Assessment plan for the curriculum of the Master's degree programme in Biomedical Engineering

Curriculum 2022/2023

1. Objectives of the degree programme

We follow The Whitaker Foundation (2006) in adopting the following definition:
"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."

Graduates of the UG BME Master's degree programme are therefore educated in the domains of engineering, biology and medicine and are skilled in the abilities described in points 1 and 2 of The Whitaker Foundation[1].

Our mission
Our mission is to educate students of the Master's degree programme BME in such a way that they are able to increase the quality of medical care and to decrease the cost and manpower, necessary for providing health care nowadays. To achieve this goal students of the MSc programme of Biomedical Engineering are trained to perform scientific research to new technologies that will contribute to more efficient health care and high quality of life. They are also trained to develop smart and advanced equipment, methods and products to improve diagnosis as well as therapy. To be prepared to work in an international setting, students must be trained as such. With the acquired knowledge and skills students will be able to contribute on three different levels to a quickly progressing health care sector:

1. Performing scientific research to develop new techniques for diagnosis and therapy, mainly done at universities, University Medical Centers and large companies with distinct research departments;
2. Designing new diagnostics and therapies at companies, universities and UMC's;
3. Applying new diagnostics and therapies at UMC's and hospitals;

2. Learning outcomes of the degree programme

A graduate with a Master of Science in BME is able to:

1. *Analyse the problem and define aim*

A Biomedical Engineer is able to analyse biomedical problems of a complex nature by choosing the appropriate level of abstraction and by critically examining existing theories, models or interpretations based on the assessment of the scientific value of current research within Biomedical Engineering. The Biomedical Engineer thereby creates a cause-effect model, distinguishes the problems that are fundamental and solvable and defines the aim which has the highest priority.

2. *Create a Design, Research & Development proposal*

A Biomedical Engineer is able to design different strategies to obtain the defined aim, and has the skills in, and the affinity with the design, use and validation of models to allow the Biomedical Engineer to consciously choose the most efficient and effective Design, Research & Development plan.

3. *Execute the Design, Research & Development plan*

A Biomedical Engineer is able to execute a Design, Research & Development plan and to adapt it when external circumstances or advancing insight requires it. Depending on the project the focus may be more on the scientific approach to increase knowledge and understanding (research), on prototyping and product improvement (development) or on the design of new devices or systems, although all three aspects are essential in the Design, Research & Development cycle of innovative products.

[1] Abu-Faraj, Ziad (2012) Handbook of Research on Biomedical Engineering Education and Advanced Bioengineering Learning Interdisciplinary Concepts. Page 3. Link

4. *Analyse and interpret the data*

A Biomedical Engineer is able to ask adequate questions and has a critical, yet constructive attitude towards analysing and solving complex real-life biomedical problems. The Biomedical Engineer is able to form a well-reasoned opinion in the case of incomplete or irrelevant data; is able to analyse and interpret the results of Design, Research & Development in terms of statistics, limitations and the relation to existing literature and devices aiming to contribute to the advancement of knowledge in his or her field of Biomedical Engineering and beyond it.

5. *Communicate results*

A Biomedical Engineer, as an interdisciplinary specialist, is able to communicate orally and in writing about Design, Research & Development with colleagues, non-colleagues and other involved parties including health care providers and patients. In addition, the Biomedical Engineer is able to debate about both Biomedical Engineering and the place of Biomedical Engineering in society.

6. *Embed the results in scientific and social context*

A Biomedical Engineer is able to analyse and to discuss the social consequences (economic, social, cultural) of new developments in Biomedical Engineering with colleagues and non-colleagues; has insight into (debates about) scientific practice and is able to analyse and to discuss the ethical and the normative aspects of the consequences and assumptions of the scientific practice with colleagues and non-colleagues and is able to integrate these ethical and normative aspects in its own work.

7. *Demonstrate a professional attitude*

A Biomedical Engineer is able to incorporate the knowledge, skills and competences described above and demonstrates a professional attitude by showing a high level of independence, responsibility and commitment. In addition, the Biomedical Engineer shows social skills as well as the ability to improve after feedback.

