BACHELOR’S PROGRAMME

TECHNISCHE NATUURKUNDE

FACULTY OF SCIENCE AND ENGINEERING

UNIVERSITY OF GRONINGEN

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Project number: Q0727

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This report was finalised on 1 October 2019

REPORT ON THE BACHELOR’S PROGRAMME APPLIED PHYSICS OF UNIVERSITY OF GRONINGEN

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 PROGRAMME

Bachelor’s programme Applied Physics

Name of the programme:	Technische Natuurkunde (Applied Physics)
CROHO number:	56962
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Specialisations or tracks:	-
Location:	Groningen
Mode of study:	full time
Language of instruction:	English
Submission deadline NVAO:	01/11/2019

The visit of the assessment panel Physics and Astronomy to the Faculty of Science and Engineering of University of Groningen took place on 13, 14 and 15 May 2019.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

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

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 1 February 2019. The panel that assessed the bachelor’s programme Applied Physics consisted of:

- Prof. dr. R. (Reinder) Coehoorn, full professor at the Eindhoven University of Technology, on the Physics and Application of Nanosystems. He is affiliated to the research group Molecular Materials and Nanosystems, in the Department of Applied Physics [chair];
- Prof. dr. M.J. (Margriet) Van Bael, professor at the Department of Physics and Astronomy of the Faculty of Science of the KU Leuven (Belgium);
- Prof. dr. G. (Garrelt) Mellema, professor at the Department of Astronomy of Stockholm University (Sweden);
- Prof. dr. S. (Sjoerd) Stallinga, professor and head of the Department Imaging Physics of Delft University of Technology;
- J. (Jeffrey) van der Gucht BSc, master’s student Physics and Astronomy at Radboud University [student member].

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

WORKING METHOD OF THE ASSESSMENT PANEL

The bachelor's programme Applied Physics at the Faculty of Science and Engineering of University of Groningen was part of the cluster assessment Physics and Astronomy. Between April 2019 and June 2019 the panel assessed 17 programmes at 5 universities.

Panel members
The panel consisted of the following members:

- Prof. dr. R. (Reinder) Coehoorn, full professor at the Eindhoven University of Technology, on the Physics and Application of Nanosystems. He is affiliated to the research group Molecular Materials and Nanosystems, in the Department of Applied Physics [chair];
- Prof. dr. M.J. (Margriet) Van Bael, professor at the Department of Physics and Astronomy of the Faculty of Science of the KU Leuven (Belgium);
- Prof. dr. H. A.J. (Harro) Meijer, professor of Isotope Physics, chairman of the Centrum voor Isotopen Onderzoek (CIO) and director of the Energy and Sustainability Research Institute Groningen at University of Groningen;
- Prof. dr. G. (Garrelt) Mellema, professor at the Department of Astronomy of Stockholm University (Sweden);
- Prof. dr. S. (Sjoerd) Stallinga, professor and head of the Department Imaging Physics of Delft University of Technology;
- Prof. dr. G. (Geert) Vanpaemel, professor for History of Science and Science Communication at KU Leuven Belgium);
- J. (Jeffrey) van der Gucht BSc, master's student Physics and Astronomy at Radboud University [student member];
- B. N. R. (Bram) Lap BSc, master's student Astronomy at University of Groningen [student member];
- L. (Laura) Scheffer BSc, master's student Physics at Utrecht University [student member].

For each site visit, assessment panel members were selected based on their expertise, availability and independence.

The QANU project manager for the cluster assessment was Peter Hildering MSc. He acted as secretary in the site visit of Leiden University and Utrecht University. In order to assure the consistency of assessment within the cluster, the project manager was present at the panel discussion leading to the preliminary findings at all site visits and reviewed all draft reports. Dr. Barbara van Balen acted as secretary in the site visits of University of Groningen and the University of Amsterdam/Vrije Universiteit Amsterdam, and drs. Mariëtte Huisjes was secretary at Radboud University. The project manager and the secretaries regularly discussed the assessment process and outcomes.

Preparation
On 15 March 2019, the panel chair was briefed by the project manager on the tasks and working method of the assessment panel and more specifically its role, as well as use of the assessment framework.

A preparatory panel meeting was organised on 12 May 2019. During this meeting, the panel members received instruction on the tasks and working method and the use of the assessment framework. The panel also discussed their working method and the domain specific framework.
A schedule for the site visit was composed. Prior to the site visit, representative partners for the various interviews were selected. See Appendix 4 for the final schedule.

Before the site visit, the programmes wrote self-evaluation reports of the programmes and sent these to the project manager. He checked these on quality and completeness, and sent them to the panel members. The panel members studied the self-evaluation reports and formulated initial questions and remarks, as well as positive aspects of the programmes.

