher education bachelor's or master's programme.

Unsatisfactory
The programme does not meet the current generic quality standards and shows serious shortcomings in several areas.

Satisfactory
The programme meets the current generic quality standards and shows an acceptable level across its entire spectrum.

Good
The programme systematically surpasses the current generic quality standards across its entire spectrum.

Excellent
The programme systematically well surpasses the current generic quality standards across its entire spectrum and is regarded as an (inter)national example.

Summary judgement

This report reflects the findings and considerations of the committee on the master's programme Applied Physics at Delft University of Technology. The two-year programme distinguishes five tracks, closely connected to the six research departments of the Faculty of Applied Sciences. Apart from choosing one of those tracks, students can also opt for the Erasmus Mundus programme in Optics and Science and Technology (OpSciTech). For students interested in pursuing a PhD position, the programme offers the so-called Casimir-track and the track Transport Phenomena and Fluid Flow.

Standard 1: Intended learning outcomes
The master's programme Applied Physics at TUD aims to distinguish itself from the physics programmes at general universities in the Netherlands by its emphasis on transferable skills that are particularly useful for positions in the private sector. Its focus is on physics topics that are applicable in devices, industrial plants, medicine, etcetera.

The committee has studied the Domain Specific Framework of Reference as established by the national council of programme directors. It agrees with the requirements the Framework sets for the intended learing outcomes of master's programmes in (applied) physics. Furthermore, it has established that the programme's intended learning outcomes adequately fulfil the requirements of the Framework and meet the criteria for level and domain of an academic master's degree programme. The committee encourages the programme to further strengthen the applied profile of its intended learning outcomes by explicitly relating its learning outcomes to the the criteria for Academic Competences and Quality Assurance (ACQA), as formulated by the three Dutch technical universities.

Standard 2: Teaching-learning environment
The master's programme Applied Physics consists of five different tracks, eight specializations and three special programmes. The committee was impressed with the broad spectrum of choices the programme offers and appreciates the special options for students who are considering to pursue a PhD project. Students are well aware of the options available to them. Some of the choices available are less popular, which sometimes results in pragmatic solutions for courses with less than five students. The viability of those options should be monitored.

The committee has established that the majority of the learning outcomes are translated well into the curriculum, but that design skills should be more visibly and structurally incorporated into the programme. The committee has concluded that students and alumni are content with the way the academic and professional orientation of the programme is balanced in the curriculum.

The programme's study load and average study duration are acceptable. The committee established that some students take more time for their final research project, despite actions already taken to prevent delays. It advises the project supervisors to make an agreement with students about time path and mutual expectations prior to the start of the project.

The committee is positive about the expertise, engagement and approachability of the teaching staff. Although BKO training for existing staff and other activities to improve the didactic skills of lecturers started relatively late, the programme is now making good efforts to catch up. The study advisor and tutors help students to find their way through the programme. The committee was impressed with the active role the Board of Studies plays in advising the programme director about all issues concerning the quality of the programme. The system of evaluation functions adequately in signalling and resolving issues or bottlenecks within the programme.

Based on those considerations, the committee concludes that the master's programme fulfils the requirements for the teaching and learning environment.

Standard 3: Assessment and achieved learning outcomes
The programme works with a variety of tests during the courses, like assignments, reports and presentations. Final tests consist of oral and written exams; often, courses work with combinations of test methods. Tests are designed by at least two staff members in collaboration.

The committee established that the tests used are sufficiently varied and adequately address the course contents. The committee appreciates the use of oral exams in the master's programme as a valid and efficient way of testing certain designated learning objectives. As the recently developed test matrices show, testing could more systematically be attuned to the intended learning outcomes per course.

The Board of Examiners is well aware of its tasks as assigned by the 2010 Law on Higher Education and has phased in appropriate measures. The assessment committee approves of this working method. The committee appreciates the measures taken and plans for the coming years. It advises the Board to further systematize its controls and checks for plagiarism and fraud. Furthermore, it urges the Board of Examiners to pay special attention to the achieved learning outcomes within the Erasmus Mundus OpSciTech programme.

Students finish their final research project by writing a master thesis. They then have an exam consisting of a public presentation and a private defense in front of an examination committee consisting of at least four staff members. After the defense, the committee decides in a closed session on the final mark.

The committee concludes positively about the way the final projects and the resulting master theses are carried out and assessed. It particularly appreciates the assessment forms used by the examiners. Based on the master theses the committee has studied and the extra session with the examiners, the committee has established that the achieved learning outcomes of the master's programme are satisfactory.

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

Standard 1: Intended learning outcomes	satisfactory
Standard 2: Teaching-learning environment	satisfactory
Standard 3: Assessment and achieved learning outcomes	satisfactory
General conclusion	satisfactory

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

Date: 30 April 2014

H. P. Blok

Dr. Henk Blok, Chair

Kees-Jan van Klaveren MA, Secretary

Description of the standards from the Assessment framework for limited programme assessments

Standard 1: Intended learning outcomes
The intended learning outcomes of the programme have been concretised with regard to content, level and orientation; they meet international requirements.
Explanation: As for level and orientation (bachelor's or master's; professional or academic), the intended learning outcomes fit into the Dutch qualifications framework. In addition, they tie in with the international perspective of the requirements currently set by the professional field and the discipline with regard to the contents of the programme.

Findings

In this paragraph the findings of the committee about the intended learning outcomes of the master's programme are described: their relation to the Domain Specific Framework of Reference, their level and orientation. After considering the findings the committee comes to a conclusion on Standard 1.

Domain Specific Framework of Reference
The national council of program directors of the Physics and Astronomy programmes has established a Domain Specific Framework of Reference (DSRK) for the assessment of the bachelor's and master's programmes in those disciplines. The program directors revised the Framework that has been written for the assessment of Physics and Astronomy in 2007. That Framework in turn was inspired by the intended learning outcomes as formulated in the European Tuning-project document *'Reference points for the design and delivery of degree programmes in physics'*, which has set an international standard. This document also uses the Dublin descriptors as guideline for differentiation between bachelor and master level. The current DSRK is furthermore based on the more recent documents *'A European Physics Bachelor Study'* en *'A European Physics Master Study'* (2009) by the European Physics Society. The DSRK for master's programmes can be found in Appendix 2. The committee agrees with the requirements the DSRK sets for the intended learing outcomes of master's programmes in (applied) physics.

The intended learning outcomes of the master's programme Applied Physics of Delft University of Technology (TUD) have been described in the critical reflection. Those learning outcomes can be found in Appendix 3. Furthermore, the critical reflection contains an overview of how the competences and skills as prescribed by the DSRK are reflected in the programme's intended learning outcomes. The committee has studied the intended learing outcomes of the master's programme Applied Physics and concludes that they adequately meet the requirements of the DSRK.

Profile
According to the critical reflection, the master's programme Applied Physics at TUD distinguishes itself from the physics programmes at general universities in the Netherlands by its emphasis on transferable skills that are particularly useful for positions in the private sector. Its focus is on physics topics that are applicable in devices, industrial plans, medicine, etcetera.

The programme distinguishes five tracks, closely connected to the six research departments of the Faculty of Applied Sciences:

- Bionanoscience;
- Fluid Flow and Transport Phenomena;
- Imaging Physics;
- Quantum Nanoscience;
- Radiation Science and Technology.

Apart from choosing one of those tracks, students can also opt for the Erasmus Mundus programme in Optics and Science and Technology (OpSciTech), which is organized in collaboration with the Imperial College in London (recently replaced by the University of Eastern Finland in Joensuu), the Friedrich Schiller University in Jena, the Université Paris-Sud 11 and the Institut d'Optique Graduate School in Paris/Palaiseau and the Warsaw University of Technology. For students pursuing a PhD position, the programme offers the so-called Casimir-track (in collaboration with the Leiden Institute for Physics Research) and the track Transport Phenomena and Fluid Flow (in collaboration with the J.M. Burgers Centre for Fluid Mechanics and the National Graduate School for Engineering Mechanics).

