Biomedische Technologie Ow 2012

Faculty of Mathematics and Natural Sciences
University of Groningen

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: Q389

CONTENTS

This report was finalized on 13-12-2012

Report on the master's programme Biomedical Engineering of University of Groningen

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

Administrative data regarding the programme

Master's programme Biomedical Engineering

Name of the programme:	Biomedical Engineering
CROHO number:	60621
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	Clinical Physics, Prostheses & Implant Interface Technology
Location(s):	Groningen
Mode(s) of study:	full time
Expiration of accreditation:	31-12-2013

The visit of the assessment committee Biomedische Technologie Ow 2012 to the Faculty of Mathematics and Natural Sciences of University of Groningen took place on 2 and 3 October 2012.

Administrative data regarding the institution

Name of the institution:	University of Groningen
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	applied (pending)

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 Biomedical Engineering consisted of:

- Prof. Dr. ir. J. Vander Sloten, professor in Engineering Sciences, KU Leuven, Belgium;
- Dr. J. Struijk, associate professor Health Science and Technology, Aalborg University Denmark;
- Prof. Dr. Ir. J.A.E. Spaan, Emeritus professor in Medical Physics, University of Amsterdam;
- Prof. R. Reilly, professor in Neurotechnology, Trinity College Dublin;

- S. van Tienhoven BSc, master student Biomedical Engineering, Eindhoven University of Technology.

The committee was supported by Dr. B.M. van Balen, who acted as secretary.

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

Working method of the assessment committee

Preparation
The assessment of the master's programme Biomedical Engineering of the University of Groningen is part of a cluster assessment of seven Biomedical Technology degree programmes offered by four universities. The entire cluster committee consists of six members. The kick off meeting for the cluster assessment was on 13 September 2012. During this meeting the committee members received an introduction into the assessment framework and evaluation procedures and the committee agreed upon its general working method. Furthermore the domain specific requirements and the most recent developments concerning the Biomedical Engineering domain were discussed. These domain specific requirements and the actual context form the starting point for the evaluation of the quality of the degree programmes.

After having established that the report fulfilled the criteria of relevance and completeness, the project leader distributed it and the additional information among the members of the assessment committee. The committee members were asked to formulate their remarks, comments and questions regarding the self-evaluation report and the additional documents prior to the site visit.

In addition to the self-assessment report, each committee member received three recent theses. In consultation with the chair, it was decided that the selection of theses should cover the full range of marks given. The committee members also received QANU's checklist for the assessment of theses to ensure that their assessments were comparable. Since the committee had to evaluate a programme leading to a scientific degree (MSc), it paid specific attention to the scientific level of the theses, requirements, accuracy of judgment by the reviewer and the assessment procedure used.

The secretary to the committee drafted a programme for the site visit. This was discussed with the chair of the committee and the coordinator of the programme. As requested by QANU, the coordinator of the programme carefully composed and selected representative panels. Before the site visit, both staff members and students were informed about the opportunity to speak to the committee confidentially during the 'consultation hour'. No requests were received for the consultation hour.

Site visit
The site visit took place on 2 and 3 October 2012. The committee members discussed their findings based on the self-evaluation report they had received prior to the site visit. They also debated their task, working methods and the questions and issues to be raised in the interviews with representatives of the programme and other stakeholders. During the site visit, the committee conducted interviews with the programme management, students, staff members, graduates, members of the Education Committee, the Board of Examiners and

student advisors. They also studied further materials made available by the programme, including study material, exams, assignments and other assessments.

After the concluding meeting with the management on the final day of the site visit, the committee members extensively discussed their assessment of the programme and prepared a preliminary report. The site visit concluded with a presentation of the preliminary findings by the chairman. This presentation consisted of a general assessment and several specific findings and impressions of the programme, as well as some recommendations. The schedule of the site visit is included in appendix 6.

Report
After the site visit, the secretary produced a draft version of the report on the programme and presented it to the members of the committee. Subsequently, the secretary processed corrections, remarks and suggestions for improvement provided by the committee members to produce the revised report. This was then sent to the faculty to check for factual errors, inaccuracies and inconsistencies. Comments and suggestions provided by the 3TU were discussed with the chair of the assessment committee and, where necessary, with the other committee members. Based on the committee's decisions to incorporate or ignore comments and suggestions, the secretary compiled the final version of the programme report.

The assessment was performed according to the NVAO (Accreditation Organization of the Netherlands and Flanders) framework for limited programme assessment (as of 20 November 2011). In this framework a four-point scale is prescribed for both the general assessment and assessment of each of the three standards. The committee used the following definitions for the assessment of both the standards and the programme as a whole.

Decision rules

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.

General Assessment

When standard 1 or standard 3 is assessed as 'unsatisfactory', the general assessment of a programme is 'unsatisfactory'.

The general assessment of the programme can be good when at least two standards, including standard 3, are assessed as 'good',

The general assessment of the programme can be excellent when at least two standards, including standard 3, are assessed as 'excellent'.

Summary judgement

Standard 1
The Biomedical Engineering master's degree programme is an interdisciplinary programme supported by the Faculty of Mathematics and Natural Sciences (FMNS) and by the University Medical Centre Groningen (UMCG).

Biomedical engineering is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice. It includes:

1. The acquisition of new knowledge and understanding of living systems through the innovative and substantive application of experimental and analytical techniques based on the engineering sciences.
2. The development of new devices, algorithms, processes and systems that advance biology and medicine and improve medical practice and health care delivery.'

The committee finds the mission as written down in the self-evaluation report clear and challenging, a good starting point to develop a master's degree programme. The intended learning outcomes describe what is expected of students graduating and the international standards for the master's level are reflected in the intended learning outcomes. The committee recommends however to make the learning outcomes after year 2 more specific and detailed, and more differentiated from the outcomes after year 1.

Standard 2
The committee established that the master programme offers the students the possibility to obtain thorough knowledge, insight and skills in Biomedical Engineering. The programme made use of the domain-specific requirements which the committee finds well described in terms of orientation. The committee has verified and established that the profile and orientation are at an academic level. The master's degree programme consists of several compulsory and optional course elements adding up to a total of 120 EC. To strengthen the coherence of the programme a few case studies are presented at the beginning of the academic year. Lecturers present patients and their medical problems. Other lecturers are able to refer in their courses to the case studies illustrating how their course element is necessary to solve the patients' problem. The committee appreciates this initiative and encourages the lecturers to subscribe to it in a more pro-active way. During the internship (15 EC) and the master's project (30 EC) students learn to apply and integrate the acquired knowledge and skills.

Most course elements of the first year are taught in an interactive format and assessed by assignments. The committee finds the described modes of instruction and teaching in the programmes appropriate. The coherence in the programme is a matter of concern in an interdisciplinary programme. The committee is of the opinion that this can be improved. The introduction of case studies for all courses is an appreciated step in that direction. The committee furthermore advises to develop learning lines for the programme in particular in regard to research skills and theory.

The teaching staff is quantitatively and qualitatively sufficient. The involvement of the FMNS and UMCG guarantees a broad input of expertise. The supporting staff - director, coordinator, counsellor and administration - is crucial for this programme.

The facilities are sufficient. The committee, however, recommends to provide a common room, which can incorporate the common identity of the programme as well as to provide a place for students to work and meet.

Standard 3
The committee has looked into the assessment system and the theses in order to answer the question if the intended learning outcomes are achieved. The committee is convinced that the assessment system is sufficiently valid and reliable. The committee noticed that the Board of Examiners has started implementing their new tasks and responsibilities as required by recent changes in the Dutch law.