3. Overview examiners and modes of assessment per course unit

There is a distinction between BME course examiner (table 3.1) and a BME Project examiner (table 3.2) within the Biomedical Engineering programme.

BME Course examiner

Course examiners are appointed by the Board of Examiners as first or second examiner of a course(s) that are part of the curriculum of the Master's and/or Bachelor's Biomedical Engineering programme (see Table 3.1).

BME Project examiner

Project examiners are appointed by the Biomedical Engineering (BME) Board of Examiners only as second examiners in Internships and Master's projects. Project examiners are appointed by the Board of Examiners based on supervised Internships and/or Master's projects in recent years (Table 3.2). Project examiners only assess Internship and/or the Master's projects as a second examiner due to the fact that they are not involved in the BME programme.

Internal and External Biomedical Engineering projects will be assessed by at least one BME course examiner.

Internal projects

Internal projects carried out at the University of Groningen (UMCG clinical departments excluded) will be assessed by (at least one) BME course examiner. The second examiner can be a Project examiner from the Faculty of Science and Engineering or the Faculty of Medical Sciences, appointed by the BME Board of Examiners.

External projects

There are two kinds of external projects; 1) at accredited universities or University Medical Center hospitals (UMC), and 2) at companies or regular hospitals.

1) External projects carried out at accredited universities and UMC's will be assessed by a BME course examiner as a first examiner, and by a scientific staff member from the hosting university/UMC as a second examiner.
2) External projects carried out at companies or regular hospitals will be assessed by two BME course examiners.

Table 3.1. Per course unit the intended assessment mode(s), the ECTS per course unit, and the BME course examiners are listed. This satisfies requirement 3 in the Protocol of Duties and Powers Status of the University Teaching Qualification (UTQ). UTQ Status examiners: UTQ finalised (UTQ); UTQ in progress (in progress), will start UTQ (start).

Course name	**Mode of assessment [a],[b]**	**ECTS**	**1st Examiner**	**2nd Examiner(s)**
Courses organized by the programme				
Applied Medical Visualization	P, R	5	dr. ir. P.M.A. van Ooijen UTQ	dr. K. Ng Wei Siang
Biofilms	AST, WE, IT,P	5	dr. B.W. Peterson UTQ	dr. P.K. SharmaUTQ
Biomaterials 2	AST	5	dr. P. van Rijn UTQ	dr. T.G. van KootenUTQ
Biomedical Instrumentation 2	WE	5	dr. R. Schirhagl UTQ	dr. J.M. Hijmans , prof. dr. N.M. Jansonius, ir. A. Maat, prof. dr. ir. N.M. Maurits
Bio-signal processing for human machine interaction	R	5	dr. E. (Elisabeth) Wilhelm UTQ	prof. dr.ir. M. Cao UTQ
Colloid and Interface Science	WE, AST	5	dr. J. Sjollema UTQ	pr. P. K. Sharma UTQ
Computed Tomography	MC, WE, PR	5	dr. M.J.W. Greuter UTQ	ir. H. Dijkstra UTQ
Control Engineering for BME	WE, R	5	dr. R. Reyes-Baéz start	dr. J. Sjollema UTQ
Conventional Imaging Techniques and Ultrasound	WE, R, P	5	ir. H. Dijkstra UTQ	dr. M.J.W. Greuter UTQ
Engineering and Biotribology	WE, P	5	dr. P.K. Sharma UTQ	*prof. dr. A. (Antonis) Vakis UTQ*
Integrated Lab Course Biomaterials	R, AST, PR	5	dr. B.W. Peterson UTQ	dr. P. K. Sharma UTQ
Interface Biology	WE, R, P	5	dr. T.G. van Kooten UTQ	dr. P. van Rijn UTQ
Introduction to MATLAB programming for BME	AST	5	dr. A.T.M. Willemsen UTQ	*dr. J.R. de Jong UTQ*
Medical Device Commercialisation	AST, R, P, PR, OR	5	prof. dr. O. Belousova UTQ	prof. dr. A.J. Groen
Medical Physics for Radiation Oncology	WE, PR	5	V.C. Hamming (Msc)	P. Kloosterman
Microscopy and Imaging	WE, P	5	dr. R. Schirhagl UTQ	dr. B.W. Peterson UTQ
MRI	OR, P	5	dr. R. J. Renken UTQ	ir. H. Dijkstra UTQ
Multidisciplinary Project	R, P	5	dr. C.C. Roossien in progress	prof. Dr. Ir. G. J. Verkerke
Product Design by FEM (for BME)	AST	5	*dr. R. Fluit in progress*	dr. C.C. Roossien in progress
Prosthetics and Orthotics	AST, P,PR, R	5	dr. C.C. Roossien in progress	prof. dr. ir. G. J. Verkerke
Quantitative Image Analysis	AST, MC, P, WE	5	*prof. dr. ir. C. (Charalampos) Tsoumpas UTQ*	*dr. M.J.W. Greuter UTQ*

