Appendices master's degree programme
Biomedical Engineering
2013-2014

Appendix I Learning outcomes of the degree programme (art. 1.3)

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.

Appendix II Specialisations of the degree programme (art. 2.2)

The degree programme is divided into the following specialisations:

a. Prostheses & Implant Interface Technology
b. Clinical Physics

Appendix III Content of degree programme (art. 2.3)

a. General course elements

Course elements	ECTS	Assessment	Practical
Biomaterials 2	5	W	no
Control Engineering	5	WR	no
Product Design by the Fin. Elem. Meth.	5	R	no
Technology and Ethics	5	E	no
Interdisciplinary Project	5	RP	yes
Biomedical Instrumentation 2	5	R	no
Internship	15	RP	yes
Master's Project	35	RP	yes

b. Course elements of the specialisation *Prostheses & Implant Interface Technology*

Master's Curriculum	ECTS	Assessment	Practical
Optional Modules	10		
Mechatronics	5	W	no
Interface Biology	5	WRP	yes
Recent Developments in Biomaterials	5	RP	yes
Integrated Lab Course Biomaterials	5	RP	yes

c. Course elements of the specialisation *Clinical Physics*

Master's Curriculum	ECTS	Assessment	Practical
Optional Modules	15		
Radiation Physics	5	W	no
Imaging Techniques in Radiology 2	5	WRP	yes
Nuclear Medicine, SPECT and PET	5	W	no

d. CEMACUBE (1st year)

Master's Curriculum	ECTS	Assessment	Practical
Basic Biomedical Knowledge 1	5	WRP	yes
Neuromechanics	5	W	no
Basic Biomedical Knowledge 2	5	WRP	yes
Imaging Techniques in Radiology 1	5	WRP	yes
Technology and Ethics	5	E	no

Interdisciplinary Project	5	RP	yes
Biomedical Instrumentation 1	5	WR	no
Internship	15	RP	yes

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

Appendix IV Optional modules (art. 2.4)

a. Prostheses & Implant Interface Technology

Master's Curriculum	ECTS	Assessment	Practical
Image Processing	5	WR	no
Computer Vision	5	WR	no
Statistical Methods in Physics	5	WR	no
Robotics	5	W	no
Surface Characterization	5	WRP	yes
Neuromechanics	5	W	no
Colloid and Interface Science	5	W	no

b. Clinical Physics

Master's Curriculum	ECTS	Assessment	Practical
Image Processing	5	WR	no
Computer Vision	5	WR	no
Statistical Methods in Physics	5	WR	no
Robotics	5	W	no
Magnetic Resonance Physics	5	W	no
Modelling and Simulation	5	R	yes
Radiation Safety	5	WR	no
Statistical Signal Processing	5	WR	no
Medical Physics in Radiation Oncology	5	WR	no

c. CEMACUBE (1st year)

Master's Curriculum	ECTS	Assessment	Practical
Robotics	5	W	no
Numerical Methods	5	WR	no

d. Backup courses

Students are allowed to follow a maximum of 2 courses from the following list of courses without permission of the Board of Examiners. Students are responsible to check whether schedules fit:

Master's Curriculum	ECTS	Assessment	Practical
Tools and Approaches in Systems Biology	5	WRP	yes
Scientific Visualization	5	R	no
Physics of Transport Phenomena 2	5	W	no
Innovative Dosage Forms	5	RP	yes

e. Courses selected by students.

Upon request of the student, the Board of Examiners can give permission to follow a course that is not mentioned in above. The request procedure must be started at least 4 weeks before the beginning of the course.

The procedure is started as soon as the Board of Examiners receives a letter in which the permission is requested. In this letter, the student must state the relevance of the selected course for their individual curriculum.

The Board of Examiners will decide on an individual basis if permission is granted. The student will be informed in writing about the decision on their permission within 4 weeks.