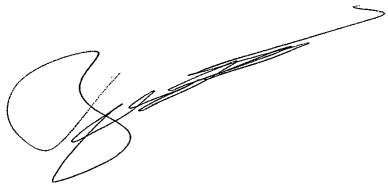
The theses are at the required level of an academic master's programme; graduates have a good foundation for a career in industry as well as in research.

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: 13-12-2012



Prof. Dr. ir. J. Vander Sloten

Dr. B.M. van Balen

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.

1. Findings

For this standard, a short introduction to the programme is given (1.1). After that, the domain specific requirements are described (1.2). In addition, the goal and intended learning outcomes of the programmes are described and discussed separately (1.3).

1.1. Introduction to the programme

The Biomedical Engineering master's degree programme is an interdisciplinary programme supported by the Faculty of Mathematics and Natural Sciences (FMNS) and by the University Medical Centre Groningen (UMCG). Formal responsibility for the practical organisation rests with the Board of the FMNS. The master's degree programme Biomedical Engineering (BME) is embedded within the School of Life Sciences. The content of the BME programme has also a strong tie with Natural Sciences and Technology and a weaker tie with Computing and Cognition.

There are two ways to directly enter the master's programme Biomedical Engineering:

1. Applied Physics BSc with a BMT minor;
2. Life Science and Technology BSc with a BMT major.

From 2006/2007 two specialisations exist in the master's programme, 'Biomaterials' and 'Medical Instrumentation and Imaging'. In 2010/2011 these were renamed into 'Prostheses and Implant Interface Technology' and 'Clinical Physics' to have a better match with the goals of the programme.

In 2010 CEMACUBE (Common European MAster's CUrriculum in Biomedical Engineering) was started, an Erasmus Mundus master's degree programme in BME for which students have to undergo a severe selection process. Students who are admitted to the programme have to study at least at two of the partner universities and will be awarded a double degree. To create a common programme, an entirely new schedule of course elements was made. The programme for regular students follows this schedule overall to maintain an efficient programme and to let regular students profit from this international setting.

The committee recognizes the need for a Biomedical Engineering programme in Groningen. This was also confirmed by the representatives of the work field the committee has spoken to. The programme should be continued and reinforced. The link to the hospital is very strong in the Groningen programme and should be exploited to the maximum.

1.2. Domain specific requirements

The self evaluation report provides the following description of the Biomedical Engineering discipline: 'Biomedical engineering is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice. It includes:

1. The acquisition of new knowledge and understanding of living systems through the innovative and substantive application of experimental and analytical techniques based on the engineering sciences.
2. The development of new devices, algorithms, processes and systems that advance biology and medicine and improve medical practice and health care delivery.'

The committee finds the mission as written down in the self-evaluation report clear and challenging, a good starting point to develop a master's degree programme.

In 2005, domain-specific requirements for biomedical engineering in the Netherlands were developed by the biomedical engineering programmes of the Eindhoven University of Technology, the University of Twente and the University of Groningen. Recently, the three original partners and the Technical University Delft confirmed these domain-specific requirements. The domain-specific requirements are presented in appendix 2. To define intended learning outcomes or competences, the programme made use of these domain-specific requirements. According to the committee, the domain-specific requirements are well described in terms of orientation.

1.3. Goals and intended learning outcomes

The master's degree programme Biomedical Engineering provides students with basic knowledge and skills in all fields in BME, so they can be employed as generalists. The students must:

- have thorough knowledge of concepts, methods and techniques of biomedical engineering and be able to apply the required mathematical and computer technological methods;
- are acquainted with the quantitative character of engineering and have insight in the main methods used in engineering;
- have the ability to communicate effectively in written and verbal form about biomedical engineering and its applications, also in a multidisciplinary environment;
- are able to manage projects and to function in a team;
- are acquainted with the BME- literature in their specialisation, able to find relevant information in the international literature and critically judge the methodical quality;
- are experienced in executing scientific research;
- have knowledge of (for the biomedical engineering important) medical subjects and specialist knowledge of a (sub) specialisation in engineering;
- have the capacity to diagnose and analyze medical problems, transfer them into technological challenges and develop a goal-oriented solution;
- are aware of potential social and ethical implications of scientific research in biomedical engineering and have the ability to critically evaluate the effects of the research carried out under his responsibility;
- recognize the need for, and has the ability to engage in ongoing learning beyond the master's level.

Students are also trained in one particular field of BME to prepare them to work as a specialist in a specific field of BME. In Groningen students can choose between two specialisations: Prostheses & Implant Interface Technology and Clinical Physics.

The specialisation 'Prostheses & Implant Interface Technology' prepares students to:

- realize restoration of body functions by designing prototypes of new, technologically innovative implants based on fundamental scientific research;
- conduct scientific research on the functioning of implants, from a biological, chemical and mechanical point of view and based on a modelling approach;
- improve existing implants in relation to interaction with the body, from a biological, chemical and mechanical point of view;

The specialisation 'Clinical Physics' prepares students to:

- conduct scientific research on the functioning of medical instruments, both from a biological and physical point of view and based on a modelling approach;
- conduct scientific research on medical imaging techniques, both from a biological and physical point of view and based on a modelling approach;
- improve diagnosis by designing prototypes of innovative medical instruments and imaging techniques that are based on fundamental scientific research;

Specific learning outcomes were formulated in more detail to realise the profiles of master's students described above. These learning outcomes are added in Appendix 3.

Considerations

The committee studied the intended learning outcomes and established that these are in line with the domain requirements as well as with the academic level that is required for a master's degree programme according to the Dublin-descriptors. The intended learning outcomes are also in line with the ABET requirements for engineering.

The committee established that the master programme offers the students the possibility to obtain thorough knowledge, insight and skills in Biomedical Engineering. The programme made use of the domain domain-specific requirements which the committee finds well described in terms orientation. The committee has verified and established that the profile and orientation are at an academic level.

The intended learning outcomes describe what is expected of students graduating and the international standards for the master's level are reflected in the intended learning outcomes. The committee recommends however to make the learning outcomes after year 2 more specific and detailed, and more differentiated from the outcomes after year 1 (pages 8 and 9 of the self-evaluation report).

Conclusion

Master's programme Biomedical Engineering: 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.

2. Findings

The structure (2.1), the didactical concept and development of research skills (2.2), intake and study load (2.3.) the quantity and quality of the staff (2.4) and the facilities (2.5) of the *master's programme Biomedical Engineering* are discussed below.

2.1. Structure

The master's degree programme consists of several compulsory and optional course elements adding up to a total of 120 EC. In general, course elements that focus on acquiring basic knowledge and skills are made compulsory, while students are able to specialise by choosing an individual programme from a set of optional course elements. A description of all course elements is included in the Appendix 4. The first year consists of general courses, an interdisciplinary project and an internship. The second year consists of specialisation courses and the master's project.

At the beginning of the master's programme an introductory lecture is organised. In this lecture information is given about the rules and procedure of the master's degree programme and the relation between learning outcomes and course elements. To strengthen the coherence of the programme a few case studies are presented. The case studies concern lecturers' presentations of patients and their medical problems. Other lecturers are able to refer in their courses to the case studies illustrating how their course element is necessary to solve the patients' problem. In that way the case studies serve as a recurrent theme throughout the academic year.

Fundamental and applied research and methodical design are important parts of the master's degree programme.. The industrial internship (15 EC) in the first year and the master's project (30 EC) in the second year are the main elements of the master's degree programme to become acquainted with scientific research and methodical design in a corporate or academic setting and to learn how to undertake it.