[a] Mode of assessment: Written exam (WE), Multiple-choice exam (MC), Oral exam (OR), Report (R), Interim Test (IT), Assignment (AST), Practical work (PR), Presentation (P).
[b] Mode of assessment can be subject to change due to Corona/Covid measures.

Table 3.1. Continued.

Course name	**Mode of assessment [a,b]**	**ECTS**	**1st Examiner**	**2nd Examiner(s)**
Courses organized by the programme				
Recent Developments in Biomaterials	R, P	5	dr. M. (M.-Ali) Shahbazi *in progress*	dr. J. Sjollema UTQ
Statistical Methods for BME	WE, P, AST	5	dr. B.W.Peterson UTQ	*dr. J. Sjollema UTQ*
Surface Characterization	WE, P	5	dr. ir. R. Schirhagl UTQ	dr. J. Sjollema UTQ
Technology and the Ethics of Research	R, P, PR	5	*dr. G. (Gorazd) Andrejc in progress*	*dr. J. Sjollema UTQ*
Internship	PR, R, P	15	BME Course examiner	BME Course or Project examiner
Master's Project [c]	PR, R, P	30	BME Course examiner	BME Course or Project examiner
Courses organized by other programmes				
Mechatronics (for BME)	PR, WE	5	prof. dr.ir. J.M.A. Scherpen	prof. dr. ir. B. Jayawardhana
MEMS, NEMS and Nanofabrication	WE, MC, P, R	5	dr. A.G.P. Kottapalli	prof. dr. Yutao Pei
Radiation Physics	WE, IT	5	dr. E.R. van der Graaf	dr. P. Dendooven
Robotics for IEM	WE, R	5	prof. dr.ir. M. Cao	prof. dr. ir. B. Jayawardhana
Extracurricular courses				
Radiation Safety	WE, MC, PR	5	dr. H.F. Boersma	
BME course not given in 2022-2023 (will return in 2023-2024)				
Physics in Nuclear Medicine	WE	5	dr. A.T.M. Willemsen UTQ	dr. J.R. de Jong UTQ
Additional BME examiners				
As approved by the Board of Examiners during 2021-2022	-	-	prof. H.A. Santos, UMCG *in progress*	

[a] Mode of assessment: Written exam (WE), Multiple-choice exam (MC), Oral exam (OR), Report (R), Interim Test (IT), Assignment (AST), Practical work (PR), Presentation (P).
[b] Mode of assessment can be subject to change due to Corona/Covid measures.
[c] Master's Project: This includes a presentation at the start symposium (poster) and end symposium (oral), the attendance of 8 Biomedical Engineering related seminars, and a short introduction to Scientific writing, Cover letter writing, and 3D-printing.

Table 3.2. Appointed BME Project examiners for the Internship (A) and the Master's project (B) at other accredited universities and UMC's. The BME Project examiner will always be the 2nd examiner of the project, next to the BME course examiner. New project examiners are indicated in Italics