The committee concludes that the programme has a clear and recognizable profile fitting for a master's programme in physics. The committee is impressed with the number of tracks and options for students to specialize in a domain of their interest, and is delighted that those tracks are strongly linked with the Faculty's research departments. Also, the committee approves of the special options for students to prepare for a PhD. However, the committee feels that there are opportunities to improve on the applied profile of the programme. The programme did not relate its intended learning outcomes to the criteria for Academic Competences and Quality Assurance (ACQA). Those ACQA criteria have been formulated by the three Dutch technical universities (3TU) in order to further specify the rather generic Dublin descriptors for applied academic programmes. The committee advises the programme to use those ACQA criteria as a tool to strengthen the applied profile of its intended learning outcomes.

Level and orientation
The programme intends to reach an academic master level. As the committee has already established that the intended learning outcomes meet the requirements of the DSRK, which in turn is based on the Dublin descriptors, the committee concludes that the intended outcomes are indeed fitting for an academic master's programme. This is also exemplified in intended learning outcome 2, which requires students to have 'in-depth knowledge of at least one area within Applied Physics', and learning outcome 3, according to which students gain 'thorough experience of research in (Applied) Physics and complete awareness of the applicability of research in technological developments'.

Considerations

The committee has studied the Domain Specific Framework of Reference as established by the national counsil of programme directors. It agrees with the requirements the DSRK sets for the intended learing outcomes of master's programmes in (applied) physics.

The committee concludes that the programme's intended learning outcomes adequately fulfil the requirements of the DSRK and meet the criteria for level and domain of an academic master's degree programme. The committee encourages the programme to further strengthen the applied profile of its intended learning outcomes.

Conclusion

Master's programme Applied Physics: the committee assesses Standard 1 as 'satisfactory'.

Standard 2: Teaching-learning environment

The curriculum, staff and programme-specific services and facilities enable the incoming students to achieve the intended learning outcomes.

Explanation:
The contents and structure of the curriculum enable the students admitted to achieve the intended learning outcomes. The quality of the staff and of the programme-specific services and facilities is essential to that end. Curriculum, staff, services and facilities constitute a coherent teaching-learning environment for the students.

Findings

In this standard the curriculum (design, coherence and translation of intended learning outcomes, studyload and feasibility) of the programme is examined. In addition, the staff, facilities and programme-specific quality assurance are discussed.

Design and coherence of the curriculum
The master's programme Applied Physics consists of 120 EC, spread over two years. The programme is structured in a core curriculum (90 EC) and a choice of eight specializations (30 EC). Within the core curriculum, students choose one of the five tracks described under Standard 1. Each of those tracks consists of two mandatory courses – Mathematical Methods for Physics (9 EC) and Ethics and Engineering (3 EC) – and a choice of two out of four general courses (the 'G-list', 12 EC). Another 12 EC is filled in with a track-related programme. Students need to make a choice of two departmental courses (referring to the research department organizing the track, the 'D-list'). Together with their thesis supervisor, they choose a thesis-related elective (6 EC), which needs to be taken from the D- or G-list, or from the 'R-list' (specialized research courses) or 'M-list' (mathematics courses). The core curriculum is concluded by the Master End Project (48 EC).

Students have a choice of eight specializations, half of which contain an internship:

- Research and Development
- Nuclear Science and Engineering
- Sustainability in Technology
- Management of Technology
- Entrepeneurship
- Astronomy and Instrumentation
- Education 1 ('tweedegraads') or 2 ('eerstegraads', only available for students who chose Education 1 as minor in the bachelor's programme)
- Casimir (as part of the Casimir track)

Students can also opt for one of the three special programmes:

- *Optical Science and Technology (OpSciTech)*: students take either the first or second year of the programme in Delft, and the other year at a university abroad (see Standard 1). If the student spends the first year in Delft, he/she will take the mandatory courses, Advanced Electrodynamics, some electives in optics and a 12 EC research project in optics. If he/she spends the second year in Delft, the student will take 12 EC of electives and finishes with a Master End Project (48 EC).
- *Casimir*: students take a special programme as developed by the Casimir Graduate School (a joint Leiden-Delft initiative). This programme prepares excellent students for a PhD

position. The curriculum has no industrial internship, but includes writing a research proposal and two minor research projects, to be carried out in a different research group (and, preferably, a different university) than the final research project.

- *Transport Phenomena and Fluid Flow (TPFF)*: this programme is intended for excellent students who are interested in pursuing a PhD position in the field of fluid and/or solid mechanics. Students at the TU Delft (the programme is also available at the other Dutch technical universities) follow a curriculum very similar to the regular AP curricula, with electives and a final project in fluid/solid mechanics and options for doing an internship. Also, students write a PhD research proposal at the end of the programme.

The committee has studied the different tracks, specializations an special programmes, and learned that the master's programme also offers options to follow an honours track or a double-degree programme. The committee is impressed with this broad spectrum of options, but also noticed that the popularity of those options varies. Lecturers explained that if less than 5 students are enrolled for a course, it is customary to replace seminars and lectures by self-study and home assignments. The committee thinks that this is a pragmatic solution, and advises the programme to critically assess whether the different options and underlying courses remain viable in terms of the number of students participating.

The committee also discussed with students and lecturers whether students were aware of all the options available to them and whether they thought the programme was coherent enough. Students confirmed that they felt well informed about the different options and emphasized that they appreciated the opportunities to specialize in a subject of their interest. They informed the committee that it is relatively easy to enrol for courses at other universities as well.

Although the programme does not prescribe a mandatory order for the different curriculum components, its design is to let students do their course work in the first year, whilst the second year is reserved for the internship and the final project. In most cases, the internship is a full-time activity for students (about three months), after which students need the remaining time to do their research project and write their thesis. This results in a slight imbalance in the spread of EC's over the years (54 versus 66 EC), but students and lecturers prefer this option over reducing the number of EC for the final project.

During the final project, students carry out their research in one of the research groups. For the duration of the project students participate in the meetings and activities of the research group. Daily supervision of their project is sometimes partly done by PhD students or PostDocs. Students and alumni reported enthusiastically about their project work, but admitted that the planning of the project was not always clear; alumni also mentioned that there was an unspoken expectation that working longer might result in a better grade. However, the lecturers denied that students would obtain a higher grade by working longer on the project. The committee advises the programme management to adopt a form in which student and supervisor agree on a time path and their mutual expectations about the research project and write this down.

Translation of intended learning outcomes in the curriculum

In the critical reflection, the programme included a table which described how and where the intended learning outcomes are realized in the programme. The committee has studied this table and compared it with the course information and the test matrices that had just been published at the moment of the site visit. The committee concludes that the majority of the learning outcomes are adequately translated in the curriculum. It emphasizes however that the large amount of tracks, specializations and options available makes it harder to ensure that each individual student will indeed acquire all the knowledge and skills defined by the intended learning outcomes. The programme management claimed that the introduction of core courses was a valuable improvement in this respect.

The committee agrees, but advises the programme management to devote special attention to skills such as oral and written presentation and working in an interdisciplinary team. It expects that the test matrices will provide an extra tool to check whether individual study paths include a reasonable amount of practice in those skills. The committee also asked students and alumni whether they felt well-prepared in this respect, as the alumni enquiry showed that "taking into account the temporal and social context" and "teamwork" aspects could be improved. The interviewed alumni stated that they needed to improve on some of those skills (and other ones, such as management skills) while working in industry – but that employers did not expect them to be thoroughly trained in this respect. Alumni argued that they preferred the extensive training in analytic and conceptual skills that the programme offers. Students and alumni both agreed that internships and activities by the student association VvTP offer the most concrete preparation for the labour market, and that they would not recommend to further expand on those activities at the cost of the programme's academic orientation. The committee concludes that the curriculum shows a satisfactory amount of professional orientation. It agrees with students and alumni that the current balance in scientific versus professional orientation seems to work well in practice.

The committee was less convinced that programme objective 5 ('[The student is] Capable of creating innovative technical designs, taking feasibility issues into account') is adequately translated into the curriculum. One of the options for students is to practice their design skills in the final research project, but this depends on the choices students make. The programme's Board of Studies informed the committee that it will advise the programme director shortly on this point, based on its finding that design skills were lacking in the programme's test matrices. The committee agrees with the Board of Studies that design skills should be translated more visibly and structurally into the curriculum.