The industrial internship needs to be performed in a company or hospital. It serves both as an introduction to daily practice of a biomedical engineer in a representative work environment and a way to integrate all acquired knowledge. Suitable institutes that offer internships with sufficiently high quality are selected by using the various contacts of the teaching staff.

The master's project is usually done at one of the research departments involved in the BME programme at the University of Groningen or University Medical Centre Groningen. The student has to work in a multidisciplinary team and is trained to do scientific research or methodical design. At the start of the project the final goal is defined, the time schedule is planned and a literature survey is performed to explore the field of research. It is followed by a practical part in which research data or a design is generated. The project can also be

performed at an institute abroad. Second supervisor is always a member of staff from the University of Groningen.

During the internship and the master's project students learn to apply and integrate the acquired knowledge and skills. Both are concluded by a report and an oral presentation to an audience with ample expertise in the subject of study, followed by a discussion.

The committee studied the content of the programme and the study guide that was provided. It also discussed the structure of the programme with the teachers and the students. During the site visit the committee was informed that the sequence of courses is also determined by the Erasmus Mundus CEMACUBE programme and the time schedules of other schools. Biomedical Engineering students follow course offered by several schools. Some of the courses in the BME programme make use of the knowledge obtained in preceding courses, but not for all courses an obligatory sequence is required. The students the committee interviewed told that they often realised afterwards why they had to obtain the knowledge in a specific course. The coherence in the BME programme is therefore not self-evident. The programme management is aware of this problem. Curriculum elements could be more integrated. In the current situation students have to integrate the elements themselves and should be more supported. The introduction of the case studies is a good start, but this is not yet fully implemented. The committee has also noted that more communication between the teachers is needed. Identification of the teachers with the programme should be intensified.

The committee established that the structure of the programme enables the students to achieve the intended learning outcomes of the programme. However, the committee has noticed that the description of the learning outcomes for the programme elements should be specified and the transfer of the intended learning outcomes to courses should be better defined.

2.2. Didactical concept and development of research skills

The didactical concept, the development of scientific and research skills, the study load and feasibility of the programme are discussed.

Most course elements of the first year are taught in an interactive format and assessed by assignments. Some course elements are taught in a lecture format and examined by a written examination. In practice each student follows an individual programme. In general, the programme for Prostheses and Implant Interface Technology contains more tutorials and project-oriented course elements, whereas Clinical Physics contains more laboratory training. The committee has the impression that the didactical concept can probably be described as a mix of components and pedagogical methods, partly due to the fact that the programme contains elements from different schools.

To facilitate the integration of knowledge and skills a multidisciplinary project is scheduled in the third quartile of the master's programme. Furthermore an internship is scheduled at the end of the first year with the same objective. Some students however choose to do their internship at the end of the second year. This is possible but discouraged. As mentioned above the coherence in the programme is a matter of concern. The management informed the committee that the case studies have been introduced to improve the coherence and integration. Not all teachers, however, already introduced this case in their lectures. The committee encourages the programme to go along with this and the teachers to take an active role. Lecturers should suggest a patient case study themselves and participate in that to have them fully involved (bottom-up approach). The committee would also encourage the

programme management to establish more coherence and a kind of team spirit within the group of teachers involved.

Research and research skills are part of several elements of the programme, e.g. in the interdisciplinary project and in the introduction-to-research-assignment course. However, it was not clear to the committee how the learning line of scientific and research skills is defined in the programme. The committee has the impression that research competences are unevenly treated in the course elements. It did not see proof that students learned research skills. In the master thesis the unevenness remains depending on the supervisor. The committee also noticed that some of the graduation projects were fully design oriented.

The committee has some concerns about the theoretical depth and the engineering approach in the programme. The committee encourages staff and management to work heavily on increasing engineering and research elements in the programme. It recommends to develop learning lines in the programme to ensure that all students develop the necessary engineering approach and achieve the theoretical depth that is required for an engineering degree. The committee advises to pay more attention to learning to conduct research.

2.3. Intake and study load

Students with a bachelor's degree in either Life Science & Technology with a major Biomedical Engineering or Applied Physics with a minor Biomedical Engineering (Biomedische Technologie) from the RUG are considered to have sufficient knowledge and skills and will be admitted to the master's degree programme directly. Students with bachelor's degrees in Physics, Physical Engineering, Chemistry, Chemical Engineering, Mechanical Engineering or Electrical Engineering are admitted under the condition that they follow the course elements Basic Biomedical Knowledge I & II to catch up on the necessary biological background knowledge. A general requirement is that applicants have sufficient proficiency in English. All other students (this includes students from other universities or from universities of applied sciences who apply for the programme are screened by the BME Admissions Board, that suggests a pre-masters programme based on the candidates previous education.
A more dedicated bachelor's programme would ensure that students have the same knowledge and competences at the start of the master's programme. The committee learned during the site visit that this has been improved. The committee recommends to enhance the mathematics and engineering line in the bachelor towards the master BMT, making use of the minor.

The student intake increased from 7 in 2006 to 30 in 2011. From 2006/2007 until 2010/2011 43 students graduated from the programme with a MSc degree. The average duration of study was 25.8 months. Approximately 50% of the students finished their studies within the time frame of 2 years. The FMNS aim is to achieve 80% of the students graduating within 2 years. The programme strives to increase the number of students who receive their master's degree within 2 years by monitoring students closely and if necessary discuss their delay individually.

The programme provided quantitative information about the study load. This is included in Appendix 5. The students reported no problems with the study load. The programme is feasible in their view. Some courses are more difficult than others but this evens out. The committee did not notice any problems with regard to study load and study duration.

2.3 Teaching staff

Most lecturers of the master's degree programme BME are active in Biomedical Engineering research. PhD students and post-doctoral fellows are also involved in teaching. The BME programme involves teachers from two Faculties and several departments, which results in a broad diversity of expertise in the field. As a consequence the input of BME in the job evaluations is limited.
The FMNS staff is now hired based on the tenure track model. During the tenure track procedure (generally a term of 6 years), teaching goals are determined during evaluations and performance reviews and a training path is agreed on to acquire and improve essential teaching skills.

Newly appointed staff needs to obtain a basic teaching qualification, the BKO (Basic Qualification in Education). Based on earlier acquired competences, a plan for teaching professionalization is devised. Upon completion of the BKO training, the staff complies with the teaching standards that the Board of the University requires for its staff. Teaching requirements and professionalization are part of all performance reviews and assessment procedures. Promotions to the next level in the organisation are only possible if teaching requirements are met. The director of the school, or the adjunct director, is a member of the appointment advice committees for tenure track staff and full professors.

The UMCG human resources management uses a similar system of teaching professionalization. The educational school of medicine provides an intensive programme for teacher professionalization in which all staff takes part. In yearly meetings between the board of the school and the chair of the discipline groups, teaching quality and quantity is part of the discussion, and if necessary, measures of improvements are agreed upon.

The programme is supported by a programme director, a course coordinator and a student counsellor. Administrative support is provided by the UMCG and the School of Life Sciences.

The committee received information about the expertise of the teaching staff and has spoken to both the teachers and supporting staff. The committee is convinced that the staff is sufficiently qualified. The students were satisfied with the didactic expertise of the teaching staff and did not report any problems with the quantity of study material. The committee has observed a lot of enthusiasm for the programme by the teachers. The teaching staff has a mix of engineering and medical background and did not seem to be overloaded with teaching. The supporting staff is very dedicated and do a very nice job. The supporting staff is crucial for the success of this programme.