a) Project examiners: Internship

prof. dr. ir. D. (Deniz) Baskent	UMCG - dB-SPL Lab, Department of Oterhinolaryngology
prof. dr. P.P. (Paul) van den Berg	UMCG - Obstetrics & Gynecology
prof. dr. R.M.F. (Rolf) Berger	UMCG - Pediatrics
prof. dr. H.J.G. (Henk) Bilo	UMCG - Internist
prof. dr. G.H. (Truuske) de Bock	UMCG - Oncological Epidemiology
dr. R.P.H. (Reinoud) Bokkers	UMCG - Intervention radiologist
dr. R.J.H. (Ronald) Borra	UMCG - Imaging/MRI
prof. dr. S. (Stefan) Both	UMCG - Radiology Oncology
dr. B. (Branislava) Curcic-Blake	UMCG - Neuroimaging
dr. K. (Kevin) Damman	UMCG - Cardiology
dr. L.V. (Lisanne) van Dijk	UMCG - Personalizing radiotherapy with Artificial Intelligence
dr. P.R. van Dijk	UMCG - Endocrinologist
prof. dr. P.U. (Pieter) Dijkstra	UMCG - Rehabilitation
dr. C. (Christian) Greve	UMCG - Movement science/Beatrixoord
prof. J.H.P. (Han) Houdijk	UMCG - Clinical Movement Sciences
ir. A.L.J (Arjen) van Hulzen	UMCG - Clinical physicist
prof. dr. P.C. (Paul) Jutte	UMCG - Orthopedics
dr. ir. E.W. (Erik) Korevaar	UMCG - Medical Physicist Radiation oncology
dr. J. (Joep) Kraeima	UMCG - 3D Lab/Imaging
dr. R. (Roald) Lambrechts	UMCG - Molecular and Cellular Biology
dr. F. (Frank) de Lange	Radboud UMC - Medical Physicist Radiology
prof. dr. H.G.D. (Henri) Leuvenink	UMCG - Groningen Institute for Organ Transplantation
dr. P. (Peter) van Luijk	UMCG - Damage and Repair in Cancer Development and Cancer Treatment
dr. J.B.C. (Jan-Bernard) Marsman	UMCG - Neuroimaging
prof. dr. ir. N.M. (Natasha) Maurits	UMCG - Neuroengineering
dr. V.E. (Vincent) de Meijer	UMCG - HPB and Liver Transplant Surgeon
dr. S.K. (Sanne) Meles	UMCG - Neuroimaging
prof. dr. S. (Sarthak) Misra	UMCG - BME/UT Twente - Surgical Robotics Lab
dr. A.R. (Rob) den Otter	UMCG - Neurosciences, Rehabilitation
dr. R.N. (Nils) Planken	UMC Amsterdam - Cardiovascular imaging
dr. R.C.L. (Richte) Schuurmann	UMCG - Surgery
prof. dr. C.K. (Corry) van der Sluis	UMCG - Rehabilitation Medicine
dr. H. (Hans) Timmerman	UMCG - Anesthesiology
dr. H.C. (Hugo) van der Veen	UMCG - Orthopedic surgery
dr. R.J.K. (Riemer) Vegter	UMCG - Human Movement Science
prof. dr. J.P.P.M. (Jean-Paul) de Vries	UMCG - (Vascular) surgery
dr. T.P. (Tineke) Willems	UMCG - Cardiovascular Centre

b) Project examiners: MSc project

dr. M.I. (Monica) Acuautla Menese	UG - Discrete Technology & Production Automation (ENTEG)
prof. dr. ir. D. (Deniz) Baskent	UMCG - dB-SPL Lab, Department of Oterhinolaryngology
prof. dr. P.P. (Paul) van den Berg	UMCG - Obstetrics & Gynecology
prof. dr. R.M.F. (Rolf) Berger	UMCG - Pediatrics
prof. dr. H.J.G. (Henk) Bilo	UMCG - Internist