The panel also studied a selection of theses. The panel studied the work and the assessment forms of 10 students, based on a provided list of graduates between 2017-2018. For this selection, the panel used the opportunity to select a lower number of theses as described in the NVAO framework when there is significant overlap between the assessed programmes in a single site visit. In the case of the bachelor's programme Applied Physics, this overlap consists of a shared Board of Examiners with the master's programme Applied Physics and the bachelor's and master's programme of Physics, as well as alignment of assessment procedures with the Astronomy Board of Examiners and an overlap in teaching staff between all six programmes. A variety of topics and tracks and a diversity of examiners were included in the selection. The project manager and panel chair assured that the distribution of grades in the selection matched the distribution of grades of all available theses.

Site visit
The site visit to University of Groningen took place on 13, 14 and 15 May 2019.

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.

During the site visit, the panel studied additional materials about the programmes and exams, as well as minutes of the Programme Committee and the Board of Examiners. An overview of these materials can be found in Appendix 5. The panel conducted interviews with representatives of the programmes: students and staff members, the programme's management, alumni and representatives of the Board of Examiners. 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 manager for peer assessment. Subsequently, the secretary sent the report to the panel. After processing the panel members' feedback, the project manager sent the draft reports to the faculty in order to have these checked for factual irregularities. The project manager discussed the ensuing comments with the panel's chair and changes were implemented accordingly. The report was then finalised and sent to the Faculty of Science and Engineering 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

Standard 1
The bachelor's degree programme in Applied Physics is provided by the Faculty of Science and Engineering of the University of Groningen. In the faculty's vision, Applied Physics is rooted in the established models and basic concepts of the physical sciences but is concerned with the utilisation of these scientific principles in practical devices and systems. The objective of the bachelor's degree programme is to offer students a solid understanding of the working of nature and to offer them the tools and techniques to apply this knowledge towards new designs. The panel appreciates that the profile of the degree programme has a strong link to the research topics and expertise of the Zernike Institute for Advanced Materials.

The programme described intended learning outcomes (ILOs) in line with its vision and within the framework of the Dublin Descriptors. The panel established that the ILOs sufficiently indicate what could be expected from students at a bachelor's level. It recommends defining them more specifically for the applied physics bachelor's programme and including the design orientation.

Standard 2
The bachelor's curriculum in applied physics consists of three coherent learning lines: basic physics, basic mathematics and skills. The curriculum builds up gradually from broad and general to deep and specialised. The required basic mathematics is concentrated in the first year. Higher-level mathematic subjects are taught as needed for later physics specialisations. Basic physics subjects are predominantly offered as 10 EC courses that run for a full semester. Skills training covers both academic and research skills and runs through the entire programme. Skills are not only taught in dedicated courses, they are also integrated in disciplinary courses and the research project. In the second half of the second year, the focus of the programme shifts from the general physics background to the applied physics profile, starting with Materials Science and Numerical Mathematics 1. In the third year, the focus is on technical-scientific aspects, with special attention being paid to applications and acquiring the knowledge and skills needed for designing. The bachelor's programme is completed by the Bachelor Research Project of 15 EC.

On paper, the first one and a half years of the applied physics curriculum is the same as the physics programme, but differs in its focus on design and engineering. The panel recommends making this specific focus more visible in the curriculum. The applied physics curriculum does not allow a minor, but offers electives to broaden the scope of the programme towards adjacent fields, such as biophysics or energy, or to deepen knowledge through more theoretically oriented courses. In addition, the panel recommends to investigate the establishment of a curriculum in which a 30 EC block is allocated for a minor, locally in Groningen or elsewhere in the Netherlands, or abroad, without interfering in any way with the major part of the curriculum.

Mentor groups in the first semester support the students to get acquainted with university teaching and learning and are aimed at group building and developing study skills. In the second semester the groups are continued as learning communities guided by staff members. The panel considers the introduction of these learning communities to be very positive.

The quality of the teaching staff is good. The panel finds that a good start has been made to innovate the teaching methods and recommends continuing in this line. The programme is feasible, and the success rates are in line with the national averages in science programmes. The choice to offer the programme in English is sufficiently substantiated according to the panel.

Standard 3
The programme director drafts an assessment plan annually at the programme level. In addition, a Course Unit Assessment Overview (CUAO) is available for each course. The programme uses different modes of assessment, such as multiple-choice and written exams, assignments, oral exams, presentations, reports and research projects. The preferred assessment method gradually shifts

towards methods more suited to assessing higher levels of knowledge and skills, reaching the level of evaluation and creation during the research project.

The panel finds the assessment system and policy adequately developed and implemented. The courses use a variety of assessment methods, which are aligned with the learning outcomes and the curriculum. The procedures are transparent for teachers and students. The panel is positive about the way the Board of Examiners is performing its tasks. The role of the BoE has obviously been extended and improved in the assessment period. The panel concluded that the examinations, tests and thesis assessment are transparent, valid and reliable. It values in particular the Course Unit Assessment Overviews for all courses.