Study load and feasibility
The critical reflection states that over the past eight years, students on average finished the programme after 25 months. International students take a shorter time than average – which can partly be explained by the extra pressure due to their study grants, and partly by the international exchange of OpSciTech-students who already finished their first year – , whilst HBO students (students with a degree from a vocational university) take longer than average. The critical reflection explains that the longer duration for HBO students is caused by the fact that they need to follow a 36 EC bridging programme. In 2010, the university introduced the 'harde knip', which forbids bachelor students to enrol for exams of master courses. In the years before this measure was introduced, bachelor students could complete some master courses before they registered as master students. Therefore, the average study duration might in fact be somewhat longer than 25 months.

The committee asked students and alumni whether there were any problems or obstacles that might negatively influence the feasibility of the programme. Students responded that they need to work hard in order to stay on track, but that no course or part of the curriculum is too challenging. They stated that the courses within the different tracks and specializations are scheduled adequately – but that scheduling courses gets more complex if students choose to mix between tracks and specializations. Finally, the committee spent special attention to the 39 EC bridging programme for HBO students, which just exceeds a six-months study load. A total of 18 EC's of these courses can be taken as part of the master's programme (replacing the industrial internship), so that only 21 EC's need to be taken before starting the master's programme. This brings the total number of EC's for bridging and master's programme to 141, which suggests a total duration of 2.5 years. However, students and alumni explained that most HBO students take a year to bridge the gap, which brings the actual duration of their master's programme to three years.

The committee studied the material of a number of courses in more detail and concludes that those courses were well set up and showed a level that might be expected for a master's programme. The literature for those courses is relevant and up-to-date, the assignments show an adequate level.

The committee concludes that it has found no substantial problems with the programme studyload and feasibility. The committee finds it acceptable that students who try to mix courses from different tracks/specializations might need to address some scheduling issues. It advises the programme management to communicate more clearly to HBO graduates that – although the number of EC's suggests otherwise – in practice, most students take a year to complete the bridging programme.

Staff and student support
The courses of the master's programme Applied Physics are mainly taught by staff from one of the five departments responsible for the tracks. The critical reflection states that all teaching staff has a PhD degree. The average number of students enrolled in the programme is 175, while the permanent scientific staff's teaching effort is calculated as 15.3 FTE. Thus, the student/staff ratio is 175/15.3=11.4. Newly appointed staff with less than five years of teaching experience is obliged to enrol for a teaching qualification track (Basis Kwalificatie Onderwijs, BKO).

In preparation of the site visit, the committee requested further details on the BKO-trajectory. The committee learned that at the moment of the site visit 48% of the permanent teaching staff met the BKO-requirements. The remaining 52% of the staff follows the regular BKO-trajectory or follows an assessment especially designed for permanent staff members. The assessment points out whether BKO modules have to be followed or can be waived. PhD candidates can also enrol for a basic BKO-course. The programme management formulated the ambition to also develop a senior teaching qualification track (Senior Kwalificatie Onderwijs, SKO) in 2015. The committee concludes that the current focus on the improvement of didactic skills is relatively late, but encourages the serious progress the teaching staff seems to be making on this point.

The committee got a positive impression of the teaching staff during the site visit. Lecturers spoke passionately about teaching in the programme. Students also praised the expertise and approachability of the staff. The committee was informed that staff members hold lunch meetings on a monthly basis, during which they exchange their impressions and ideas about education.

The committee also asked students about their experiences with counselling and tutoring. Students reported positively both on the role of the study advisor and on the system of tutoring for first-year international students. The tutors are recruited amongst second-year international students. The committee concludes that the system of student counselling and tutoring is functioning adequately.

Programme specific quality assurance
The programme director is responsible for the course quality. In order to monitor the quality of the courses, the programme is regularly evaluated in a number of ways. Each course is monitored through questionnaires which are handed out at the exam. Second, the student association VvTP organizes Lecture Response Group (College Responsiegroep, CRG) meetings. The results of the questionnaires and the reports of the CRGs are sent to the programme director and to the lecturers involved. Negative evaluations are also discussed with the programme's board of studies.

During the site visit, students and lecturers emphasized that evaluations in many cases have led to promptly initiated improvements. Especially the CRGs have been proven effective to quickly identify problems and solve them even during the course. The committee also got a positive impression of the programme's board of studies (opleidingscommissie Technische Natuurkunde, OCTN). The board recently advised on the use of the programming language Python and is preparing an advice to the programme director on embedding design skills throughout the curriculum. Student members of the board of studies are often recruited based on their work for student association VvTP, where they also stay in touch with their fellow students. The committee advises to secure that the student members represent all students and suggests that elections might help to achieve that.

The committee is impressed with the programme's quality assurance on a concrete level: problems are quickly identified and addressed. However, the committee also noticed that the recommendations of the 2007 assessment committee committee concerning learning outcomes per course and the limited practice in design skills have only recently led to improvements. The committee encourages the programme management to be as vigorous in its vision on the long term as it has already proven to be in its problem-solving ability on the short term. Based on the plans that the programme management shared with the committee during the site visit (better embedding of design skills in the curriculum, the ambition to implement a SKO trajectory), the committee is confident that the management will indeed do so.

Considerations

The master's programme Applied Physics consists of five different tracks, eight specializations and three special programmes. The committee was impressed with the broad spectrum of choices the programme offers and appreciates the special options for students who are considering to pursue a PhD project. Students are well aware of the options available to them. Some of the choices available are less popular, which sometimes results in pragmatic solutions for courses with less than 5 students. The viability of those options should be monitored.

The committee has established that the majority of the learning outcomes are translated well into the curriculum, but that design skills should be more visibly and structurally incorporated into the programme. The committee has concluded that students and alumni are content with the way the academic and professional orientation of the programme is balanced in the curriculum.
The programme's study load and average study duration are acceptable. The committee established that some students take more time for their final research project, and advises the project supervisors to make an agreement with students about time path and mutual expectations prior to the start of the project.

The committee is positive about the expertise, engagement and approachability of the teaching staff. Although BKO training for existing staff members and other activities to improve the didactic skills of lecturers started relatively late, the programme is now making good efforts to catch up. The study advisor and tutors help students to find their way through the programme. The committee was impressed with the active role the Board of Studies plays in advising the programme director about all issues concerning the quality of the programme. The system of evaluation functions adequately in signalling and resolving issues or bottlenecks within the programme.

Based on these considerations, the committee concludes that the master's programme fulfils the requirements for the teaching and learning environment.

Conclusion

Master's programme Applied Physics: the committee assesses Standard 2 as 'satisfactory'.

Standard 3: Assessment and achieved learning outcomes

The programme has an adequate assessment system in place and demonstrates that the intended learning outcomes are achieved.

Explanation:
The level achieved is demonstrated by interim and final tests, final projects and the performance of graduates in actual practice or in post-graduate programmes. The tests and assessments are valid, reliable and transparent to the students.

Findings

In this section, the system of testing and assessment is discussed and the findings of the committee with regard to the level achieved by the master graduates are described.

System of testing and assessment
Since 2010, the Board of Examiners is required by law to control the system of testing and assessment within the master's programme. The Board of Examiners of the faculty of Applied Sciences has implemented a number of changes in the past years and will continue to do so in the years to come in order to fully embrace its legal tasks. In the past years, the board made sure that the intended learning outcomes for each individual course were made explicit. Test matrices were formulated, and to each course two examiners have been asssigned. Furhermore, assessment forms and a 'grading scheme' have been introduced in order to ensure a more transparent assessment of the master theses. In the next phase, the Board of Examiners will annually critically review the test matrices. Also, the board will hold random checks on the quality of the master theses. Those checks will at least include the theses with the lowest grades. Members of the Board of Examiners will continue to act as second or third examiner in examination committees for graduation candidates.

