

**MSc Biomedical Engineering**

This document provides a definitive record of the main features of the programme and the learning outcomes that a typical student may reasonably be expected to achieve and demonstrate if s/he takes full advantage of the learning opportunities provided. This programme specification is intended as a reference point for prospective students, current students, external examiners and academic and support staff involved in delivering the programme and enabling student development and achievement.

**Programme Information**

Programme Title	Biomedical Engineering			
Award(s)	MSc			
Programme Code	B9A1			
Associateship	City and Guilds of London Institute			
Awarding Institution	Imperial College London			
Teaching Institution	Imperial College London			
Faculty	Faculty of Engineering			
Department	Department of Bioengineering			
Mode and Period of Study	1 academic year, full-time			
Cohort Entry Points	Annually in October			
Relevant <a href="#">QAA Benchmark Statement(s)</a> and/or other external reference points	<a href="#">Master's Awards in Engineering UK-SPEC</a>			
Total Credits	ECTS:	90	CATS:	180
<a href="#">FHEQ Level</a>	Level 7			
<a href="#">EHEA Level</a>	2 <sup>nd</sup> cycle			
External Accrator(s)	<a href="#">Institute of Physics and Engineering in Medicine (IPEM)</a> <a href="#">Institution of Mechanical Engineers (IMechE)</a> <a href="#">Institute of Materials, Minerals &amp; Mining (IOM3)</a>			

<b>Specification Details</b>	
Student cohorts covered by specification	2016/17 entry
Person responsible for the specification	Professor Martyn Boutelle
Date of introduction of programme	1991
Date of programme specification/revision	August 2016
<b>Description of Programme Contents</b>	
<p>Biomedical Engineering is the fastest growing engineering discipline with prospects for employment in industry and research. The MSc Biomedical Engineering programme provides students with technical knowledge, expertise and transferable skills in this exciting area. The programme streams have been designed with employer needs in mind and there are opportunities for students to carry out research projects in industry.</p> <p>All streams are modular, consisting of a core and options. The core material is largely common between the streams, but the options differ. It is necessary for applicants to choose the most suitable stream at the time of applying. All four streams lead to the award of the MSc in Biomedical Engineering and can be studied on a full-time basis. The following streams are available:</p> <p><b><u>Biomechanics</u></b></p> <p>The Biomechanics stream is focused on bioengineering problems related to major diseases associated with an ageing population, such as cardiovascular disease, glaucoma, and bone and joint disease. These are major causes of mortality and morbidity, and this stream prepares engineers for a career in these key growth areas.</p> <p><b><u>Biomaterials</u></b></p> <p>The Biomaterials stream is offered jointly with the Department of Materials. It addresses the selection and use of biomaterials in medical and surgical devices, including their application, properties, interaction with tissues and drawbacks. Existing and new biomaterials are studied, including bioactive and biodegradable materials, implants and dental materials. Modules also cover the development of materials for new applications, the response of cells and the design of materials as scaffolds for tissue engineering, which involves tailoring materials so that they guide stem cells to produce new tissue.</p> <p><b><u>Medical Physics</u></b></p> <p>The Medical Physics stream trains students in the physical understanding required for healthcare and medical research, focusing on human physiology, and the use of radiation in treatment and in clinical imaging, as well as the signal and image processing methods needed for the design and optimal use of such systems in diagnosis and research.</p> <p><b><u>Neurotechnology</u></b></p> <p>The Neurotechnology stream covers the development of new technology for the investigation of brain function, focusing on the application of this to benefit society—for example the development of neuroprosthetic devices, new neuroimaging techniques, and developing drugs and robotic assistive devices for those with central nervous system disorders, as well as in biologically-inspired control engineering.</p>	

## Learning Outcomes

The Imperial Graduate Attributes are a set of core competencies which we expect students to achieve through completion of any Imperial College degree programme. The Graduate Attributes are available at: [www.imperial.ac.uk/students/academic-support/graduate-attributes](http://www.imperial.ac.uk/students/academic-support/graduate-attributes)

### **Knowledge and Understanding**

#### ***Biomechanics***

Knowledge and Understanding of:

- Physiology of organs and cell function taught by lectures and problem classes.
- Signal and image processing techniques taught by lectures and computer laboratory exercise.
- Equipment and techniques to image the human body taught by lectures, group work and visits.
- Equipment and techniques to acquire physiological and chemical information from the human body taught by lectures and laboratory classes.