Standard 4
The panel verified the alignment between the programme's intended learning outcomes and the courses and exams in the curriculum. It concluded that this alignment ensures that graduates have achieved the intended learning outcomes. It studied a selection of ten bachelor theses and their assessments. The theses demonstrated that the minimum level required for a bachelor's programme in applied physics had been reached and had been exceeded in many cases.

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

Bachelor's programme Applied Physics

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

Date: 1 October 2019

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

The bachelor's degree programme Technische Natuurkunde (international name: Applied Physics) is provided by the Faculty of Science and Engineering of the University of Groningen. This Faculty also offers the bachelor's degree programmes Physics and Astronomy and the master's programmes Physics, Applied Physics and Astronomy which are also being assessed in this cluster assessment. This report concerns the assessment of the bachelor's degree programme Applied Physics; the assessments of the other bachelor's and the master's degree programmes are described in separate reports.

The Faculty of Science and Engineering (FSE) is a large faculty, its programmes in research and education range from nanomaterials and bio-machinery to astronomy and also include mathematics, pharmacy, neurosciences, computer science and biology. Research at FSE is carried out in a number of institutes. Applied physics is strongly connected to the Zernike Institute for Advanced Materials (ZERNIKE).

All bachelor's degree programmes of the FSE are organised in the Undergraduate School of Science and Engineering (USSE), which is managed by the director together with the programme directors of the respective programmes.

Standard 1: Intended learning outcomes
The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings
The self-evaluation report describes that applied physics is rooted in the established models and basic concepts of the physical sciences but is concerned with the utilisation of these scientific principles in practical devices and systems, and in the application of physics in other areas of science. Applied Physics in Groningen has a strong focus on the design and scientific study of materials for functionality through its association with the Zernike Institute for Advanced Materials. It is directed towards unravelling the relations between the properties that determine their functionality and their chemical composition and structure. The panel established that there is indeed a strong link of the degree programme with the research topics and expertise of the Zernike Institute. The applied physics education prepares the students to enter the realm of nanoscience and nanotechnology and to participate in the quest to understand how things work at the microscopic level by providing them with a solid basis of established and contemporary physics knowledge, appropriate connections to adjacent fields, and a broad range of research and academic skills. The University of Groningen is the only university in the Netherlands offering a bachelor's programme in Physics alongside the bachelor's programme in Applied Physics.

The programme described intended learning outcomes (ILOs) within the framework of the Dublin Descriptors (see Appendix 2). The panel established that the ILOs are formulated in line with the mission and sufficiently indicate what could be expected from students at a bachelor's level. The intended learning outcomes indicate the content, level and orientation of the bachelor's programme. The distinction between the ILOs of the bachelor's and the master's programme is clear. The panel advises specifying the ILOs more in the direction of the programme's objectives. Currently, the ILOs resemble those for the physics programme and only differ in the adjective 'applied', whereas the focus of the Applied Physics programme is clearly different from the Physics bachelor's programme. The panel recommends emphasizing this design focus in the ILOs to underline the applied character of the programme (see also Standard 2).

The programme has aligned its ILOs with the domain-specific reference framework Physics (Appendix 1). This framework is used by all Physics and Astronomy programmes in the Netherlands. It was developed in a joint process at the European level (Tuning Physics) to align the Physics and Astronomy programmes at an international level. The ILOs use the Dublin descriptors to describe the knowledge, insights and skills that each bachelor's student in either Physics or Astronomy should acquire, regardless of his or her specialisation. The panel established that there is an alignment of the Physics and Astronomy programmes at a European level.

Considerations
The panel concluded that the ILOs of the bachelor's degree programme Applied Physics meet the Dutch qualification framework and the international standards. They sufficiently reflect the academic bachelor's level. The panel appreciates the strong link with the research topics and expertise of the Zernike Institute for Advanced Materials. The ILOs are aligned with the domain-specific reference framework for Physics, which was developed at the European level to align the Physics, Applied Physics and Astronomy programmes at an international level.

The panel recommends defining the ILOs more specifically for the bachelor's programme Applied Physics and include the design orientation.

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

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

Findings

Curriculum
The bachelor's curriculum in Applied Physics consists of three coherent learning lines:
- Basic physics: Mechanics & Relativity, Electricity & Magnetism, Thermodynamics & Statistical Physics, Quantum Mechanics 1, Waves & Optics, and Structure of Matter;
- Basic mathematics: Calculus 1+2, Linear Algebra 1, and Mathematical Physics;
- Skills: Physics Laboratory 1-3, Computational Methods for Science & Technology, Electronics & Signal Processing, and Physics, Astronomy, Ethics & Society.