2.4. Facilities

The master's degree programme uses facilities from both the FMNS and the UMCG. General lecture facilities are available at several locations, such as the UMCG in Groningen, and the Chemistry Building at the Zernike complex. A substantial part of the teaching in the master's degree programme occurs in laboratories and conference rooms of the departments, which are distributed over all locations. All laboratories are used by research units or discipline groups from Research Institutes and contain all basic and specialised equipment needed current research.

All lecture rooms and conference rooms are equipped with blackboards or whiteboards, and modern IT facilities including beamers. All locations provide ample computer and network access for students and staff, both in dedicated IT rooms and in laboratories. The 'university

workstation' allows all students and staff to access the university server from any workstation connected to the server, facilitating working in different places in different faculties.

The committee had a round tour and saw some research facilities available for Biomedical Research, master's students doing their research for the graduation can use these facilities. Students told the committee that they have lectures on both locations, but did not mind the distance between those. In the view of the committee the facilities in general are alright but the programme lacks a common meeting place. It is not obvious where to find 'the Biomedical Engineering programme' or where to meet other students and teachers. The committee therefore strongly recommends to provide for a 'common room', a place where students can work, can discuss and can meet each other.

Considerations
The committee has investigated the different aspects of the teaching-learning environment to assess whether the intended learning objectives can be achieved. The meetings with management, students, staff, and the educational committee gave clear information about the level and orientation of the programme. The committee observed enthusiasm in the representatives of the work field, the teachers, students and alumni for the programme.

The master's programme is sufficiently structured and contains all courses and trainings necessary to enable the students to achieve the intended learning outcomes. The programme enables the students to do an internship as well as a considerable research project. The described modes of instruction and teaching in the programmes are appropriate. The teaching staff involved is quantitatively and qualitatively sufficient. The involvement of the FMNS and UMCG guarantees a broad input of expertise. The supporting staff - director, coordinator, counsellor and administration - is crucial for this programme.

The programme, therefore, meets the requirements, but some aspects can be improved. The committee noted that the coherence in the programme is a matter of concern. This concern is recognized by the programme management. The introduction of a common case study for all courses is very much appreciated by the committee, but this is not yet fully implemented. The committee also has some concerns about the theoretical depth and the engineering approach in the programme. It advises to pay more attention to the development of research competences and to develop learning lines for the programme in regard to research skills and theory.

The programme facilities are sufficient, but the programme should have a common room, which can incorporate the common identity of the programme as well provide a place for students to work and meet.

Conclusion
Master's programme Biomedical Engineering: 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.

3. Findings

For this standard, the assessment methods (3.1) and the achieved learning outcomes (3.2) of the programme are discussed.

3.1. Assessment methods

Depending on the type of the course element different methods are employed to assess whether students have achieved the intended learning outcomes. In general, course elements in which knowledge is essential are assessed by written or oral examinations. Course elements, which train students' attitude and skills, are assessed by assignments, presentations and reports. When reports have to be written, they can be scanned on plagiarism. Ephora, a software tool for this, is available on Nestor.

Due to the interdisciplinary nature of the master's degree programme, learning outcomes of most course elements refer to both knowledge and academic skills. Hence, the majority of course elements is assessed by a combination of assignments and written or oral examinations.

The marks for internship and master's thesis are based on the assessment of two supervisors: one of the mentors of the master's degree programme Biomedical Engineering and the project supervisor, which can be a local supervisor or an external specialist. The quality of master's thesis is guarded by the mentors. By mentoring several master theses per year, they are able to compare the quality of different master theses. For the master's thesis standardized assessment forms are used within the faculty to facilitate the comparability of teaching standards between the master's degree programmes. The results are evaluated once a year in the Course Committee.

The Board of Examiners is responsible for the exams. An executive committee carries out treatment of current issues.

The FNWS is recently developing a comprehensive assessment system and wants to enforce the role of the Board of Examiners (BE). The BE will be more involved in evaluating proposals and quality of the final report for internship and master thesis.

The committee had a meeting with the Board of Examiners and learnt that the composition has recently changed. The new role of the BE is being implemented, supported by replacement of board members. The committee encourages this new composition of the BE and advises to continue the exchange of good practices between different boards within the university.

3.2. Achieved learning outcomes

During the site visit examinations including the students' answers were available for inspection by the committee. They were found to be at an adequate level and well-marked.

The committee has studied a random and stratified selection of fifteen master's theses to assess whether the intended learning outcomes are achieved. The master's theses the committee has studied were adequately assessed. The theses indicate that the graduates have achieved the level that can be expected in a master's degree programme. The form and content of the theses however differed substantially. Some of the theses were research based and some were purely design oriented. It was not clear to the committee what the requirements for the master's projects in general were. In particular the requirements for design oriented theses need some attention. The committee would recommend to reconsider the requirements for the thesis, to align them and to develop a thesis writing manual for the students.

The representatives of the working field were very positive about the level achieved by the graduates of the programme. There is a need for biomedical engineers in the region. Graduates of the programme have achieved a level that is suitable for employment. The committee therefore concludes that the programme meets the requirements for Standard 3. It is however of the opinion that the programme can be improved when the engineering profiling is reinforced.

The committee also advises to develop an active alumni policy. The alumni the committee has met were positive about the idea. Contacts with alumni can stimulate a positive image of the Groningen biomedical engineering programme and can give input for continuous improvement of the programme.

Considerations
The committee has looked into the assessment system and the theses in order to answer the question if the intended learning outcomes are achieved. The committee is convinced that the assessment system is sufficiently valid and reliable. The committee has seen that the Board of Examiners has made a start with the implementation of their new tasks and responsibilities and encourages the Board and the Management to continue these efforts.

The theses are at the required level of an academic master's programme; graduates have a good foundation for a career in industry as well as in research.

Conclusion
Master's programme Biomedical Engineering: the committee assesses Standard 3 as **satisfactory**.

General conclusion

The committee concludes that master's programme Biomedical Engineering meets the requirements for accreditation. The intended learning outcomes are formulated in line with the Domain Specific Framework and the requirements for an academic master's programme. The curriculum enables the students to achieve the intended learning outcomes. The programme has an adequate assessment system in place and demonstrates that the intended learning outcomes are achieved.

Conclusion
The committee assesses the *master's programme Biomedical Engineering* as **satisfactory**.

Appendices

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

Prof. Dr. ir. J. (Jos) Vander Sloten obtained his PhD in Applied Sciences with Greatest Honours in 1990 at the KU Leuven. Since 1999 he is Full Professor at the Division of Biomechanics and Engineering Design of the KU Leuven. From 2006 until 2012 he was Programme director of the Master of Science programme in Biomedical Engineering at the same university. Since 2000, Professor Vander Sloten is chair of the CRITTO (Commissie Ruimtelijk Inzicht, Technisch Tekenen en Ontwerpen, Technologisch Instituut, Koninklijke Vlaamse Ingenieursvereniging). He is also a member of the Boards of Custom 8 N.V. (a KU Leuven spin-off company) and Materialise N.V., and is a member of various scientific advisory boards and editorial boards of scientific journals.

Dr. J. (Jan) Struijk obtained his PhD at the Biomedical Engineering Division of the University of Twente in 1992. His thesis was called *Immediate Effects of Spinal Cord Stimulation*. He was Visiting Professor in 1988, at Case Western Reserve University, Cleveland (USA). He was Associate Professor at the Department of Medical Informatics and Image Analysis at Aalborg University (Denmark). Subsequently, he was Director of Studies, Medicine and Technology, Head of Center for Sensory-Motor Interaction/Motor Control and Neurorehabilitation Technology, and since 2009 Associate Professor at the Medical Informatics Group, all of the Department of Health Science and Technology. He also was Chairman and member of several PhD evaluation committees.