Appendix V Entry requirements and compulsory order of examinations (art. 3.2)

Module	After successfully passing exams of the course elements
Integrated Lab Course Biomaterials	Interface Biology
Medical Physics for Radiation Oncology	Radiation Physics
Nuclear Medicine, SPECT and PET	Radiation Physics
Biomaterials 2	Biomaterials 1

Appendix VI Admission to the degree programme and different specializations (art. 4.1.1 + art. 4.2)

Admission to the Master's degree programme

1. Holders of a Bachelor's degree in Life Science & Technology with a major Biomedical Engineering from the University of Groningen are considered to have sufficient knowledge and skills and will be directly admitted to the Master's degree programme.

2. 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 1 and 2 to catch up on the necessary biological background knowledge.

3. All other students (this includes students from other universities or from universities of applied sciences) who apply for the Master's degree programme are screened by the BME Admissions Board, which suggests a pre-Masters programme based on the candidates previous education.

4. International students (these are students with a non-Dutch Bachelor degree) need to submit their application via the online application system of the University of Groningen to the Admissions Office. The admission deadlines are presented in Appendix IV. All international candidates are screened by the BME Admissions Board, which suggests a Master's programme based on the candidates previous education.

Admission to the different specializations

Admission requirements for the two specializations:

- specialisation Prostheses & Implant Interface Technology: Mechatronics as elective in the first year
- specialisation Clinical Physics: Radiation Physics as elective in the first year

Teaching and Examination Regulations Master's degree Biomedical Engineering

Common Rules for the Erasmus Mundus Programme CEMACUBE

Contents

Section 1 General Provisions

Article 1.1 Applicability

These Regulations apply to the modules and final assessment of the CEMACUBE Erasmus Mundus Master's degree programme in Biomedical Engineering, hereinafter referred to as 'the degree programme'. The degree programme is organised by the Faculty of Mathematics and Natural Sciences of the University of Groningen and by the Faculties or corresponding bodies of the other CEMACUBE partner universities: Czech Technical University in Prague, Czech Republic; Trinity College in Dublin, Ireland; Aachen University, RWTH, in Aachen, Germany; Ghent University in Ghent and the Vrije Universiteit Brussel ('Free University Brussels') (VUB) in Brussels, Belgium. In cases in which these regulations provide no guidance, the local rules of the concerned partner university have to be applied.

Article 1.2 Definitions

The following definitions apply to these Regulations:

a. student: a person enrolled at the university for the purpose of taking modules and/or examinations and the final assessment leading to the conferral of a university degree.
b. module: a teaching unit or other part of the degree programme.
c. practical: a learning-by-doing exercise
d. final assessment: the final assessment of the degree programme.
e. ECTS: credits in accordance with the European Credit Transfer and Accumulation System.
f. semester: part of the academic year, representing 30 ECTS in modules
g. ECTS grading table: an European system for the interpretation and conversion of grades.
h. the Board of Examiners consists of the local coordinators of the programme at the participating universities.
i. European or Category B student: Student holds valid passport of a country belonging to the European Union (EU) or European Economic Area (EEA).
j. non-European or Category A student: Student holds valid passport from a non-EU/EEA country. If the student has been in any EU/EEA country for over 12 months in the last 5 years, the applicant is considered an EU/EEA or Category B applicant.

Article 1.3 Aim of the degree programme

The learning outcomes of the master's degree programme are specified in Appendix A.

Article 1.4 Type of degree programme

The degree programme is full-time and lasts 2 academic years.

Article 1.5 Teaching language

The degree programme is taught in English.

Section 2 Structure of the degree programme

Article 2.1 Study load

The degree programme has a study load of 120 ECTS.

Article 2.2 Specializations

Appendix B sets out the specializations of the degree programme.

Article 2.3 Content of the degree programme

Appendix C sets out the (compulsory) end requirements of the first and second year of the degree programme and a list of course elements. Appendix B lists the specializations of year 2, which consist of 1 semester (30 ECTS) of courses and a master thesis of 1 semester (30 ECTS).