The main goals of the first year are orientation, selection and basic education. The content and level of the first year are representative of the programme as a whole. Many courses are shared with Physics, Astronomy and Mathematics to facilitate the possibility to switch programmes. Teaching the required basic mathematics is concentrated in the first year. Basic physics subjects are predominantly offered as 10 EC courses that run for a full semester. From the second half of the second year, the focus of the programme shifts from a general physics background to the Applied Physics discipline, starting with Materials Science and Numerical Mathematics 1. In the third year, the focus shifts to technical-scientific aspects, with special attention being paid to applications and acquiring the knowledge and skills needed for designing. The programme concludes with the Bachelor Research Project of 15 EC. An overview of the programme is included in Appendix 3.

The Applied Physics curriculum does not allow a minor, but offers electives to broaden the scope of the programme towards adjacent fields, such as biophysics or energy, or to deepen knowledge through more theoretically oriented courses. However, the panel found that the Applied Physics curriculum leaves little freedom to choose for deepening or broadening. During the site visit, the panel discussed with the programme's representatives what the distinctive character of the Applied Physics is as compared to the Physics bachelor's programme, with which it shares many similarities in curriculum. Management and staff explained the panel that, although the curricula of the two programmes seem similar at first glance, there is clearly a different focus in the Applied Physics programme. For instance, the assignments and practicals for the Applied Physics students are specifically aimed at designing. Furthermore, the specific Applied Physics courses, including the bachelor project, are mainly taught and supervised by teachers associated with the Zernike Institute for Advanced Materials. The panel was able to verify this distinction in the interviews with teaching staff and students. It recommends to make this focus more visible in the description of the curriculum so the distinction between the programmes is also better visible on paper.

The skills training covers both academic and research skills and runs through the entire programme. Skills are not only taught in dedicated courses, they are also integrated in disciplinary courses and in the research project. When asked during the site visit, the students remarked that, in general, sufficient attention is paid to the development of presentation skills, which was confirmed by the teachers. The student chapter in the self-evaluation report stated that the students find that some attention is paid to other academic skills, such as writing reports and cooperating in a team. It is obvious that lab skills are trained in the lab courses (Physics Laboratory 1-3) and that computer, reporting and research skills are trained throughout the programme. In the self-evaluation report, the following courses were labelled for skills training: Computational Methods for Science & Technology, Electronics & Signal Processing, and Physics, Astronomy, Ethics & Society. Both teachers and students are of the opinion that computer skills and programming should be developed more without sacrificing any fundamental physics. The students suggested incorporating the development of computer skills, the Python course, in the physics courses. Teachers agreed with this suggestion and are already searching for a good place in the curriculum.

The panel finds the curriculum to be well-developed, managed and implemented, and there is a good alignment between it and the intended learning outcomes. It appreciates the coherent learning lines in the programme and established that ample attention is paid to the development of skills.

The University of Groningen chose to offer the programme in English with the aim to create an international academic environment. This choice is sufficiently substantiated according to the panel. An international academic community environment adds to the quality of the programme and prepares the students for their future career.

One of the recommendations of the former assessment panel was to pay more attention to career preparation in the programme. The panel learned during the site visit that the study association organises career-related activities, such as company visits. They are not very popular, however. Students assume this has to do with the fact that these activities are extracurricular. They would like to have more career orientation built into the bachelor’s curriculum. The programme management is now developing plans to invite guest lecturers from companies and offer field trips as part of the regular curriculum. The panel encourages it to develop and implement these plans.

Teaching forms
Courses are generally taught in the form of lectures and tutorials with various levels of student-teacher interactivity. During the site visit teachers informed the panel that almost all of them had followed the University Teaching Qualification training, which stimulated many of them to introduce activating teaching methods, for instance flipping the classroom and the use of quizzes. Active participation by the student is promoted and expected in the tutorials and during practical work and other group-based work forms. Limited-scale implementation of academic learning communities has been initiated in several course units. In these courses students work as a group on assignments, partly unsupervised.

In the first semester of the first year, students are placed in mentor groups, mentored by a more advanced student and supervised by a tutor (a teaching staff member). These mentor groups support the students to get acquainted with university teaching and learning and are aimed at group building and developing study skills. In the second semester of the first year, the learning communities can be seen as a continuation of the mentor groups guided by staff members of the associated research institutes. They have been recently introduced, and according to the management, the first evaluations are positive. The composition of the mentor groups, aiming for a mix of female and male as well as national and international students, is done by the academic advisor. Mentors are trained in intercultural competency.

The panel established that the teaching forms used in the programme are aligned with the intended learning outcomes and the content of the curriculum. It appreciates the introduction of more activating teaching forms and the implementation of learning communities.

Feasibility
The academic year is divided into two semesters, each divided into two periods of eight instruction weeks followed by two exam weeks. In every period three course components of 5 EC are taught. The nominal workload for students is 40 hours per week.

Nearly all students who drop out do so in the first and second years. The programme management monitors study success in the first few months with an early warning system, particularly based on the results for the Calculus 1 course. The academic advisor acts when flags go up and invites the student to discuss his/her study progress and planning. The programme management attributes dropouts primarily to switching between the programmes or to the negative Binding Study Advice (BSA).