Prof. Dr. ir. J.A.E. (Jos) Spaan is Emeritus Professor in Medical Physics at the Academic Medical Centre of the University of Amsterdam since February 2010. In 1970 he got a degree in Engineering, Physics at TU Eindhoven. In 1976 he obtained his PhD at the same university. His thesis was entitled *Oxygen transfer in layers of hemoglobin solutions*. He had appointments at various universities in the Netherlands: TU Delft, University of Leiden and University of Amsterdam. Professor Spaan also was Secretary General of the International Federation of BioMedical Engineering (1992-1998), Chairman of the Cardiovascular Research Institute Amsterdam (2003-2005) and the first elected president of the European Alliance of Medical and Biological Engineering and Sciences (2005).

Prof. dr. R. (Richard) Reilly got a degree in Biomedical Engineering (1989) and obtained his PhD in Biomedical Signal Processing (1992) at University College Dublin. He is and was researcher and biomedical engineer in various hospitals and institutes. He is currently Full Professor of Neural Engineering at the School of Medicine and School of Engineering of Trinity College Dublin and director of the Trinity Centre for Bioengineering. Professor Reilly also is President of the European Society of Engineering and Medicine (2011-2015).

Ms. S. (Sandra) van Tienhoven, BSc is a master student in Biomedical Engineering at TU Eindhoven. She obtained her BSc-degree in Biomedical Engineering at the same university. She also is assistant of the programme director. She was student member of the education committee and faculty board and member of the faculty council.

Appendix 2: Domain-specific framework of reference

A. Domain specific requirements for level and orientation of graduates

Biomedical Engineering (BME) is an engineering discipline focused at the interface of engineering and life sciences. BME education should include basic general engineering requirements (as for example indicated by ABET) and a thorough understanding of life sciences.
BME programs must demonstrate that their students attain, according to the shared Dublin descriptors:

Knowledge and understanding:

a. Knowledge of the basic disciplines mathematics, sciences, and engineering (mechanical, electrical, and chemical engineering and applied physics) to be applied in the field of Biomedical Engineering in a broader sense; i.e. including directly adjacent fields.
b. Knowledge and understanding of concepts of physiology, (cell-) biology, anatomy, biochemistry, pharmacology and pathology as applicable in the field of Biomedical Engineering.

Applying knowledge and understanding:

c. The capability to apply and integrate advanced mathematics, sciences, and engineering to model and solve complex biomedical problems (see also d).

Making judgments:

d. An ability to conduct scientific research in areas of biomedical engineering and technology that are relevant to the advancement of knowledge and insight into fundamental and applied aspects of health and disease.
    - An ability to make measurements on and interpret data from living systems, addressing problems associated with the interaction between living and non-living materials and systems.
    - An ability to translate a clinical or health-relevant problem or question into an experiment, system, component, or process (design) to meet desired needs and, governed by scientific research or modeling, to advise in issues like clinical research in biomedical engineering, diagnosis and therapy.

Communication:

e. A capability to bridge the gap between fundamental and applied research in biomedical engineering and medical (life) sciences by:
    - Demonstrating an ability to communicate effectively in written and verbal form, and
    - Collaboration in a multidisciplinary setting, which may include clinicians, other healthcare workers and industrialists alike.
f. An awareness of potential societal and ethical implications of scientific research in Biomedical Engineering and, in this context, an ability to critically evaluate the effects of his research.

Learning skills:

g. An ability to develop new concepts within the field of BME.

h. An ability to study international scientific research.

i. Recognition of the need for, and an ability to engage in life-long learning.

B. Domain specific requirements of the BSc (Cycle 1) and MSc (Cycle 2) programs

The Bachelor's program focuses on general knowledge, based on advanced textbooks and including some aspects informed by knowledge of the forefront of their BME specialization, basic skills and solving recognizable problems.

The master's program focuses on deepening theoretical knowledge in one or more specific parts of Biomedical Engineering and provides ample experience in setting up, executing and reporting research and design. It leads to an attitude of scientific involvement.

BSc students acquire knowledge and understanding in:

a. Basic beta disciplines: mathematics, sciences, and engineering (mechanical, electrical, and chemical engineering and applied physics) to be applied in the field of Biomedical Engineering in a broader sense; i.e. including directly adjacent fields.

b. Life sciences: physiology, (cell-) biology, anatomy, biochemistry, pharmacology and pathology as applicable in the field of Biomedical Engineering.

BSc students learn to apply knowledge and understanding:

a. Of mathematics, sciences and engineering to model and solve simple biomedical problems.

BSc students learn to make judgments:

b. Involving the making of measurements on and the interpretation of simple data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems at a basic level.

c. Involving the ability to translate simple clinical or health-relevant problems or questions into an experiment, system, component, or process to meet desired needs and, governed by scientific research or modeling, to advise in issues like clinical research in biomedical engineering, diagnosis and therapy.

d. By demonstrating an awareness of potential societal and ethical implications of scientific research in Biomedical Engineering and, in this context, an ability to critically evaluate the effects of his research.

BSc students learn to communicate:

e. By bridging the gap between fundamental and applied research in biomedical engineering and medical (life) sciences by:

- Demonstrating an ability to communicate effectively in Dutch in written and verbal form, and
- Collaboration in a multidisciplinary setting.

BSc students acquire learning skills:

f. As demonstrated in their recognition of the need for, and an ability to engage in lifelong learning at the BSc+ level with a high level of autonomy.

MSc students acquire knowledge and understanding:

a. Of in depth biomedical engineering, in a coherent set of specialties, that builds on the basic knowledge acquired in the Bachelor's phase, and that provides a basis or opportunity for originality in developing or applying ideas in this specialization.

MSc students learn to apply knowledge and understanding:

a. In order to apply and integrate advanced mathematics, sciences and engineering knowledge as well as specialized knowledge to model and solve complex biomedical problems in new and unfamiliar environments.

MSc students learn to make judgments:

b. In an ability to conduct scientific research in areas of biomedical engineering and technology that are relevant to the advancement of knowledge and insight into fundamental and applied aspects of health and disease.

- An ability to make measurements on and interpret complex data from living systems, addressing the complex problems associated with the interaction between living and non-living materials and systems, and the ability to successfully recognize and address new problems in this field.
- An ability to translate a complex, not well-defined, clinical or health-relevant problem or question into an experiment, system, component, or process to meet desired needs and, governed by scientific research or modeling, to advise in issues like clinical research in biomedical engineering, diagnosis and therapy.

MSc students learn to communicate:

c. With a capability to bridge the gap between complex fundamental and applied research in biomedical engineering and medical (life) sciences by

- Demonstrating the ability to communicate effectively in written and verbal form in Dutch and English, by underpinning knowledge and rationale (restricted scope) to specialist and non-specialist audiences alike, and
- Collaboration in a multidisciplinary setting, which may include clinicians, other healthcare workers and industrialists alike.

d. An awareness of potential societal and ethical implications of scientific research in Biomedical Engineering and, in this context, an ability to critically evaluate the effects of the research carried out under his responsibility.

BSc students acquire learning skills

e. An ability to study international scientific research.

f. Recognition of the need for, and an ability to engage in life-long learning at MSc+ level in a manner that may be largely self-directed or autonomous.