The committee appreciates the measures by the Board of Examiners and encourages the board to implement its remaining plans. The committee deems it wise that the Board of Examiners has taken up its new tasks in phases, in order to convince the teaching staff of the value of new instruments such as test matrices. The committee has informed itself about the different testing methods of the programme via the online learning environment and by studying the test material of a selection of courses. The programme works with (combinations of) tests during the course (assignments, reports, presentations), oral exams and written exams. The committee concludes that the testing methods are adequate for testing the course contents, and that they are sufficiently varied. The committee especially values the use of oral exams in the master's programme, as this testing method challenges students to reproduce their knowledge of the subject material on the spot. The committee appreciates the fact that lecturers cooperate in designing the tests. During the site visit, the committee has studied the test matrices that had just been completed. Those matrices are an important first step towards a more systematic approach of testing the learning outcomes per course. The committee thinks that the quality of the test matrices needs to improve in order to optimally do so. In the current version, the quality and breadth of descriptions vary per course, which still makes it somewhat difficult to compare the learning outcomes per course.

The committee also discussed the topic of plagiarism and fraud with the Board of Examiners. The board explained that professional surveyors keep watch during written exams. Lately, the teaching staff uses the Blackboard plagiarism checker more regularly. The committee appreciates the increased attention for plagiarism and fraud, and advises the Board of Examiners to further systematize its controls and checks.

The committee has given special attention to the difficult but important task of guaranteeing that each student reaches a satisfactory level of achieved learning outcomes, given the number of tracks and options students can choose from. Especially with regard to the international OpSciTech programme, this is a challenging task for the Board of Examiners. The Board has installed procedures to make sure that students finishing their master's programme in Delft have successfully completed all curriculum components, and will also randomly check the quality of their theses. Apart from agreements about the curriculum, the board has no supervision on the quality of the work of students in their year at one of the other participating universities. The committee urges the Board of Examiners to make firm arrangements about the quality assurance of this programme with their colleagues at the other universities.

Achieved learning outcomes
As described under Standard 2, students finish the master's programme with a final project consisting of 48 EC. Each student is supervised by a staff member who acts as direct supervisor. The examination committee consists of at least three staff members, including the responsible supervisor. One of the examiners should belong to a different research group than the group where the project is carried out, and at least one of the examiners should be a full professor. External experts may be member of the committee. Students hand in their report and subsequently will have an exam consisting of a public presentation (45 minutes) and a private defense in front of the committee (60 minutes). After the defense, the committee decides in a closed session on the final mark, based on five criteria: theoretical knowledge, method and approach, the work done, report and presentation and a set of competences. A form addressing those criteria is filled in by the committee.

Prior to the site visit the assessment committee has studied fifteen master's theses to check whether students have achieved the intended learning outcomes. It concludes that the quality of the theses is good and matches the academic level that may be expected of a master's thesis. In general, it agrees with the marks assigned to the theses. The committee was especially impressed with the quality of the assessment forms. The committee initially had some doubts about the quality of one master thesis that had been graded with a 6 by the examiners. Therefore, a representation of the committee planned an extra session with the examiners of this thesis during the site visit. The examiners explained that the execution of the research project on which the thesis was based, was actually more complex than the report suggests. Failed experiments have not been included in the report. Furthermore, the project supervisor explained that he deliberately refrained from further improving the quality of the master thesis in order to have a fair and open discussion with his colleagues about whether this thesis could be assessed as sufficient. Based on this explanation, the assessment committee concludes that the grade given is tenable.

Considerations

The committee has established that the system of testing and assessment adequately meets the requirements for generic quality. Tests are designed by at least two cooperating staff members. The tests used are sufficiently varied and adequately address the course contents. The committee appreciates the use of oral exams in the master's programme. As the recently developed test matrices show, testing could more systematically be attuned to the intended learning outcomes per course.

The Board of Examiners is well aware of its tasks as assigned by the 2010 Law on Higher Education and has phased in appropriate measures. The committee approves of this working method and appreciates the measures taken and the plans for the coming years. It advises the Board of Examiners to further systematize its controls and checks for plagiarism and fraud.

The committee concludes positively about the way the final projects and the resulting master theses are carried out and assessed. It particularly appreciates the assessment forms used by the examiners. Based on the master theses the committee has studied and the extra session with the examiners, the committee has established that the achieved learning outcomes of the master's programme are satisfactory.

Conclusion

Master's programme Applied Physics: the committee assesses Standard 3 as 'satisfactory'.

General conclusion

In the committee's judgement the master's degree programme Applied Physics at Delft University of Technology fulfils the criteria for accreditation. It has noted many positive aspects and suggested several points for improvement. Weighing those points and the individual assessment of each standard, the committee concludes that the programme 'meets the current generic quality standards and shows an acceptable level across its entire spectrum' and consequently can be assessed as 'satisfactory'.

Conclusion
The committee assesses the *master's programme Applied Physics* as 'satisfactory'.

Appendices

Appendix 1: Curricula Vitae of the members of the assessment committee

Dr. H.P. (Henk) Blok studied Experimental Physics at the VU University Amsterdam. He got his PhD in 1972 at the same university and stayed at this university as assistant professor and PI. He did experimental work with the VU cyclotron and the electronics accelerator of NIKHEF and other places (Boulder, Osaka, Darmstadt, Orsay, JLab, DESY). He teached and supervised undergraduate, graduate and PhD students. Between 1998 and 2004 he occupied the position of programme director Physics and educational director of the Faculty of Sciences at the VU University Amsterdam. He retired in 2005 from these functions but is still active in experimental work and teaching.

Prof. dr. W. (Wim) de Boer from the Karlsruhe Institute of Technology is a leading expert in the fields of particle - and astroparticle physics. His main interest focuses on the search for the elusive dark matter, which makes up more than 80% of the matter in the universe, but its nature is unknown. Prof. De Boer participates in the search for dark matter using the CMS detector at the Large Hadron Collider (LHC) at the European Particle Physics Laboratory CERN in Geneva and the AMS-02 detector on the International Space Station. He also contributed to the phenomenology of Supersymmetry by showing that Supersymmetry can lead to a Grand Unified Theory with a perfect candidate for a dark matter particle. Prof. De Boer received his PhD at Delft University of Technology in 1974. Since 2009, he is member of the Advisory Committee IMAPP, Radboud University Nijmegen.

Dr. J. (Jaap) Flokstra was until his retirement in 2013 associate professor Applied Physics at University of Twente. Flokstra studied Applied Physics at Delft University of Technology. Since 1971 he was appointed at University of Twente in a number of positions. In 1977, he finished his dissertation *The role of the environment in low-frequency relaxation experiments*. Flokstra is (co)author of approximately 240 publications in scientific journals. He is well experienced in the field of academic education and has held several managerial positions at the University of Twente. From 2006 until 2013, Flokstra was program director of the bachelor's programme Advanced Technology and the master's programme Nanotechnology. In 2013 he started his own enterprise Vinci Focus.

Dr. J. (Jan) Hoogenraad did his master's degree in Physics and got his PhD in 1996 at the FOM Institute for Nucleair and Moleculair Physics (AMOLF) in Amsterdam. He was Research Scientist of the Philips Natuurkundig Laboratorium (1996-1998), System Engineer, Special Applications divisie, ASM Lithography (1998-1999), Product Development Manager Software Releases, ASM Lithography (1999-2004) and Manager Test and Quality, Nederlandse Spoorwegen (2003-2009). Since 2009 he has his own company, *Spoorgloren* for change management and quantative services in public transport. He publised 20 papers in acknowledged international Physics Journals and is member of the *Nederlandse Natuurkundige Vereniging*, The Institute of Physics (Londen), the American Physical Society and INCOSE (Association for Systems Engineering).

C. (Christianne) Vink MSc is didactic coach, educational advisor/trainer and partner at Academic Factory. She studied Psychology at VU University Amsterdam, where she graduated in 2009. From 1999 until 2006, she was a lecturer in refresher courses for (para)medic personnel. From 2010 until 2013, she was a lecturer at the at the University of Amsterdam Faculty of Science. Vink is specialized in teaching and in developing academic programmes designed to ensure training in 'critical reflection'. Vink is involved as assessor in multiple 'BKO'-trajectories and is well experienced in curriculum assessments of academic programmes. Together with a colleague Vink works on a book on the design of interdisciplinary curricula, forthcoming summer 2014.