The panel discussed the feasibility of the programme with both the teachers and the students. It concluded from these discussions that there are no obstacles in the programme that hinder the students from finishing their studies in time. In its opinion, the mentor groups and the early warning system are good measures to keep the students on track and support them in their first months at university.

Staff
The tenured staff members contributing to the programme all have a PhD degree and are actively involved in research. As mentioned, the teaching staff for specific Applied Physics courses is mainly connected to the Zernike Institute for Advanced Materials. Some 75% of the active teaching staff has acquired a University Teaching Qualification (UTQ), and 40% of the academic staff has an international background. During the site visit the teachers added that they found the didactical training to be very useful as they learnt to use more activating teaching methods. PhD students and postdocs are also involved in teaching, mainly as teaching assistants for tutorials. In the next academic year a mandatory didactical training will be offered for PhD students and postdocs.

The students are positive about the teachers and report that they are accessible; in their experience, the teachers are very willing to help and answer questions. The students are also very positive about the added value of the academic advisor; she knows how to get things done and helps students with their planning.
The panel established that the bachelor's programme is taught by experts strongly connected to research and that a high proportion of the tenured staff has sufficient didactical training. The proficiency in English of all tenured teacher staff is sufficient.

Facilities
The student chapter of the self-evaluation report mentioned that the facilities for the programme (lab spaces, lecture rooms and study places) are mostly adequate with the exception of the practical equipment which is outdated in their opinion. Not all students, however, experience this as a major problem. The panel agrees with the students that the facilities are mostly adequate, but thinks that the lab equipment needs some attention. The management informed the panel that investments are being made to update lab equipment and facilities.

Considerations
The curriculum of the bachelor's programme Applied Physics enables the students to achieve the intended learning outcomes. On paper, the first one and a half years of the applied physics curriculum is the same as the physics programme, but differs in its focus on design and engineering. The panel recommends making this specific focus more visible in the curriculum. It found the curriculum to be well-developed, managed and implemented, and there is a good alignment between it and the intended learning outcomes.

The panel established several positive aspects in the teaching-learning environment. It appreciates that the bachelor's programme is offered by experts who are closely connected to the Zernike Institute. Sufficient attention is paid to skills development in the programme.
In the panel's opinion the introduction of academic learning communities is a very positive development, with the intention to enhance student participation, sense-of-community, and ownership of the study programme. It encourages the programme management to monitor these communities closely.

The quality of the teaching staff is good, and the students are positive about the quality and dedication of their teachers. The university has an adequate policy and good intensive training programmes for enhancing the didactic quality of the teaching, resulting in awareness of the benefits of activating teaching methods. The panel thinks that a good start has been made to innovate the teaching methods and recommends continuing in this line.

The panel also appreciates the mentoring system and that the students are closely followed in the first semester to support their transition from secondary school to university. The programme is feasible, as the success rates are in line with the national averages for science programmes.

The programme-specific facilities are adequate, but the lab equipment needs some attention.

The choice to offer the programme in English is sufficiently substantiated according to the panel. The panel agrees with the faculty that an international academic environment adds to the quality of the programme and prepares the students for their future career.

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

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

Findings

Assessment policy
An assessment plan is drafted annually by the programme director and approved by the Faculty Board. It consists of a list of the examiners, modes of assessment of all course units, a list of individual Research Project supervisors and a matrix clarifying the relationship between the learning outcomes of the course units and the final learning outcomes of the degree programme. In addition to this assessment plan at the programme level, a Course Unit Assessment Overview (CUAO) is available for each course. This overview is a systematic description of the links between the learning outcomes, modes of instruction and modes of assessment and grading, and the position of the course in the curriculum. These overviews are updated annually. A summary of the CUAO is made available to the students. The panel studied several CUAOs during the site visit. It is very positive about these overviews.

The programme uses different modes of assessment, such as multiple-choice and written exams, assignments, oral exams, presentations, reports and research projects. The preferred assessment method throughout the curriculum gradually shifts towards ones more suited to assessing higher levels of knowledge and skills, reaching the level of independent creation during the research project.

As a rule, exams and assignments of course units are always drafted by two lecturers, or checked by a colleague (peer review). Individually supervised course units, like the bachelor research project, are assessed using a standard assessment form. Furthermore, at least two examiners are involved: the supervisor and a second examiner. The panel viewed the assessment forms used for the bachelor research project and discussed the use of this form as well as the procedure followed by the examiners with the teachers and the Board of Examiners during the site visit. It noticed that there is no grading rubric included in the form and that some of the completed forms lacked motivation for the grades. The students did inform the panel that they received extensive oral feedback on their bachelor's theses and that they were quite satisfied with that. The panel would, nevertheless, recommend formalising motivation of the grading on paper.