prof. dr. G.H. (Truuske) de Bock	UMCG - Oncological Epidemiology
dr. R.P.H. (Reinoud) Bokkers	UMCG - Intervention radiologist
dr. R.J.H. (Ronald) Borra	UMCG - Imaging/MRI
prof. dr. S. (Stefan) Both	UMCG - Radiology Oncology
prof. dr. R. (Raffaella) Carloni	UG - Robotics Lab
dr. B. (Branislava) Curcic-Blake	UMCG - Neuroimaging
dr. K. (Kevin) Damman	UMCG - Cardiology
dr. L.V. (Lisanne) van Dijk	UMCG - Personalizing radiotherapy with Artificial Intelligence
dr. P.R. van Dijk	UMCG - Endocrinologist
prof. dr. P.U. (Pieter) Dijkstra	UMCG - Rehabilitation
dr. C. (Christian) Greve	UMCG - Movement science/Beatrixoord
prof. J.H.P. (Han) Houdijk	UMCG - Clinical Movement Sciences
ir. A.L.J (Arjen) van Hulzen	UMCG - Clinical physicist
prof. dr. P.C. (Paul) Jutte	UMCG - Orthopedics
prof. dr. M.M.G. (Marleen) Kamperman	UG - Polymer Science
dr. ir. E.W. (Erik) Korevaar	UMCG - Medical Physicist Radiation oncology
dr. J. (Joep) Kraeima	UMCG - 3D Lab/Imaging
dr. R. (Roald) Lambrechts	UMCG - Molecular and Cellular Biology
dr. F. (Frank) de Lange	Radboud UMC - Medical Physicist Radiology
prof. dr. H.G.D. (Henri) Leuvenink	UMCG - Groningen Institute for Organ Transplantation
dr. P. (Peter) van Luijk	UMCG - Damage and Repair in Cancer Development and Cancer Treatment
dr. J.B.C. (Jan-Bernard) Marsman	UMCG - Neuroimaging
prof. dr. ir. N.M. (Natasha) Maurits	UMCG - Neuroengineering
prof. dr. H.C. (Henny) van der Mei	UMCG - Biomedical Engineering
dr. V.E. (Vincent) de Meijer	UMCG - HPB and Liver Transplant Surgeon
dr. S.K. (Sanne) Meles	UMCG - Neuroimaging
prof. dr. S. (Sarthak) Misra	UMCG - BME/UT Twente - Surgical Robotics Lab
dr. A.R. (Rob) den Otter	UMCG - Neurosciences, Rehabilitation
dr. R.N. (Nils) Planken	UMC Amsterdam - Cardiovascular imaging
prof. H.A. (Hélder) Santos	UMCG - Biomedical Engineering
dr. R.C.L. (Richte) Schuurmann	UMCG - Surgery
dr. A.-M. (Ali) Shahbazi	UMCG - Biomedical Engineering
prof. dr. C.K. (Corry) van der Sluis	UMCG - Rehabilitation Medicine
dr. H. (Hans) Timmerman	UMCG - Anesthesiology
dr. H.C. (Hugo) van der Veen	UMCG - Orthopedic surgery
dr. R.J.K. (Riemer) Vegter	UMCG - Human Movement Science
prof. dr. J.P.P.M. (Jean-Paul) de Vries	UMCG - (Vascular) surgery
dr. T.P. (Tineke) Willems	UMCG - Cardiovascular Centre
dr. M.K. (Gosia) Wlodarczyk-Biegun	UG - Polymer Science

4. Relationship between course units and details of the learning outcomes

In table 4.1 is the relation between learning outcomes (as listed in section 2) and the course elements of the Master's degree programme given per track. A description of all course elements and the learning outcomes students must acquire is available via OCASYS. The programme also includes compulsory training in a number of relevant society-oriented subjects during courses such as Technology and Ethics and Multidisciplinary Project.

Table 4.1. Relationship between the Learning outcomes and Course elements of the Biomedical engineering Master's degree, given per track.

a. Track Biomaterials, Science and Engineering

		Learning outcomes							
	Courses	**1. Acquire expertise in Biomedical Engineering**	**2. Analyse the problem and define aim**	**3. Create a Design, Research & Development proposal**	**4. Execute the Design, Research & Development plan**	**5. Analyse and interpret the data**	**6. Communicate results**	**7. Embed the results in scientific and social context**	**8. Demonstrate a professional attitude**
	Year 1								
1a	Biomaterials 2	2	1	2		1	2	2	1
1a	Introduction to MATLAB programming for BME	2	1	1	2		1		
1a	Interface Biology	1	2	1	1	2	2	2	1
1b	Biofilms	1	2	1		2	2	1	
1b	Surface Characterization	2	1	2	2	2	2	1	
2a	Biomedical Instrumentation 2	1	2			2			
2a	Multidisciplinary Project	1	2	2	2	1	2	2	2
2a	Statistical Methods in BME		2	1	2	2	2	1	1
2b	Internship	2	2	2	2	2	2	2	2
	Year 2								
1a	Integrated Lab Course in Biomaterials	1	1	1	1	2	2	2	1
1a	Microscopy and Imaging *	1	1		2	2	1		
1a	Product Design by FEM (for BME) *	2	2	2	2	2	2	1	2
1a	Recent Developments in Biomaterials	2	1	2	1	2	2	1	
1b	Colloid and Interface Science	2	1			2	1	1	
1b	Medical Device Commercialization	2	1			1	2	2	1
1b	Technology and the Ethics of Research	1	2			2	2	2	2
2a 2b	Master's thesis project	2	2	2	2	2	2	2	2
	Start symposium	1					2	1	
	End symposium	1					2	2	
	Seminars	2					2		