C. Description of derivation process of sections A and B

The formulation of the Domain specific requirements have taking into account our mutual aims, requirements, and experiences from other sources. In the past, representatives of the programs participate in international discussions on BME education and accreditation (Europe: the BIOMEDEA project [project leaders: Joachim Nagel, Stuttgart, Dick Slaaf, Eindhoven, and Jan Wojcicki, Warsaw] under the auspices of EAMBES, the European

Alliance of Biomedical Engineering and Science; USA: Whitaker BEES I (2000) and BEES II (2005) summit on BME education and accreditation in Lansdowne, Virginia.

The derivation process included the following steps:

- Comparison with standards derived by the academic BME community
    - Netherlands: compilation of the aims of the BME programs, which were based on international surveys (see below). In-line with basic requirements of engineering programs such as Mechanical Engineering, Applied Physics, etc.
    - Europe
        - European BME programs did not serve as reference, since no fully integrated Bachelor/Master's programs were available at the time.
        - EAMBES
            - IFMBE White paper on harmonization and accreditation of European BME programs,
            - BIOMEDEA conferences, papers and discussions
    - USA
        - The IFMBE-White paper
        - Whitaker Foundation:
            - Information on website
            - First and second BEES summit
        - and personal contacts from:
            - Duke University, Durham
            - Marquette University, Milwaukee
            - Northwestern, Evanston
            - University of Illinois, Chicago
            - Case Western Reserve University, Cleveland
            - Rensselaer Polytechnic institute, Troy
            - Massachusetts Institute of Technology, Boston
            - University of Pennsylvania, Philadelphia
            - Drexel University, Philadelphia
            - Johns Hopkins University, Baltimore
            - University of Utah, Salt Lake City

- Comparison with standards of independent bodies
    - NL: BME degree program standards were not available. KIVI, the Dutch engineering alumni association has set up a BME branch, but standards for BME still have to be prepared.
    - Europe
        - EAMBES-BIOMEDEA: The process of harmonization of accreditation is ongoing. We are actively participating.

        - EURACE: the European Accreditation of Engineers is active in preparing evaluation standards of engineering programs in Europe. The process is rather similar to that of QANU. However, they formulated no BME standards.
    - USA
        - ABET: Accreditation Board of Engineering and Technology. ABET has general engineering standards and specific standards for BME.

- Field of employment
    - NL: no representation yet. Each program has its own External Advisory Board or is setting it up. We used their input. The BME-branch of the Royal Institute of Engineers (KIVI/NIRIA) is active in the field of employment.

      It is interesting to note that the BME student societies SvBMT Protagoras (TU/e), Idun (RUG) and Paradoks (UT) are actively seeking contacts with the field of employment.
    - Europe: ESEM.
    - USA: BMES, lead society for BME in ABET. BMES formulates the specific BMES standards for ABET.

Appendix 3: Intended learning outcomes

Specific learning outcomes were formulated in more detail to realise the profiles of master's students described above. Students are entering the master's degree programme with different backgrounds (see 'Intake of students'). As a result it is necessary to make sure that all students have the same knowledge before they start to specialize in the 2nd year of the master's degree programme. Hence, we formulated learning outcomes after year 1 and after year 2:

Learning outcomes after year 1

Students have basic knowledge of:

- Anatomy of the musculoskeletal, circulatory, digestive, respiratory, excretory, endocrine and nervous systems and general knowledge of tissues;
- Physiology of the muscular, circulatory, digestive, respiratory, sensory, nervous system;
- General (patho)physiologic mechanisms (inflammation, infection, immunology, repair);
- Principles of biochemistry and cell biology;
- Bio-instrumentation; overview of diagnostic instruments, their possibilities, limitations, physical principles, phenomena they measure, the relation with the required information;
- Medical imaging in terms of an overview of present equipment for diagnostics, their possibilities and limitations, their physical principles, the phenomena they measure;
- Biochemistry in terms of cell compartments; biological macromolecules; enzyme mechanisms; structure and function of membranes, antibodies, carbohydrates, lipids, proteins;

Students have advanced knowledge of:

- Biomaterials in terms of an overview of potential materials, their properties, applications and limitations in terms of biocompatibility and failure mechanisms and current research into biomaterials;
- Signal analysis, system dynamics and computational mathematics and current research into signal analysis;
- Biomechanics in terms of statics, mechanics of materials (strength, stiffness, stress, deformation), dynamics (kinematics, kinetics, including gait analysis) and current research into biomechanics;
- Biotransport in terms of heat transport, mass transport, biofluid mechanics;
- Design/development; methodology, risk analysis, project management, market survey.
- Ethics, including regulatory affairs and social implications;
- Practical training in a European industry or hospital;

Student skills: students are able to:

- apply knowledge and understanding in performing research to realise new techniques for diagnosis and therapy;
- apply knowledge and understanding in designing new/improved diagnostic instruments and therapy devices;
- make judgements, integrating medical, cultural, social, ethical insights into her/his work;
- communicate in English having very good command of written and spoken language;
- co-operate with other biomedical engineers and with medical experts;
- co-operate with international colleagues;
- reason soundly and to critically reflect on their own and others work;

Learning outcomes after year 2

a. for the specialisation 'Prostheses & Implant Interface Technology'

Students must have knowledge of:

- concepts of prostheses, implants and tissue engineering and its application;
- biological failure mechanisms of prostheses and implants;
- materials to be used for prostheses, implants and tissue engineering;

Students must have insight into:

- numerical simulation methods for the functioning of prostheses and implants;

- measuring methods for the physical functioning of prostheses and implants;
- evaluation methods for the biological functioning of prostheses and implants;
- methods for realizing function restoration;
- methods regarding tissue engineering (such as related to stem cell and gene therapy);

Students must be able to apply:

- methods to determine biomechanical properties of biological tissues;
- cell biology evaluations;

Students must be able to integrate:

- acquired knowledge of concepts and methods for realizing function restoration;
- acquired knowledge of concepts and methods for performing research on new technologies to improve therapy.

b. for the specialisation Clinical Physics

Students must have knowledge of:

- concepts of control engineering;

Students must have insight into:

- methods for determining the physical functioning of measuring and control equipment;
- methods for performing non-invasive anatomical and functional measurements;

Students must be able to apply:

- signal analysis methods;

Students must be able to integrate:

- acquired knowledge of facts and concepts and acquired methods for realizing improvements in Medical Instrumentation and Imaging;
- acquired knowledge of concepts and methods for performing research on new technologies to improve diagnosis.

c. Additional aspects for CEMACUBE programme

The international design of the CEMACUBE programme prepares students indirectly to work in a European setting. By studying at two different European universities and interacting with their peers, students indirectly gain insight in:

- the health care situation in several countries in Europe;
- cultural differences within Europe;

Students are able to:

- make judgements, integrating medical, cultural, social and ethical insights on an international level into their work;
- co-operate with international colleagues;

Appendix 4: Overview of the curriculum

SCHEDULE MASTER MODULES BME 2011-2012

	period Ia		period Ib										period IIa										period IIb													
	2011														2012																			(holidays)
Month	September				October					November				December				January					February				March				April			
	5	12	19	26	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	6	13	20	27	5	12	19	26	2	9	16	23

Month (cont.)		April (cont.)	May				June				July		
		30	7	14	21	28	4	11	18	25	2	9	16

1st year: General Courses

(BSc LS&T)	Period Ia	Period Ib		January	Period IIa	Period IIb
	Reasoning and Arguing	Technology & Ethics		Quality of Life	Interdisciplinary Project	(Industrial) Internship
	Biomaterials 2	*Mechatronics*			*(Elective)*	
	Neuromechanics	Colloid & Interface Sci. **or**		Electronics	*(Elective)*	