The panel finds the assessment system and policy adequately developed and implemented.

Board of Examiners
The Board of Examiners (BoE) for the bachelor's and master's degree programmes Physics and Applied Physics consists of four members, chosen from the teaching staff, and one external member. Since the last programme assessment several actions were taken to strengthen the role and the task performance of BoE. The BoE is responsible for ensuring the quality of examinations and final assessments. The BoE checks whether the Assessment Plan is appropriate for the intended learning outcomes of the programme, whether the suggested examiners are qualified for their role, whether there is sufficient variety in the modes of assessment and whether they are appropriate for the specific learning outcomes.

To check the assessment of the research projects, the BoE annually reviews at least 8 theses. Priority is given to theses with grades 6, 6.5 or 9 and higher. In the last assessment period the BoE generally agreed with the marks awarded by the supervisors. One aspect of improvement identified by the BoE was that the supervisors could elaborate more on the justification of grades on the assessment form. This aspect was also noted by the panel, as described above.

The CUAO is an important instrument for the BoE to check the quality of the assessments of the course units. To ensure the quality of examinations, the BoE checks the assessments of about eight course units annually. The panel is positive about the way the BoE is performing its tasks. Its role has obviously been extended and improved in the assessment period. The panel concluded that the examinations, tests and the thesis assessment are transparent, valid and reliable.

Considerations
The panel finds the assessment system and policy adequately developed and implemented. The courses use a variety of assessment methods, which are aligned with the learning outcomes and the curriculum. The procedures are transparent for teachers and students.

The panel is positive about the way the Board of Examiners is performing its tasks. Its role has obviously been extended and improved in the assessment period. The panel concluded that the examinations, tests and the thesis assessment are transparent, valid and reliable.

The panel particularly values the Course Unit Assessment Overviews (CUAOs) for all courses.

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

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

Findings
The self-evaluation report indicated that the bachelor's programme Applied Physics guarantees that students are educated regarding knowledge, skills, and attitude as specified in the learning outcomes by presenting a matrix of the intended learning outcomes and the curriculum. The panel verified this matrix and concluded that the curriculum ensures that graduates have achieved the intended learning outcomes. It studied a selection of ten bachelor's theses and their assessments. The theses showed that the graduates are capable of drawing up a research question and designing, planning and conducting research. They demonstrated that they can translate a physics problem into a plan of approach while taking practical boundary conditions into account. They showed that they are able to report on their research, are aware of the societal, ethical and social aspects of their project, and are able to write the report in English.

Almost all bachelor graduates proceed to a master's programme, usually the master's programme Applied Physics at the University of Groningen (73.4%), but also to the master's programme Physics of the same university, other master's programmes at the University of Groningen or master's programmes at other Dutch universities. The alumni felt well prepared for their master's programme.

Considerations
The panel concluded that graduates of the bachelor's programme Applied Physics have achieved the intended learning outcomes. It found the level of the bachelor's theses to be good. The graduates are well prepared for continuing their study in a master's programme.

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

GENERAL CONCLUSION

The panel judged that the bachelor's programme in Applied Physics offered by the University of Groningen meets all standards of the NVAO assessment framework for limited programme assessment. The panel therefore recommends accreditation of the programme.

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

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

Introduction
The goal of a university programme is to prepare students for an independent practice 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 in the 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 that used in the Teaching Programme Assessment (Onderwijsvisitatie) of 2013. This in its turn 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 Project63[1] and, to a lesser extent, the document 'A European Specification for Physics Master Studies' of the European Physical Society (2009). The 2013 framework has been modified and updated in three ways: (1) the programme descriptors are now divided over the usual five Dublin indicators, instead of over the original three categories: cognitive competences, practical skills, and generic competences, (2) several competences have been rephrased, (3) the competence 'Estimation skills' has been added.

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. Essential is that the local choices for, and focus of the programme fit the internationally accepted standards.

Programme descriptors
The descriptors for the Bachelor's degree programmes in Physics, Applied Physics, and Astronomy are divided over the five Dublin descriptors, where the highest or most relevant descriptor is used for this division. The number in the second column is the 'Rating of importance' at the Bachelor level mentioned in the Tuning Physics document. The competence 'Estimation skills' and the related competence 'Problem solving skills' are combined (ratings 2 and 9). The three colors indicate the type of competence: light color = core curriculum, medium color = familiarity with physics research, dark color = general skills.

[1] In May 2018 a new version of the Tuning document was published, as output of the CALOHEE project (https://www.calohee.eu/). In this document, a different structure of competences is proposed (nine 'disciplines', each divided into 'knowledge', 'skills' and 'wider competences'). The compilers of the present framework have decided to follow the simpler, yet elegant structure of the Tuning 2008 document. Where relevant, aspects of the Tuning (2018) have been incorporated.