Article 2.4 Alternative modules

The Board of Examiners may permit the student to select one or more modules from another master's degree programme (from the University of Groningen or from another CEMACUBE partner university).

Section 3 Examinations and final assessment in the degree programme

Article 3.1 General

Assessment of modules will be done by the local Board of Examiners and is expressed in the ECTS grading scale, shared by all participating universities. C**onversion of local grades to the ECTS table is presented below**:

<table>
<tr><th>ECTS</th><th>Aachen</th><th>Ghent</th><th>Groningen</th><th>Dublin</th><th>Prague</th></tr>
<tr><td rowspan="5">A</td><td rowspan="2">1,0</td><td>20</td><td>10,0</td><td>100-92</td><td>1,0</td></tr>
<tr><td>19-17</td><td>9.0-8.5</td><td>93-80</td><td>1,1</td></tr>
<tr><td rowspan="3">1,3</td><td rowspan="3">16</td><td rowspan="3">8,0</td><td>80-75</td><td>1,2</td></tr>
<tr><td>74-70</td><td>1,3</td></tr>
<tr><td>69</td><td>1,4</td></tr>
<tr><td rowspan="4">B</td><td rowspan="3">1,7</td><td rowspan="3">15</td><td rowspan="4">7,5</td><td>68</td><td>1,5</td></tr>
<tr><td>67</td><td>1,6</td></tr>
<tr><td>66</td><td>1,7</td></tr>
<tr><td rowspan="3">2,0</td><td rowspan="3">14</td><td>65</td><td>1,8</td></tr>
<tr><td rowspan="4">C</td><td rowspan="4">7,0</td><td>64</td><td>1,9</td></tr>
<tr><td>63</td><td>2,0</td></tr>
<tr><td>2,3</td><td>62</td><td>2,1</td></tr>
<tr><td rowspan="2">2,7</td><td rowspan="3">13</td><td>61</td><td>2,2</td></tr>
<tr><td rowspan="4">D</td><td rowspan="3">6,5</td><td>60-59</td><td>2,4</td></tr>
<tr><td>58</td><td>2,5</td></tr>
<tr><td>3,0</td><td rowspan="2">12</td><td>57-55</td><td>2,6</td></tr>
<tr><td>3,3</td><td rowspan="2">6,0</td><td>54-53</td><td>2,7</td></tr>
<tr><td>3,7</td><td>11</td><td>52-51</td><td>2,9</td></tr>
<tr><td>E</td><td>4,0</td><td>10</td><td>5,5</td><td>50</td><td>3,0</td></tr>
<tr><td>F</td><td>>4,0</td><td>>10</td><td>>5,5</td><td>>50l</td><td>>3,0</td></tr>
</table>

Article 3.2 Frequency

There will be an opportunity to sit the examinations for the modules two times.

Article 3.3 Assessing the Final Degree Project

The assessment of a final degree project (thesis or research project) takes place within a general assessment framework. The supervisors (at least three, two of them being active teachers of the degree programme, and from minimally 2 different universities) who have been appointed as the Thesis Board by the Board of Examiners will determine the mark together. When no consensus can be reached, they will consult an external supervisor.

Article 3.4 Marking of Examinations and Publication of Grades

1. Examination results must be made known to the student according to the timeframe indicated by the local rules of the partner universities. The results of all examinations

and re-examinations should be made known before 21 September, with exception of Groningen and Dublin (1 September)

2. The Education and Examinations Office at the coordinating university (Groningen) is responsible for the registration of the individual results of all students. The corresponding bodies of the other participating universities are responsible for the registration of the results of the locally registered students and for the transfer of these results to the Education and Examinations Office at the University of Groningen.

3. A printout of individual student results is a valid confirmation of these results if authorized by or on behalf of the Board of Examiners. Request for printouts should be addressed to the Education and Examinations Office at the coordinating university (Groningen).

Article 3.5 Validity

Examinations that have been passed remain valid for five years.

Article 3.6 Final Assessment

1. The Board of Examiners shall determine the final assessment after the student has presented proof that he has passed all the examinations of the degree programme.