* Electives: Student needs to choose one of these courses.

b. Track Medical Device Design

		Learning outcomes							
	Courses	**1. Acquire expertise in Biomedical Engineering**	**2. Analyse the problem and define aim**	**3. Create a Design, Research & Development proposal**	**4. Execute the Design, Research & Development plan**	**5. Analyse and interpret the data**	**6. Communicate results**	**7. Embed the results in scientific and social context**	**8. Demonstrate a professional attitude**
	Year 1								
1a	Biomaterials 2	2	1	2		1	2	2	1
1a	Introduction to MATLAB programming for BME	2	1	1	2		1		
1a	Control Engineering for BME	2	2	2	2	2	1		2
1b	Engineering and Biotribology	2	2	1	1	2	2	2	1
1b	Mechatronics	2	2	1	1	2	1		
2a	Prosthetics and Orthotics	2	2	2	2	2	2	2	1
2a	Multidisciplinary Project	1	2	2	2	1	2	2	2
2a	Statistical Methods in BME		2	1	2	2	2	1	1
2b	Internship	2	2	2	2	2	2	2	2
	Year 2								
1a	Product Design by FEM (for BME)	2	2	2	2	2	2	1	2
1a	Bio-signal processing for human machine interaction	1	2		1	2	1		
1a	Robotics for IEM		1	2	2	2	2	1	
1b	MEMS, NEMS and Nanofabrication			1	1	2	2	1	
1b	Medical Device Commercialization	2	1			1	2	2	1
1b	Technology and the Ethics of Research	1	2			2	2	2	2
2a 2b	Master's thesis project	2	2	2	2	2	2	2	2
	Start symposium	1					2	1	
	End symposium	1					2	2	
	Seminars	2					2		

c. Track Medical Imaging

		Learning outcomes							
	Courses	**1. Acquire expertise in Biomedical Engineering**	**2. Analyse the problem and define aim**	**3. Create a Design, Research & Development proposal**	**4. Execute the Design, Research & Development plan**	**5. Analyse and interpret the data**	**6. Communicate results**	**7. Embed the results in scientific and social context**	**8. Demonstrate a professional attitude**
	Year 1								
1a	Radiation Physics	1	1	2	2	2	2	1	
1a	Introduction to MATLAB programming for BME	2	1	1	2		1		
1a	Quantitative Image Analysis	2		2	2	2	2	2	
1b	Conventional Imaging Techniques and Ultrasound	1	1	1		2	1		
1b	Computed Tomography	2	2	2	2	2	2	2	2
2a	Medical Physics for Radiation Oncology	1	1	1	1	2	1		
2a	Multidisciplinary Project	1	2	2	2	1	2	2	2
2a	Statistical Methods in BME		2	1	2	2	2	1	1
2b	Internship	2	2	2	2	2	2	2	2
	Year 2								
1a	Microscopy and Imaging	1	1		2	2	1		
1a	Applied Medical Visualization	2	1	2	1	1	1	1	
1a	MRI	2	1		1	1	2		
1b	Physics in Nuclear Medicine	2	1			2			
1b	Medical Device Commercialization	2	1			1	2	2	1
1b	Technology and the Ethics of Research	1	2			2	2	2	2
2a 2b	Master's thesis project	2	2	2	2	2	2	2	2
	Start symposium	1					2	1	
	End symposium	1					2	2	
	Seminars	2					2		