(A) Knowledge and understanding

	Rating of importance	Specific competence	Description. On completion of the degree course, the student should
A1	5	Knowledge and understanding of physics	have a good understanding of the important physical theories (logical and mathematical structure, experimental support, physical phenomena described).
A2	14	Understanding of the physics culture	be familiar with the most important areas of physics and with the common approaches, which span many areas in physics.
A3	8	Frontier research (MSc only)	have a good knowledge of the state of the art in (at least) one of the presently active topics in physics research.

(B) Applying knowledge and understanding

		Specific competence	Description. On completion of the degree course, the student should
B1	2, 9	Problem solving skills, Estimation skills	be able to frame, analyse and break down a problem in phases defining a suitable algorithmic procedure; 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.

B2	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.* critically think about how to construct physical models.
B3	7	Mathematical skills	be able to understand and master the use of the most commonly used mathematical and numerical methods.
B4	10	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.
B5		Computer skills	be able to use appropriate software, programming language, computational tools and methods in physical and mathematical investigations.
B6	6	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.

(C) Judgement

C1	13	Human / professional skills	be able to develop a personal sense of responsibility; be able to gain professional flexibility through the wide spectrum of scientific techniques offered in the curriculum; be able to organize the personal learning process, evaluate personal work, consult experts for information (*e.g.* about career opportunities) and support when

			appropriate; have had the opportunity to take courses that prepare for teaching physics at secondary school, as well as the opportunity to gain in-depth interdisciplinary skills.
C2	18	Absolute standards	have become familiar with highly regarded research in the field, thus developing an awareness of the highest standards.
C3	17	Ethical awareness (relevant for physics)	be able to understand the socially related problems related to the profession, and to comprehend the ethical characteristics of research and of the professional activity in physics and its responsibility to society; be able to conduct processes of decision making and inspect the consequences of actions taking into account principles, norms, values and standards both from a personal and a professional standpoint.
C4	12	Management skills (MSc only)	be able to work with a high degree of autonomy, even accepting responsibility in (project) planning, and in the managing of structures.

(D) Communication

D1	11	Communication skills	be able to listen carefully and to present difficult ideas and complex information in a clear and concise manner to a professional as well as to lay audiences; be able to work in a multidisciplinary or in an interdisciplinary team.
D2	16	Language skills	be able to read, speak, and write in technical English.

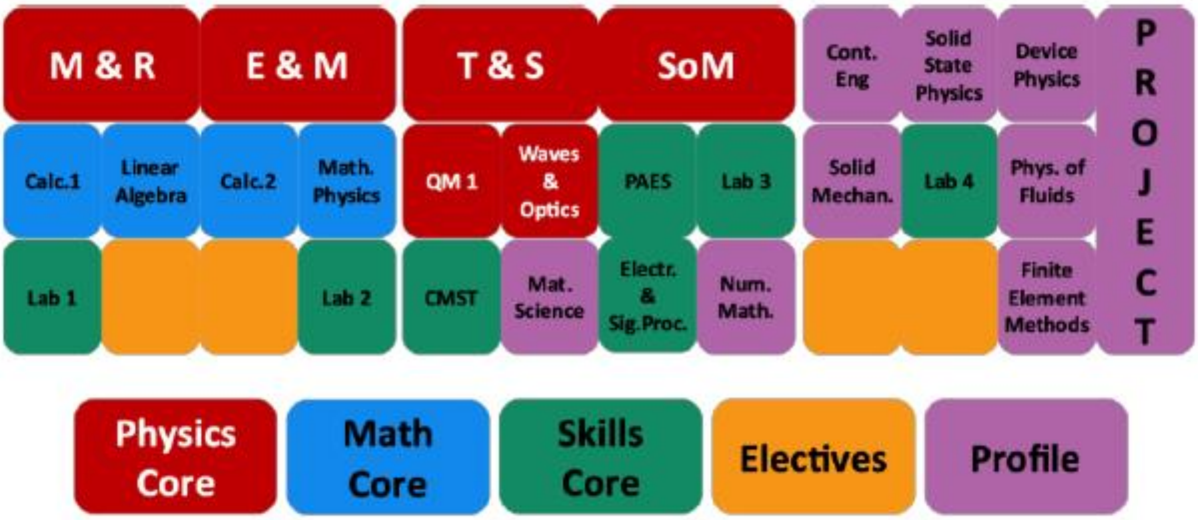
(E) Learning

E1	3	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.
E2	4	Learning ability	be able to enter new fields through independent study; have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy (lifelong learning).
E3	15	Updating skills (MSc only)	enjoy the facility to remain informed of new developments and methods, and be able to provide professional advice on their possible impact or range of applications.