C.T. (Carmen) van Schoubroeck is a third year bachelor student in Physics & Astronomy and Mathematics at Radboud University Nijmegen. As a student of the course "United Nations & Multilateral Diplomacy", she acts as member of the United Netherlands delegation. As a member of this delegation, she participated in a 2013 *Model United Nations*-conference at Harvard University. Van Schoubroeck is student member of the Education Policy Committee of the Nijmegen Faculty of Science. As member of the Physics promo-team, she helps at Information Days by answering questions of prospective bachelorstudents. She also helps secundary school students in preparing for exams in mathematics at the Stichting Studiebegeleiding Leiden.

Appendix 2: Domain-specific framework of reference

The goal of a university programme is to prepare students for an independent practise of the profession of the relevant discipline, and to give them the ability to apply the knowledge and skills they have acquired. Dutch university programmes in the domain of (applied) physics and astronomy are required to reach a level which allows the graduate to be competitive in the international research or job market, in particular with respect to countries which have a high profile in these areas. The domain-specific reference frame is meant to be a gauge for reaching this goal.

The framework is based on the one used in the Teaching Programme Assessment (Onderwijsvisitatie) of 2007. The basis for that framework was derived from the qualifications as formulated in the document '*Reference points for the design and delivery of degree programmes in physics',* which was a product of the so-called *Tuning Project*. The frame of reference to be presented below has been updated by also making use of the more recent '*A European Specification for Physics Master Studies'* of the European Physical Society (2009). The descriptors for the programmes have been formulated in terms of competences acquired by the graduating student, which leads to specific requirements for the curriculum. Programmes with the same name at different (Dutch) universities will in general not be identical. Different specialisations in the research staff or focus on particular subjects leads to differences in the eligible part of the programmes, and there is a structural difference between (the goals of) general universities and universities of technology. As a consequence, there are different ways to comply with the requirements of the reference frame. It is essential, however, that the local choices for, and colouring of the programme fits the internationally accepted standards.

Programme descriptors
Very similar to the BSc programmes, the descriptors for the MSc programmes can be described with three types of competences, as is done below. The sequence within each category is, with few exceptions, taken from what is called the 'Rating of Importance Order' in the Tuning document. The basic difference with the descriptors for the BSc programmes is the different emphasis. While a BSc programme aims at including some aspects of the forefront of knowledge, an MSc programme aims at providing a basis (or opportunity) for originality.

<u>(a) Discipline-related cognitive competences.</u>

	Specific competence	**Description. On completion of the degree course, the student should**
1	Modelling skills	be able to identify the essentials of a process/situation and to set up a working model of the same; be able to perform the required approximations; i.e. critical thinking to construct physical models
2	Problem solving skills	be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems
3	Knowledge and understanding of Physics	have a good understanding of the important physical theories (logical and mathematical structure, experimental support, physical phenomena described);

4	Familiarity with basic and applied research	acquire an understanding of the nature and ways of physics research and of how physics research is applicable to many fields other than physics, e.g. engineering; be able to design experimental and/or theoretical procedures for: (i) solving current problems in academic or industrial research; (ii) improving the existing results
5	Frontier research	have a good knowledge of the state of the art in (at least) one of the presently active physics specialties
6	Human / professional skills	be able to develop a personal sense of responsibility, given the free choice of elective/optional courses; be able to gain professional flexibility through the wide spectrum of scientific techniques offered in the curriculum
7	Physics culture	be familiar with the most important areas of physics and with those approaches, which span many areas in physics.
8	Absolute standards	have become familiar with highly regarded research in the field with respect to physical discoveries and theories, thus developing an awareness of the highest standards

(b) Discipline-related practical skills.

	Specific competence	**Description. On completion of the degree course, the student should**
9	Mathematical skills	be able to understand and master the use of the most commonly used mathematical and numerical methods
10	Computer skills	be able to perform calculations independently, even when a small PC or a large computer is needed, including the development of software programmes
11	Experimental skills	have become familiar with most important experimental methods and be able to perform experiments independently, as well as to describe, analyse and critically evaluate experimental data; and to be able to scientifically report the findings

(c) Discipline-related generic competences.

	Specific competence	**Description. On completion of the degree course, the student should**
12	Literature search	be able to search for and use physical and other technical literature, as well as any other sources of information relevant to research work and technical project development; have good knowledge of technical English.
13	Learning ability	be able to enter new fields through independent study
14	Ethical behaviour (relevant to physics)	be able to understand the socially related problems that confront the profession, and to comprehend the ethical characteristics of research and of the professional activity in physics and its responsibility to protect public health and the environment
15	Specific communication skills	be able to listen carefully and to present difficult ideas and complex information in a clear and concise manner to professional as well as to lay audiences; be able to work in an interdisciplinary team.

16	Managing skills	be able to work with a high degree of autonomy, even accepting responsibility in (project) planning, and in the managing of structures.
17	Updating skills	enjoy the ability to remain informed of new developments and methods, and be able to provide professional advice on their possible impact or range of applications.
18	Foreign language skills	be able to gain command of foreign languages through, usually elective, participation in courses taught in foreign language.

Note that in the generic competences in particular, learning ability and managing and updating skills receive more attention than in the description for the BSc programmes.

2. Programme

The variation in MSc programmes within the domains of Physics, Applied Physics, or Astronomy can be substantial. A general requirement is that the programme aims at teaching the student how to practice their profession in an independent manner. Central to the programme is therefore the individual research assignment, in which the student becomes acquainted with the daily research practice at a frontier of science. Similar requirements apply to Applied Physics programmes, with the understanding that the individual assignment can have a more applied character, and that a project can also have a focus on design. In all cases, the graduation assignment should preferentially be performed within a research group, and the student should be able to function as a fully-fledged member of the group. This requires a workplace which allows daily (social) contacts, and regular exchange of ideas, questions and thoughts with colleagues. This ensures the acquisition of a broad range of research skills.

These days, it is almost inevitable that physicists and astronomers operate in an international setting. The required level of the programme can therefore be indicated by referring to the exchange of information as occurs at scientific conferences and in scientific journals. The graduation work, delivered in the form of a thesis, should therefore link to that level. It should enable the student to enter the international market in a credible way, and research performed during the Master should regularly lead to, or be part of, a scientific publication. Apart from that, the research also has to be presented in oral manner.

In view of their future practicing of a profession, it is important that students learn to work with time constraints. The traditionally large freedom which Dutch students had and partly still have, can easily lead to the neglect of this aspect in study programmes. As this freedom is currently becoming less, it is the more important that the programmed safeguards and stimulates the progress of the student. Time management should be an explicit part of elements of the programme, in particular for a research project or an internship.

Apart from the research practice, the student should deepen his/her knowledge of physics by studying more specialised subjects, often through formal lecture series or study groups. Study programmes will probably want to offer a common core, but much of the direction for study will be furnished by the local research specialisations, and can therefore by quite different in focus.

An increasingly important facet of a disciplinary Master programme is that it can be combined with a different specialization in order to broaden the scope of professions which are open to the graduated student. Prime examples are specializations in the direction of education (leading to the profession of high school teacher, among others), science communication, or science-based business. In the latter case, study elements aiming more specifically at management or governance may be important. It can be expected from a programme that it allows students to orient themselves on the possibilities and ways to match their talents and interests with the job market. In the current Dutch system of a 2-year (120 EC) programme, the minimal requirement for a master's degree in Physics, Applied Physics or Astronomy is deemed to be one year of disciplinary studies. This leaves up to a year for such other specializations.