1st year: General Courses

CemaCube	Period Ia	Period Ib		January	Period IIa	Period IIb
	Basic Biomedical Knowledge 1	Technology & Ethics		Quality of Life	Interdisciplinary Project	(Industrial) Internship
	Material Science	Biomedical Instrumentation			Imaging Techniques in Radiology	
	Neuromechanics	Basic Biomedical Know-		ledge 2	Numerical Methods **or**	Transport in Biological Systems

2nd year: Specialisation Courses

Clinical Physics	Period Ia	Period Ib		January	Period IIa	Period IIb
	Control Engineering **or** Computer Vision	Introduction to Research -		Assignment	Research Project (MSc Project)	Research Project (MSc Project)
	Principles of Measurement Systems	Nuclear Medicine **or**		Appl. Signal Proc.		
	Radiation Physics	Med. Phys. Rad. Onc. **or**		MR Physics		

2nd year: Specialisation Courses

Prostheses & Implant Interface Technology	Period Ia	Period Ib		January	Period IIa	Period IIb
	Physics of Transport Phenomena 2	Introduction to Research -		Assignment	Research Project (MSc Project)	Research Project (MSc Project)
	Interface Biology	Recent Developments -		in Biomaterials		
	Surface Charact. **or** Neuromechanics*	Integr. Lab Course **or** Solid Mechanics		Product Design **or**		

* Neuromechanics is only available for 2nd year students when there are still places available after enrollment of the 1st year students.

course	mandatory course
course **or** course	select one of the two/three courses
course	elective

Alternative Electives:

Scientific Visualization
Philosophy of the Exact Sciences
Radiation Safety
Robotics
Stem Cells& Regenerative Medicine
Molecular Biophysics

Specializations of the degree programme

The degree programme is divided into the following specializations:
a) specialization: Prostheses & Implant Interface Technology
b) specialization: Clinical Physics

a. Prostheses & Implant Interface Technology

Master's Curriculum	**ECTS**	**Mode of examination**
Biomaterials 2	5	W
Imaging Techniques in Radiology	5	RPW
Biomedical Instrumentation	5	RW
Numerical Methods	5	RW
Technology and Ethics	3	E
Multidisciplinary Project	5	RP
Neuromechanics	5	W
Quality of Life	2	R
Introduction Research Assignment	5	RP
Colloids and Interface Science	5	W
Recent Developments in Biomaterials	5	RP
Optional Modules	25	
Research Assignment	30	RP
Internship	15	RP

b. Clinical Physics

Master's Curriculum	**ECTS**	**Mode of examination**
Material Science	5	W
Imaging Techniques in Radiology	5	RPW
Biomedical Instrumentation	5	RW
Numerical Methods	5	RW
Technology and Ethics	3	E
Multidisciplinary Project	5	RP
Neuromechanics	5	W
Quality of Life	2	R
Introduction Research Assignment	5	RP
Electronics	5	RPW
Radiation Physics	5	W
Principles of Measurement Systems	5	W

Optional Modules	20	
Research Assignment	30	RP
Internship	15	RP

Mode of examination:
(W) Written or Oral Examination
(R) Practical or Report
(P) Presentation
(E) Essay

Appendix 5: Quantitative data regarding the programme

Data on intake, transfers and graduates

Table 1 Intake and educational background

Academic year	BSc RUG (LST)	BSc RUG (Others)	BSc (NL university)	BSc HBO	Non Dutch Diploma	Total
2006/07	2	4	0	0	1	7
2007/08	6	0	0	0	0	6
2008/09	11	1	0	2	1	15
2009/10	9	1	0	3	1	14
2010/11	8	1	0	0	6	15
2011/12	15	0	0	2	13	30
Total	**51**	**7**	**0**	**7**	**22**	**87**
Percentage	59%	8%	0%	8%	26%	100%

Table 2 Study duration per cohort

Academic year	BSc RUG		BSc (NL university)		BSc HBO		Non Dutch Diploma	
	Gradu-ates	Study duration	Gradu-ates	Study duration	Gradu-ates	Study duration	Gradu-ates	Study duration
		In months		In months		In months		In months
2006/07	2*	20	-	-	2	31	2	48
2007/08	4	18	-	-	3	25	2	54
2008/09	8	19	-	-	-	-	1	30
2009/10	4	19	-	-	1	24	-	-
2010/11	10	27	-	-	1	27	-	-
Averages	**28**	**20.6**	**-**	**-**	**7**	**27.8**	**5**	**44**

Teacher-student ratio achieved

Table 3 Student-staff ratio

Academic year	**Quantity of staff (fte)**				**Number of master's students**	**Student/staff-ratio**
	FMNS	UMCG	External	Total		
2008/2009	0,50	1,25	0,06	1,82	20	11,0
2009/2010	0,40	0,93	0,03	1,38	17	12,3
2010/2011	0.55	1,42	0.05	2.00	33	16,5

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

Table 4 4 Face- to face instruction

	Lectures	Tutorials	Project oriented	Laboratory practical	Private study	Presen-tations	**Total**
year 1	200	40	600	100	700	40	1680
year 2	60	40	1000		520	60	1680

Appendix 6: Programme of the site visit

3 oktober 2012

09.00-11.00 **Preparatory meeting review committee**
Prof. dr. ir. J. van der Sloten *(chairman)*, Prof. R.B. Reilly, Prof. dr. ir. J. Spaan, Dr. J.J. Struijk, Mw. S. van Tienhoven *(BSc, master student)*, dr. B. van Balen *(secretary)*

11.00-11.30 **Inspection of documents**

11.30-12.00 **Field experts**
Ing. L. Boudewijn, Ir. R. Lap, T. Boutkan, E. Vredeveld

12.00-13.00 **Representatives BME**
prof.dr. T.H. Elzenga, prof.dr. D. Hoekstra,
prof.dr.ir. G.J. Verkerke, drs. I.A. Neven, dr I.C. Knevel

13.00-13.45 **Lunch and walk-in consultation**

13.45-14.45 **Students (2 biomat, 2 CI Physics, 2 EM)**
K. Leemhuis, S. van Engelshoven, D. de Jong

14.45-15.45 **Teaching staff (max 8)**
prof.dr.ir. G.J. Verkerke, mw. prof.dr. H.C. van der Mei, dr M. Greuter, Dr. E. Maeckelberghe, dr. T.R. Koiter, dr. M.A. Hofstee

15.45-16.00 **Break**

16.00-16.45 **Exam committee & Study counsellor**
dr. T.R. Koiter, prof. dr. A.M.J. Paans, dr. F.W. Wubs, drs. I.A. Neven, prof.dr. H.C. van der Mei

16.45-17.15 **Study programme committee**
Prof.dr.ir. G.J. Verkerke, A. van der Schaaf, Mw. dr. M.A. Hofstee, drs. I.A. Neven, dr. F.W. Wubs, K. Cazemier, E. Kho

17.15-17.30 **Break**

17.30-18.00 **Alumni**
M. van Diest, J. Herz, R. Visser, E. Vredeveld

4 oktober

09.00-09.30 **Tour along research facilities and labs**
prof.dr.ir. G.J. Verkerke

09.30-10.00 **Preparatory meeting final session Management**

10.00-10.45 **Final session Management**
Representatives of the Faculty of Mathematics and Natural Sciences:
prof.dr. J. Knoester *(dean),*
prof.dr. P.J.M. van Haastert *(vice-dean Education),*
Representatives of the Faculty of Medical Sciences:
prof.dr. F. Kuipers *(dean),*
prof.dr. J. C. C. Borleffs *(vice-dean Education),*
prof.dr. L.F.M.H. de Leij *(vice-dean Research),*
Representatives Life Sciences Educational Institute:
prof.dr. T.H. Elzenga *(director School of Life Sciences),* prof. dr. D. Hoekstra *(course director Life Science & Technology)*, prof.dr.ir. G.J. Verkerke *(course director Master's program Biomedical Engineering)*, drs. I.A. Neven, dr. I.C. Knevel *(course coordinators)*