APPENDIX 2: INTENDED LEARNING OUTCOMES

Dublin-descriptors	**Learning outcomes**	
Alumni of the programme have:		
1. Knowledge and understanding	A1	general knowledge of the foundations and history of mathematics, natural sciences and technology, in particular those of Applied Physics.
	A2	mastered the basic concepts of Applied Physics and are familiar with the interrelationships of these concepts within their own discipline as well as with other disciplines.
	A3	in-depth knowledge of several contemporary topics within Applied Physics.
	A4	familiarity with the quantitative character of the fields of mathematics and natural sciences and an understanding of the methods used in these fields, and particularly within Applied Physics, including computer-aided methods.
	A5	sufficient knowledge and understanding of mathematics and natural sciences to successfully complete a follow-up Master's degree programme in Applied Physics.
Alumni of the programme are able to:		
2. Applying knowledge and understanding	B1	draw up a research question, design, plan and conduct research and report on it independently with an appropriate degree of supervision. Bachelor's graduates are able to evaluate the value and limitations of their research and assess its applicability outside their own field.
	B2	translate a physics problem into a plan of approach and – taking into account practical boundary conditions – find a solution.
	A4	understand the quantitative character of the fields of mathematics and natural sciences and understand the methods used in these fields, and particularly within Applied Physics, including computer-aided methods.
Alumni of the programme are:		
3. Making judgements	A6	aware of the societal, ethical and social aspects involved in the fields of mathematics and natural sciences, and act accordingly.
	B4	able to collaborate in teams on technical-scientific problems.
	B6	able to assess their own actions and those of others in a natural sciences context, bearing in mind the social/societal and ethical aspects.
Alumni of the programme are able to:		
4. Communication	B5	communicate in English, both orally and in writing, in academic and professional contexts, with both colleagues and others. They are familiar with the relevant means of communication.
	B3	gather relevant information using modern means of communication and to critically interpret this information.
Alumni of the programme are able to:		
5. Learning skills	B7	apply learning skills that enable them to pursue a follow-up degree and acquire knowledge in new fields with a high level of autonomy.

APPENDIX 3: OVERVIEW OF THE CURRICULUM



Schematic layout of the Bachelor's degree Programme in Applied Physics (2018-2019) going from year 1 on the left to year 3 on the right, with each column representing a 10 week block. Each "box" represents 5 ECTS.

The core consists of three coherent learning lines:

- Basic Physics: Mechanics & Relativity, Electricity & Magnetism, Thermodynamics & Statistical Physics, Quantum Mechanics 1, Waves & Optics, and Structure of Matter;
- Basic Mathematics: Calculus 1 and 2, Linear Algebra 1, and Mathematical Physics
- Skills: Physics Laboratory 1-3, Computational Methods for Science & Technology, Electronics & Signal Processing, and Physics, Astronomy, Ethics & Society.

APPENDIX 4: PROGRAMME OF THE SITE VISIT

12 May 2019
17.00 – 19.00 Internal panel meeting

13 May 2019
09.00 – 09.15 Arrival and welcome
09.15 – 09.45 Internal panel meeting
09.45 – 10.45 Management bachelor + master Physics + Applied Physics
10.45 – 11.00 Break
11.00 – 11.45 Bachelor and master students Physics
11.45 – 12.00 Break
12.00 – 12.45 Teaching staff Physics
12.45 – 13.30 Lunch + internal panel meeting
13.30 – 14.15 Show cases, poster presentations by students
14.15 – 14.30 Break
14.30 – 15.15 Bachelor and master students Applied Physics
15.15 – 15.30 Break
15.30 - 16.15 Teaching staff Applied Physics
16.15 – 16.30 Break
16.30 – 17.15 Board of Examiners Physics and Applied Physics
17.15 – 17.30 Break
17.30 – 18.15 Alumni + External Advisory Panel (combined)
18.15 – 18.45 Visit to the observatory

14 May 2019
09.00 – 09.45 Internal panel meeting (overleg)
09.45 – 10.30 Management bachelor + master Astronomy
10.30 – 10.45 Break
10.45 – 11.30 Bachelor and master students Astronomy
11.30 – 11.45 Break
11.45 – 12.30 Teaching staff Astronomy
12.30 – 13.00 Lunch
13.00 – 13.30 Consultation hour
13.30 – 14.15 Tour of the facilities and poster presentation students
14.15 – 14.30 Break
14.30 – 15.15 Board of Examiners Astronomy
15.15 – 16.00 Internal panel meeting preparation meeting with formal management
16.00 – 17.00 Formeel management (combined)

15 May 2019
09.00 – 12.00 Concluding panel meeting, formulating judgements
12.00 – 12.15 Preliminary feedback
12.15 – 12.30 Break
12.30 – 13.30 Development Dialogue (combined) – including lunch

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 10 theses of the bachelor'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 (partly as hard copies, partly via the institute's electronic learning environment):

- Course Unit Assessment Overviews of a sample of courses
- Study Handbooks
- Internship reports, including the assessment forms
- Exemplary journal articles used in the courses
- Year reports of the Boards of Examiners and the Programme Committees
- Quality Assurance Manuals