Appendix 3: Intended learning outcomes

1. **Physics knowledge.** Mastery of Applied Physics at an advanced academic level. This means mas- tery of advanced general physics subjects (such as Quantum Mechanics, Solid State Physics, Fluid Dynamics, Quantum Electronics and Electrodynamics) and the necessary mathematics, in addition to a choice of advanced technical subjects (such as Linear System Theory, Computer Science, Materials Science, Electronics, Data Analysis, Process Management and Control), as well as skills in the field of experimental techniques, theoretical analysis, simulation and modelling. This knowledge and these skills should be mastered at a level that is considered at least equal to that of other comparable Master's degrees at international, top-quality, educational institutions.
2. **In depth knowledge.** In-depth knowledge of at least one area within Applied Physics, so that inter- national research literature can be understood.
3. **Research experience.** Thorough experience of research in (Applied) Physics and complete aware- ness of the applicability of research in technological developments.
4. **From abstraction to solution.** Capable of understanding a wide variety of different problems and being able to formulate these at an abstract level, whilst being able to see the relation between diverse problems at this abstract level and to contribute creatively to their solution, focusing on practical applications.
5. **Design.** Capable of creating innovative technical designs, taking feasibility issues into account.
6. **Collaboration/communication.** Capable of working in a (possibly interdisciplinary) team of experts, performing the aforementioned activities and communicating easily in both written and spoken English.
7. **Working independently**. Capable of working independently and taking initiatives where necessary. Identifying areas where expertise is lacking and resolving the situation.
8. **Presentation skills.** Capable of making Dutch and/or English language presentations of personal research activities to varied audiences. Capable of adapting to the background and interest of the audience.
9. **Societal awareness.** Knowledge of technology-related developments in society, such as sustain- ability issues. Capable of developing and defending opinions in this area.

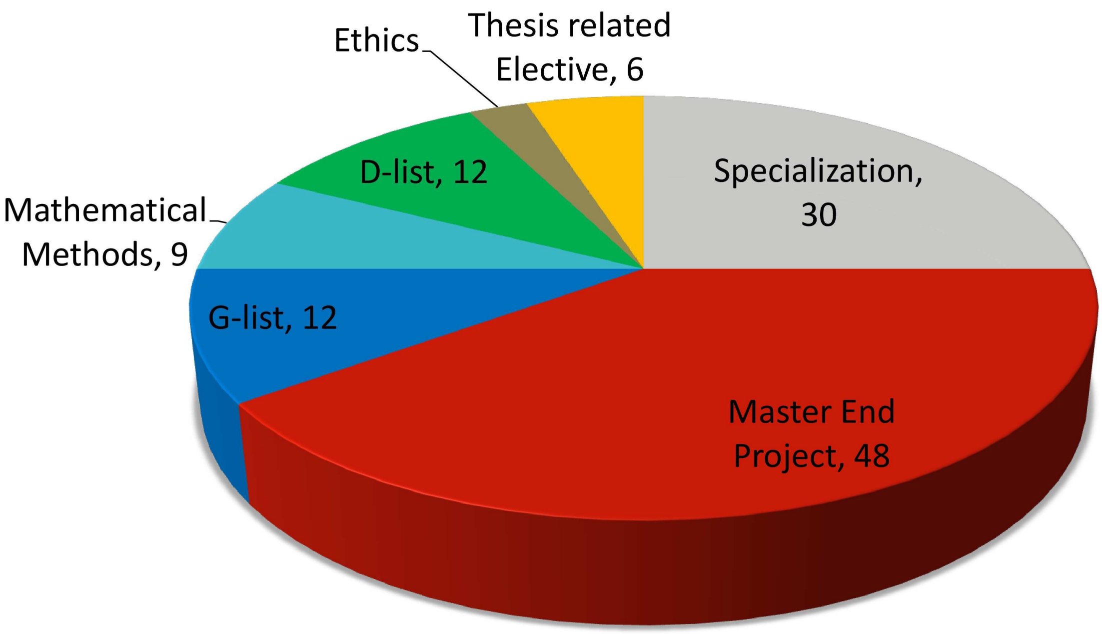
Appendix 4: Overview of the curriculum

The Applied Physics programme is a two-year Master's programme and comprises 120 EC. The programme has a core specialization structure and is very flexible and offers many possibilities to tailor it to the own interests of students. The actual programme students follow is determined by selecting courses from one of the tracks as well as additional specializations. Roughly speaking, the first year comprises course work, while the second year is primarily devoted to thesis work. Within the programme there is a choice of research tracks:

- Bionanoscience (BN)
- Imaging Science and Technology (IST)
- Transport Phenomena and Fluid Flow (TPFF)
- Quantum Nanoscience (QN)
- Radiation Science and Technology (RST)

The core programme comprises 90 EC and has the same structure for all tracks and students:

- 12 EC of G-list (General) modules: choose two (out of four) general advanced physics courses.
- 12 EC of D-list (Departmental/track) electives. At least one of those should be chosen from the department where students do their thesis project.
- 9 EC Mathematical Methods for Physics.
- 3 EC Ethics and Engineering - Students will explore the ethical and social aspects and problems related to technology and to their future work as a professional.
- 6 EC Thesis related elective(s).
- 48 EC Master's thesis work to be carried out in one of the applied physics departments within the faculty of Applied Sciences (BN, IST, TPFF , QN or RST) or in an affiliated group.



Combining the core programme with a 30 EC specialization completes the Master's programme. The specialization allows for either a deepening or a broadening of the student's degree programme. One of eight specializations can be chosen:

- Research and Development (R&D)
- Astronomy and Instrumentation (AI)
- Nuclear Science and Engineering (NSE)
- Technology in Sustainable Development (TiSD)
- Education (Ed1/Ed2)
- Management of Technology (MoT)
- Annotation in Entrepreneurship (AE)
- Casimir pre-PhD specialization (Cas)

The R&D, NSE and TiSD specializations have 3-month industrial internships (18 EC).

Appendix 5: Quantitative data regarding the programme

Data on intake, transfers and graduates

Intake

Year	Same University	Outflow Bachelor	Other Dutch University	HBO	Other	Total	Graduates
03/ 04	38	33	2	5	5	50	50
04/ 05	31	36	3	3	6	43	49
05/ 06	47	44	2	4	4	57	50
06/ 07	49	42	3	2	8	62	41
07/ 08	75	69	4	5	10	95	48
08/ 09	69	72	2	1	16	88	56
09/ 10	110	76	1	9	12	126	67
10/ 11	51	83	4	0	18	74	65
11/ 12	45	88	1	2	15	63	78

Course duration

	Same University			Other Dutch University		HBO		Other	
Graduation year	Nr. of Graduates	Course Duration (months)	Including BSc	Nr. of Graduates	Course Duration (months)	Nr. of Graduates	Course Duration (months)	Nr. of Graduates	Course Duration (months)
04/ 05	49	24	80						
05/ 06	44	26	80			2	27	4	24
06/ 07	38	24	84			1	44	2	25
07/ 08	36	25	75	1	33	2	51	9	23
08/ 09	45	25	82	1	68	1	38	9	12
09/ 10	56	26	82					9	16
10/ 11	56	26	81	1	57	2	40	6	14
11/ 12	65	30	80	3	50			10	33

Teacher-student ratio achieved

Ratio number of students per fte teaching staff (175/15.3):	11.4

Average amount of face-to-face instruction per stage of the study programme

Year	1	2
Contact hours	18	n/a*

* During the second year, most students will be working on their internship and/or final research project.