2. Before the final assessment can be determined, the Board of Examiners may itself decide to test the student's knowledge of one or more modules or aspects of the degree programme, if and in as much as the grades for these modules provide a reason for doing so.

3. Students are deemed to have passed the final assessment if they have obtained a sufficient grade for each module of the degree programme (see Article 3.1).

Article 3.7 Degree

1. A student who has satisfied all the requirements of the final assessment shall be awarded the degree of "Master of Science".

2. The degree awarded shall be registered on the final certificate.

Section 4 Selection procedure

Article 4.1 Previous education

1. The admission to the degree programme is set out in appendix D.

2. Students with Bachelor's degrees other than those referred to in article 4.1.1 will be admitted at the discretion of the Admissions Board. Admission will be considered if: the previous qualification is equivalent to the Bachelor's degree programmes requested in article 4.1.1.

Article 4.2 Admissions Board

1. Admission to the degree programme and the various modules is assigned to the Admissions Board of the degree programme. This Board consists of:
   - the local coordinator of the University of Groningen (chairperson)
   - a minimum of two members selected from the other local coordinators of the degree programme.

2. The members of the Admissions Board are appointed by the Board of Examiners.

Article 4.3 Applications procedure

1. The application deadlines for admission to the degree programme and given modules are set out in Appendix E. The application must be submitted to the Admissions Board.

2. The Admissions Board will make a decision before 1 March respectively.

Article 4.4 Conditional admission

The Admissions Board may admit a student who has still to complete their Bachelor degree programme (listed in Article 4.1.1) upon application, to the degree programme on condition that: he or she hands over the diploma before 1 September of the first academic year at the latest.

Article 4.5 Student Mobility

Students are required to spend the first and the second year of the programme at two different CEMACUBE partner universities.

Section 5 Final Provisions

Article 5.1 Amendments

1. Any amendments to these Regulations will. be confirmed by the Faculty Boards or corresponding bodies of the participating universities in a separate decree.

2. An amendment to these Regulations does not apply to the current academic year, unless it may reasonably be assumed that the amendment will not harm the interests of students.

3. An amendment may not harm the interests of students by affecting decisions taken by the Board of Examiners within the meaning of these Regulations.

Article 5.2 Publication

1. These Regulations, any rules and guidelines formulated by the Board of Examiners, and any amendments to these documents will be published on the CEMACUBE website

2. Copies of the documents referred to in Article 5.2.1 are made available to the students by all CEMACUBE partner universities at the start of each academic year.

Article 5.3 Appeal procedure and unexpected events

1. Appeals against decisions made by an examiner or the Board of Examiners may be filed with the CEMACUBE International Course Advisory Committee, which acts as the Board of Appeal for Examinations.

2. In exceptional cases or cases not covered by these regulations, the Board of Examiners shall have the final say.

Article 5.4 Date of Commencement

These Regulations shall take effect on 1 September 2013.

Appendix A. Learning outcomes of the degree programme (art. 1.3)

The graduate in Biomedical Engineering:

1. has basic knowledge in the general field of BME;
2. is familiar with existing scientific knowledge, skills and attitudes in a specific BME field of expertise and is able to increase and develop these through study;
3. is capable of designing and conducting scientific research and of designing devices or systems in the field of expertise;
4. is capable of effective communication with other experts in the fields of biomedical science and technology and with lay people, both in writing and orally;
5. is capable of cooperating with other experts in international and multidisciplinary teams;
6. is capable to critically analyze and evaluate scientific literature;
7. is capable of systematic and creative working and thinking in analyzing complex problems;
8. is capable to reason soundly, integrate medical, ethical, cultural and social aspects into her/his work and to reflect critically on his/her own and others' work;
9. is prepared for a professional career in science and technology or in management and policy;
10. is capable of following a post-graduate training in BME, performing a PhD project and training him/herself continuously

Appendix B. Specializations of the degree programme (art. 2.2)