10.45-11.00 **Break**

11.00-13.00 **Drafting first results and lunch**

13.00-13.45 **Preliminary results presentation and informal closing**

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:

1713663
1802313
1469258
1531069
1353020
1383345
1487000
1541269
1353152
1607960
1365088
1339494
1404660
1460552
1425749
1752057

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):

Course materials for courses and projects:
- Course outlines
- Assignments
- Answers and assignment papers by students
- Evaluation forms
- Exams and tests

Educational committee:
- Annual educational reports
- Course evaluations

Board of Examiners
- Annual reports
- Letters and communications to staff

Professional Field Advisory Board
- Minutes

Appendix 8: Declarations of independence

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: Jos Vander Sloten

HOME ADDRESS: Langestraat 62
3190 Boortmeerbeek
Belgium

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN EXPERT / SECRETARY:

BSc & MSc TU Twente

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

1

nvao
nederlands - vlaamse accreditatieorganisatie

HEREBY CERTIFIES TO NOT HAVING MAINTAINED SUCH CONNECTIONS OR TIES WITH THE INSTITUTION DURING THE PAST FIVE YEARS;

CERTIFIES TO OBSERVING STRICT CONFIDENTIALITY WITH REGARD TO ALL THAT HAS COME AND WILL COME TO HIS/HER NOTICE IN CONNECTION WITH THE ASSESSMENT, INSOFAR AS SUCH CONFIDENTIALITY CAN REASONABLY BE CLAIMED BY THE PROGRAMME, THE INSTITUTION OR NVAO;

HEREBY CERTIFIES TO BEING ACQUAINTED WITH THE NVAO CODE OF CONDUCT.

PLACE: Boortmeerbeek DATE: 11/9/12

SIGNATURE:

2

Q309

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: Johannes J. Struijk

HOME ADDRESS: Aalborgvej 11
9575 Terndrup
Denmark

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN EXPERT / SECRETARY:

Biomedical Technology B. Sc.
Biomedical Engineering M.Sc.

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

University of Twente

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

1

nvao
nederlands - vlaamse accreditatieorganisatie

HEREBY CERTIFIES TO NOT HAVING MAINTAINED SUCH CONNECTIONS OR TIES WITH THE INSTITUTION DURING THE PAST FIVE YEARS;

CERTIFIES TO OBSERVING STRICT CONFIDENTIALITY WITH REGARD TO ALL THAT HAS COME AND WILL COME TO HIS/HER NOTICE IN CONNECTION WITH THE ASSESSMENT, INSOFAR AS SUCH CONFIDENTIALITY CAN REASONABLY BE CLAIMED BY THE PROGRAMME, THE INSTITUTION OR NVAO;

HEREBY CERTIFIES TO BEING ACQUAINTED WITH THE NVAO CODE OF CONDUCT.

PLACE: Aalborg DATE: 10 sept. 2012

SIGNATURE:

2

nvao
nederlands - vlaamse accreditatieorganisatie

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: Jos A E Spaan

PRIVÉ ADRES:

C. Boyerstraat 10
1325 LH Almere

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

Biomedical Engineering,

AANGEVRAAGD DOOR DE INSTELLING:

TUE

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: Eindhoven DATUM: 6 juli 2012

HANDTEKENING:

2

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: Richard Reilly

~~HOME~~ Office ADDRESS: Trinity College Dublin, Dublin 2, Ireland

home address 10 Nutley Road
Ballsbridge
Dublin 4, Ireland

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS AN EXPERT / SECRETARY:

University of Twente BSc and MSc Biomedical Engineering

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

University of Twente.

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

1

nvao
nederlands - vlaamse accreditatieorganisatie

HEREBY CERTIFIES TO NOT HAVING MAINTAINED SUCH CONNECTIONS OR TIES WITH THE INSTITUTION DURING THE PAST FIVE YEARS;

CERTIFIES TO OBSERVING STRICT CONFIDENTIALITY WITH REGARD TO ALL THAT HAS COME AND WILL COME TO HIS/HER NOTICE IN CONNECTION WITH THE ASSESSMENT, INSOFAR AS SUCH CONFIDENTIALITY CAN REASONABLY BE CLAIMED BY THE PROGRAMME, THE INSTITUTION OR NVAO;

HEREBY CERTIFIES TO BEING ACQUAINTED WITH THE NVAO CODE OF CONDUCT.

PLACE: University of Twente DATE: 13/3/2012

SIGNATURE:

2

nvao
nederlands - vlaamse accreditatieorganisatie

ONAFHANKELIJKHEIDS- EN GEHEIMHOUDINGSVERKLARING

INDIENEN VOORAFGAAND AAN DE OPLEIDINGSBEOORDELING

ONDERGETEKENDE

NAAM: S. van Tienhoven (Sandra)

PRIVÉ ADRES: Hoogstraat 426
5654 NK Eindhoven

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

Biomedische Technologie (Bachelor)
Biomedical Engineering (Master)

AANGEVRAAGD DOOR DE INSTELLING:

Rijksuniversiteit Groningen
Universiteit Twente

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

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: Eindhoven

DATUM: 11-5-2012

HANDTEKENING:

2

nvao
nederlands - vlaamse accreditatieorganisatie

DECLARATION OF INDEPENDENCE AND CONFIDENTIALITY

TO BE SUBMITTED PRIOR TO THE ASSESSMENT OF THE PROGRAMME

THE UNDERSIGNED

NAME: Linda van der Grijspaarde

HOME ADDRESS:

Opwierderweg 150
Oppingedam

HAS BEEN ASKED TO ASSESS THE FOLLOWING PROGRAMME AS ~~AN EXPERT~~ / SECRETARY:

Biomedical Engineering

APPLICATION SUBMITTED BY THE FOLLOWING INSTITUTION:

Universiteit Twente, TU Delft, TU/e

HEREBY CERTIFIES TO NOT MAINTAINING ANY (FAMILY) CONNECTIONS OR TIES OF A PERSONAL NATURE OR AS A RESEARCHER / TEACHER, PROFESSIONAL OR CONSULTANT WITH THE ABOVE INSTITUTION, WHICH COULD AFFECT A FULLY INDEPENDENT JUDGEMENT REGARDING THE QUALITY OF THE PROGRAMME IN EITHER A POSITIVE OR A NEGATIVE SENSE;

1

nvao
nederlands - vlaamse accreditatieorganisatie

HEREBY CERTIFIES TO NOT HAVING MAINTAINED SUCH CONNECTIONS OR TIES WITH THE INSTITUTION DURING THE PAST FIVE YEARS;

CERTIFIES TO OBSERVING STRICT CONFIDENTIALITY WITH REGARD TO ALL THAT HAS COME AND WILL COME TO HIS/HER NOTICE IN CONNECTION WITH THE ASSESSMENT, INSOFAR AS SUCH CONFIDENTIALITY CAN REASONABLY BE CLAIMED BY THE PROGRAMME, THE INSTITUTION OR NVAO;

HEREBY CERTIFIES TO BEING ACQUAINTED WITH THE NVAO CODE OF CONDUCT.

PLACE: Oppingedam

DATE: 21 november 2012

SIGNATURE:

2