Appendix 6: Programme of the site visit

<table>
<tr><th colspan="3">Dag 1:</th></tr>
<tr><td>10.00</td><td>13.30</td><td>Voorbereidend overleg van de commissie + inzage documenten</td></tr>
<tr><td>13.30</td><td>13.45</td><td>Studenten (bachelor-2)
C.J. (Tijn) Molengraaf, 2e jaars
N. (Nena) Batenburg, 2e jaars
B.C. (Bram) van Meurs, 3e jaars</td></tr>
<tr><td>13.45</td><td>14.45</td><td>Management
<table>
<tr><td></td><td>TN</td><td>AP</td></tr>
<tr><td>Opleidingsdirecteur</td><td>Prof.dr.ir. P. (Pieter) Kruit</td><td>Dr. J.M. (Jos) Thijssen</td></tr>
<tr><td>Opleidingscoördinator</td><td>Ir. G.J. (Gert-Jan) Broekman</td><td>Ir. A.J.W. (Arno) Haket</td></tr>
<tr><td>Decaan TNW</td><td colspan="2">Prof.dr.ir. T.H.J.J. (Tim) van der Hagen</td></tr>
<tr><td>Directeur Onderwijs</td><td colspan="2">Prof.dr. R.F. (Rob) Mudde</td></tr>
<tr><td>Hoofd O&S TNW</td><td colspan="2">Dr. I.M. (Irma) Croese</td></tr>
</table></td></tr>
<tr><td>14.45</td><td>15.45</td><td>Studenten
<table>
<tr><td>TN</td><td>AP</td></tr>
<tr><td>A.J. (Arian) Stolk, 3e jaars
F.V. (Floris) van der Gronden, 1e jaars
C.C. (Coosje) Pothoven, 1e jaars</td><td>Y. (Katy) Wei BSc,
zij-instroom Cambridge, 2e jaars, track Bionanoscience -internationaal
L. (Lucinda) Kootstra BSc,
1e jaars, track Quantum Nanoscience
N. (Nick) Spook BSc,
2e jaars, track Imaging Science & Technology
J.V. (Julius) Huijts BSc,
2e jaars, track Radiation Science & Technology
Reserve:
Ing M.P. (Maudy) Mulder,
zij-instroom HBO, 2e jaars,
track Transport Phenomena & Fluid Flow</td></tr>
</table></td></tr>
<tr><td>16.00</td><td>17.00</td><td>Docenten
<table>
<tr><td>TN</td><td>AP</td></tr>
<tr><td>Prof.dr.ir. L.M.K. (Lieven) Vandersypen, Quantum Transport</td><td>Prof.dr.ir. H.S.J. (Herre) van der Zant, Molecular Electronics & Devices</td></tr>
<tr><td>Dr. C.W. (Cees) Hagen,
Deeltjesoptica</td><td>Dr. S.W.H. (Stephan) Eijt,
Fundamentals of Materials and Energy</td></tr>
<tr><td>Dr. M. (Miriam) Blaauboer,
Theoretische Natuurkunde</td><td>Dr.ir. S.F. (Silvania) Pereira,
Optica</td></tr>
<tr><td>Ir.drs. A.G.M. (Fons) Daalderop,
Numerieke Wiskunde</td><td>Dr. C.J.A. (Christoffe) Danelon
Bionanoscience</td></tr>
</table></td></tr>
<tr><td>17.00</td><td>17.30</td><td>Alumni
Ir. R. (Rianne) van den Berg
zij-instroom UU, Quantum Nanoscience, promotie UvA, aug 2012 afgestudeerd
Ir. F.P. (Rick) Bulk
zij-instroom HBO, Radiation Science & Technology,
ministerie van economische zaken, aug 2012 afgestudeerd
Ir. V.J.J. (Vincent) van Dijk
TN, Transport Phenomena & Fluid Flow,
IHC Merwede, nov 2011 afgestudeerd
Ir. R. (Robert) van Driel
TN, Transport Phenomena & Fluid Flow,
Allseas, april 2010 afgestudeerd
Ir. S.V. (Sander) den Hoedt
TN, Imaging Science & Technology,
eigen bedrijf – Delmic, dec 2010 afgestudeerd
Ir. R.P.J. (Robert) Nieuwenhuizen
TN, Imaging Science & Technology,</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>17.30</td><td>18.15</td><td>Intern overleg commissie</td></tr>
<tr><td>19.00</td><td></td><td>Diner (alleen commissie)</td></tr>
</table>

<table>
<tr><th colspan="3">Dag 2:</th></tr>
<tr><td>9.00</td><td>10.00</td><td>Intern overleg commissie</td></tr>
<tr><td>10.00</td><td>10.30</td><td>OLC (studenten en docenten)
<table>
<tr><td>Opleidingscie vz</td><td>Prof.dr. H.P. (Paul) Urbach</td></tr>
<tr><td>Docenten</td><td>Prof.dr. P.C.M. (Paul) Planken</td></tr>
<tr><td></td><td>Dr.ir. M. (Martin) Rohde</td></tr>
<tr><td></td><td>Dr. A.H. (Ad) Verbruggen</td></tr>
<tr><td></td><td>Dr. H.J.E. (Bertus) Beaumont (reserve)</td></tr>
<tr><td>Studentleden</td><td>J.M.J, (Jules) de Winter</td></tr>
<tr><td></td><td>M. (Michiel) Bongaerts</td></tr>
<tr><td></td><td>M.H.H. (Ellen) Tolboom</td></tr>
<tr><td></td><td>A.M.H. (Daan) Achterbergh BSc</td></tr>
<tr><td></td><td>J.D. (Dirk-Jan) Korpershoek (reserve)</td></tr>
</table></td></tr>
<tr><td>10.30</td><td>11.15</td><td>Examencie en studieadviseur
<table>
<tr><td></td><td>TN</td><td>AP</td></tr>
<tr><td>Examencie vz</td><td>Prof.dr.ir. C.R. (Chris) Kleijn</td><td>Prof.dr. E.H. (Ekkes) Brück</td></tr>
<tr><td>Examencie leden</td><td>Dr. M. (Miriam) Blaauboer
Dr. S.W.H. (Stephan) Eijt</td><td>Dr. B. (Bernd) Rieger
Prof.dr. Y.M. (Yaroslav) Blanter</td></tr>
<tr><td>Studieadviseurs</td><td>Drs. M. (Marisha) Reedijk</td><td>Ir. A.J.W. (Arno) Haket</td></tr>
</table></td></tr>
<tr><td>11.15</td><td>11.45</td><td>Open spreekuur</td></tr>
<tr><td>11.45</td><td>13.00</td><td>Lunch en voorbereiden eindgesprek</td></tr>
<tr><td>13.00</td><td>13.45</td><td>Eindgesprek met management
<table>
<tr><td></td><td>TN</td><td>AP</td></tr>
<tr><td>Opleidingsdirecteur</td><td>Prof.dr.ir. P. (Pieter) Kruit</td><td>Dr. J.M. (Jos) Thijssen</td></tr>
<tr><td>Opleidingscoördinator</td><td>Ir. G.J. (Gert-Jan) Broekman</td><td>Ir. A.J.W. (Arno) Haket</td></tr>
<tr><td>Decaan TNW</td><td colspan="2">Prof.dr.ir. T.H.J.J. (Tim) van der Hagen</td></tr>
<tr><td>Directeur Onderwijs</td><td colspan="2">Prof.dr. R.F. (Rob) Mudde</td></tr>
<tr><td>Hoofd O&S TNW</td><td colspan="2">Dr. I.M. (Irma) Croese</td></tr>
</table></td></tr>
<tr><td>13.45</td><td>16.00</td><td>Opstellen bevindingen</td></tr>
<tr><td>16.00</td><td>16.30</td><td>Mondelinge rapportage</td></tr>
</table>

Appendix 7: Theses and documents studied by the committee

Prior to the site visit, the committee studied the theses of the students with the following student numbers:

1104640	1192051	4142713
1224174	1549928	1347527
1272861	1323520	4195094
1266918	1307487	1336665
1321242	1361821	4120493

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

- Study material: books and syllabi, readers, study manuals;
- Minutes and reports of relevant committees (Educational Committee, Board of Examiners);
- Tests and assignments with the assessment criteria and standard answers;
- Summary and analysis of evaluation results;
- Regulations and manuals for internships and thesis;
- Information and documentation for students;
- Documents on the BKO programme;
- Alumni-surveys.

Furthermore, the committee has requested al available course materials for a selection of courses of the past academic year. The following courses have been selected:

- Advanced Electrodynamics
- Imaging Systems
- Nanotechnology

Appendix 8: Declarations of independence

nvao
nederlands - vlaamse accreditatieorganisatie

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: H. P. Blok

PRIVÉ ADRES:

Prinses Ireneplantsoen 18

1191 CB Ouderkerk aan de Amstel

IS ALS DESKUNDIGE / SECRETARIS GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

AANGEVRAAGD DOOR DE INSTELLING:

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

1

nvao
nederlands - vlaamse accreditatieorganisatie

VERKLAART HIERBIJ ZODANIGE RELATIES OF BANDEN MET DE INSTELLING DE AFGELOPEN VIJF JAAR NIET GEHAD TE HEBBEN;

VERKLAART STRIKTE GEHEIMHOUDING TE BETRACHTEN VAN AL HETGEEN IN VERBAND MET DE BEOORDELING AAN HEM/HAAR BEKEND IS GEWORDEN EN WORDT, VOOR ZOVER DE OPLEIDING, DE INSTELLING OF DE NVAO HIER REDELIJKERWIJS AANSPRAAK OP KUNNEN MAKEN.

VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: Nijmegen

DATUM: 3 nov. 2013

HANDTEKENING: H. P. Blok

2

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: Willem de Boer

PRIVÉ ADRES: Dekan-Hofheinz-Str. 26
D-76229 Karlsruhe

IS ALS DESKUNDIGE / SECRETARIS GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

AANGEVRAAGD DOOR DE INSTELLING:

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

1

[redacted]

VERKLAART HIERBIJ ZODANIGE RELATIES OF BANDEN MET DE INSTELLING DE AFGELOPEN VIJF JAAR NIET GEHAD TE HEBBEN;

VERKLAART STRIKTE GEHEIMHOUDING TE BETRACHTEN VAN AL HETGEEN IN VERBAND MET DE BEOORDELING AAN HEM/HAAR BEKEND IS GEWORDEN EN WORDT, VOOR ZOVER DE OPLEIDING, DE INSTELLING OF DE NVAO HIER REDELIJKERWIJS AANSPRAAK OP KUNNEN MAKEN.

VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: Karlsruhe DATUM: 21. 11. 2013

HANDTEKENING:

2

nvao
nederlands - vlaamse accreditatieorganisatie

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: J. Flokstra

PRIVÉ ADRES:

Andoorn 106
7577 AZ Oldenzaal.

IS ALS DESKUNDIGE / SECRETARIS GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

Technische Natuurkunde / Applied Physics

AANGEVRAAGD DOOR DE INSTELLING:

Technische Universiteit Delft

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

1

nvao
nederlands - vlaamse accreditatieorganisatie

VERKLAART HIERBIJ ZODANIGE RELATIES OF BANDEN MET DE INSTELLING DE AFGELOPEN VIJF JAAR NIET GEHAD TE HEBBEN;

VERKLAART STRIKTE GEHEIMHOUDING TE BETRACHTEN VAN AL HETGEEN IN VERBAND MET DE BEOORDELING AAN HEM/HAAR BEKEND IS GEWORDEN EN WORDT, VOOR ZOVER DE OPLEIDING, DE INSTELLING OF DE NVAO HIER REDELIJKERWIJS AANSPRAAK OP KUNNEN MAKEN.

VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: Delft DATUM: 28-01-2014

HANDTEKENING:

2

nvao
nederlands - vlaamse accreditatieorganisatie

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: J.H. HOOGENRAAD

PRIVÉ ADRES:

POSTBUS 2717

3500 GS UTRECHT

IS ALS DESKUNDIGE / SECRETARIS GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

AANGEVRAAGD DOOR DE INSTELLING:

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

1

nvao
nederlands - vlaamse accreditatieorganisatie

VERKLAART HIERBIJ ZODANIGE RELATIES OF BANDEN MET DE INSTELLING DE AFGELOPEN VIJF JAAR NIET GEHAD TE HEBBEN;

VERKLAART STRIKTE GEHEIMHOUDING TE BETRACHTEN VAN AL HETGEEN IN VERBAND MET DE BEOORDELING AAN HEM/HAAR BEKEND IS GEWORDEN EN WORDT, VOOR ZOVER DE OPLEIDING, DE INSTELLING OF DE NVAO HIER REDELIJKERWIJS AANSPRAAK OP KUNNEN MAKEN.

VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: UTRECHT

DATUM: 8 OKTOBER 2013

HANDTEKENING:

2

nvao
nederlands - vlaamse accreditatieorganisatie

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: Christianne R Valk
____

PRIVÉ ADRES: Turnerstraat 33C
1076 VC
Amsterdam
____

IS ALS DESKUNDIGE / SECRETARIS GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

____

____

AANGEVRAAGD DOOR DE INSTELLING:

____

____

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

1

nvao
nederlands - vlaamse accreditatieorganisatie

VERKLAART HIERBIJ ZODANIGE RELATIES OF BANDEN MET DE INSTELLING DE AFGELOPEN VIJF JAAR NIET GEHAD TE HEBBEN;

VERKLAART STRIKTE GEHEIMHOUDING TE BETRACHTEN VAN AL HETGEEN IN VERBAND MET DE BEOORDELING AAN HEM/HAAR BEKEND IS GEWORDEN EN WORDT, VOOR ZOVER DE OPLEIDING, DE INSTELLING OF DE NVAO HIER REDELIJKERWIJS AANSPRAAK OP KUNNEN MAKEN.

VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: Utrecht DATUM: 8-10-2013

HANDTEKENING:

2

nvao
nederlands - vlaamse accreditatieorganisatie

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: Carmen van Schoubroeck

PRIVÉ ADRES:
JACOB CANISSTRAAT 11F
6521 HG NIJMEGEN

IS ALS DESKUNDIGE / SECRETARIS GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

Natuur- en Sterrenkunde

AANGEVRAAGD DOOR DE INSTELLING:

[illegible]

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

1

VERKLAART HIERBIJ ZODANIGE RELATIES OF BANDEN MET DE INSTELLING DE AFGELOPEN VIJF JAAR NIET GEHAD TE HEBBEN;

VERKLAART STRIKTE GEHEIMHOUDING TE BETRACHTEN VAN AL HETGEEN IN VERBAND MET DE BEOORDELING AAN HEM/HAAR BEKEND IS GEWORDEN EN WORDT, VOOR ZOVER DE OPLEIDING, DE INSTELLING OF DE NVAO HIER REDELIJKERWIJS AANSPRAAK OP KUNNEN MAKEN.

VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: NIJMEGEN DATUM: 7-11-13

HANDTEKENING:

2

nvao
nederlands - vlaamse accreditatieorganisatie

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: Kees-Jan van Klaveren

PRIVÉ ADRES: Catharijnesingel 56
3503 RA Utrecht

IS ALS ~~DESKUNDIGE~~ / SECRETARIS GEVRAAGD VOOR HET BEOORDELEN VAN DE OPLEIDING:

Natuur- en Sterrenkunde

AANGEVRAAGD DOOR DE INSTELLING:

TU Delft

VERKLAART HIERBIJ GEEN (FAMILIE)RELATIES OF BANDEN MET BOVENGENOEMDE INSTELLING TE ONDERHOUDEN, ALS PRIVÉPERSOON, ONDERZOEKER / DOCENT, BEROEPSBEOEFENAAR OF ALS ADVISEUR, DIE EEN VOLSTREKT ONAFHANKELIJKE OORDEELSVORMING OVER DE KWALITEIT VAN DE OPLEIDING TEN POSITIEVE OF TEN NEGATIEVE ZOUDEN KUNNEN BEÏNVLOEDEN;

1

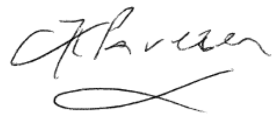
VERKLAART HIERBIJ ZODANIGE RELATIES OF BANDEN MET DE INSTELLING DE AFGELOPEN VIJF JAAR NIET GEHAD TE HEBBEN;

VERKLAART STRIKTE GEHEIMHOUDING TE BETRACHTEN VAN AL HETGEEN IN VERBAND MET DE BEOORDELING AAN HEM/HAAR BEKEND IS GEWORDEN EN WORDT, VOOR ZOVER DE OPLEIDING, DE INSTELLING OF DE NVAO HIER REDELIJKERWIJS AANSPRAAK OP KUNNEN MAKEN.

VERKLAART HIERBIJ OP DE HOOGTE TE ZIJN VAN DE NVAO GEDRAGSCODE.

PLAATS: Utrecht DATUM: 6 januari 2014

HANDTEKENING:



Technische Universiteit Delft (2)	Opleiding (CROHO-nummer)	Variant	Vervaldatum accreditatie
	B Technische Natuurkunde (56962)	Voltijd	31-12-2014
	M Applied Physics (60436)	Voltijd	31-12-2014
Secretaris:	Kees-Jan van Klaveren		
Commissieleden	Wim de Boer, Jan Hoogenraad, Jaap Flokstra, Henk Blok, Christianne Vink, Carmen van Schoubroeck		