University	*Specialization*
Groningen	• Prostheses & Implant Interface Technology • Clinical physics
Ghent	• Radiation physics and medical imaging • Computational methods for medical applications
Dublin	• Neural engineering
Prague	• Medical instrumentation • Medical imaging instrumentation
Aachen	• Artificial organs and implants • Tissue Engineering

Appendix C. Content of degree programme (art. 2.3)

Competences after year 1

Students have basic knowledge of:

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

Students have advanced knowledge of:

h. Biomaterials in terms of an overview of potential materials, their properties, applications and limitations, in terms of biocompatibility and failure mechanisms.
i. Signal analysis, system dynamics and computational mathematics
j. Biomechanics in terms of statics, mechanics of materials (strength, stiffness, stress, deformation), dynamics (kinematics, kinetics, including gait analysis).
k. Biotransport in terms of heat transport, mass transport, biofluid mechanics.
l. Design/development; methodology, risk analysis, project management, market survey.
m. Ethics, including regulatory affairs, social implications.
n. Practical training in a European industry and hospitals, entrepreneurship as part of their professional development, IP.

Student skills: students are able to:

o. apply knowledge and understanding in designing new/improved diagnostic instruments
p. apply knowledge and understanding in designing new or improved therapy devices.
q. make judgements, integrating medical, cultural, social and ethical insights into her/his work
r. communicate in English having very good command of written and spoken language.
s. communicate in one other language on a basic level, being the language of a host country.
t. co-operate with other biomedical engineers and with medical experts.
u. co-operate with international colleagues.
v. reason soundly and to critically reflect on their own and others work

Competences after year 2

w. Students have advanced knowledge of a particular field in Biomedical Engineering (one of the specialisations, offered by the consortium).
x. Students are able to apply and integrate knowledge of that particular field.
y. Students are able to perform a research or design project by integrating all acquired knowledge and skills, and to show appropriate behaviour given the professional context.
z. Students are able to present their work in English both in writing and orally, and respond adequately to criticism.

During the **first two semesters**, in total 60 ECTS, each university gives course elements (modules) on basic BME-topics. The programme of these two semesters, offered by each consortium university is comparable in content and will contain at least the following *biomedical modules:*

- Biochemistry;
- Cell Biology;
- Anatomy and Histology;
- (Patho)physiology;
- Ethics

and the following *general engineering modules*:

- Methodical Design;
- Project Management (including teamwork);
- Biotransport;
- Working Culture (comprising a traineeship, lectures on health care organisation and culture)

and the following *engineering modules, focused on diagnostics*:

- Imaging Techniques;
- Biomedical Instrumentation;
- Signal Analysis

and the following *engineering modules, focused on therapy*:

- Biomaterials;
- Biomechanics

These modules define the basic level of competence of students. With these courses the student can follow every specialization, offered in the third semester. When a student obtains exemptions for following modules, preventing him/her from obtaining 60 ECTS, (s)he has to choose (an) alternative module(s), offered by the university.

Traineeships have to be done in an industrial company or in a hospital

During the **third and fourth semesters**, spent at a different partner university of CEMACUBE, students will follow 30 ECTS of specialization courses and perform a research or design project, corresponding to 30 ECTS.

Appendix D. Admission to the degree programme and different specializations (art. 4.1.1)

a. Holders of a Bachelor's degree in either Biomedical, Electrical, Mechanical, Chemical Engineering, Applied Physics or similar are considered to have sufficient knowledge and skills and can be admitted to the Master's degree programme.
b. If necessary the applicant proves to have sufficient proficiency in the English language to participate in the programme with at least the following scores on an English Language test (IELTS test score of 6.5, TOEFL-score of 580 (paper-based), 237 (computer-based) or 92 (internet -based) or equivalent).

Appendix E. Application deadlines for admission (art. 4.3)

Deadline of Application	Non-EU/EEA students	EU/EEA students
Biomedical Engineering	1 December 2013	5 January 2014