#### ***Biomaterials***

Knowledge and Understanding of:

- Various components of the human body, their function and the effects of ageing.
- Vascular pathologies: atherosclerosis, aneurysms.
- The major classes of biomedical implant materials, their means of fixation, stability and the procedures and physiological principles involved in the replacement of various parts of the body with implants or tissue engineered constructs.
- Advantages and disadvantages of current implants.
- The reasons of failure of implants in various clinical applications.
- The relative merits of replacing a body part with a tissue engineering construct.
- Drug delivery devices
- How devices can be surface modified to improve function.
- Characterisation of material: biomaterial-tissue and biomaterial-cell interfaces.
- Challenges involved with transfer of laboratory inventions to a clinical product.

#### ***Medical Physics***

Knowledge and Understanding of:

- Human physiology and cell function taught by lectures and problem classes.
- Signal and image processing techniques taught by lectures and computer laboratory exercise.
- Equipment and techniques to image the human body taught by lectures, group work and visits.
- Equipment and techniques to acquire physiological and chemical information from the human body taught by lectures and laboratory classes.
- Use of radiation in therapy and diagnosis taught by lectures.

#### ***Neurotechnology***

Knowledge and Understanding of:

- Systems neuroscience, with particular emphasis on applications of technology to neuroscience, taught by lectures and problem classes.
- Signal and image processing techniques taught by lectures and computer laboratory exercise.

- Equipment and techniques to image the human body taught by lectures, group work and visits.
- Equipment and techniques to acquire physiological and chemical information from the human body taught by lectures and laboratory classes.

**Intellectual Skills**

- Brainstorming for identifying hazards (*all streams*)
- Critical review of scientific literature (*all streams*)

**Practical Skills**

- Ability to communicate alternative means to repair or replace parts of the body to both healthcare professionals and patients. (*Biomaterials*)
- Ability to perform original research by producing a dissertation (*all streams*)
- Ability to perform data and statistical analysis (*all streams*)
- Ability to present data (*all streams*)

**Transferable Skills**

- Group work (*all streams*)
- Initiative (*all streams*)
- Critical thinking (*all streams*)

**Entry Requirements**

Academic Requirement	<p>Minimum 2.1 UK Honours degree (or equivalent) in a physical science, engineering or mathematical subject.</p> <p>Although applicants will typically have a background in engineering or physical science, the course is potentially open to those from life sciences or medicine, provided they also have proven mathematics ability.</p>
Non-academic Requirements	None
Applicants may be invited to attend an interview with one or more members of academic staff.	
English Language Requirement	IELTS 6.5 with a minimum of 6.0 in each element or equivalent.
<p>The programme's competency standards document can be found at:  <a href="http://www.imperial.ac.uk/media/imperial-college/faculty-of-engineering/bioengineering/public/student/Competency-Standards---Bioengineering-UG-PG---June-2016-Final.pdf">http://www.imperial.ac.uk/media/imperial-college/faculty-of-engineering/bioengineering/public/student/Competency-Standards---Bioengineering-UG-PG---June-2016-Final.pdf</a></p>	

<b>Learning &amp; Teaching Strategy</b>	
Scheduled Learning & Teaching Methods	<ul style="list-style-type: none"> <li>• Lectures</li> <li>• Guided practical classes / laboratory work, and demonstrations</li> <li>• Seminars</li> <li>• Workshops</li> <li>• Group exercises</li> <li>• Presentations</li> <li>• Individual research project</li> </ul>
E-learning & Blended Learning Methods	<ul style="list-style-type: none"> <li>• Virtual Learning Environment using Blackboard.</li> <li>• Lectures recorded using Panopto.</li> <li>• YouTube videos.</li> <li>• Anonymous feedback using Learning Catalytics, and Mentimeter.</li> <li>• Online groups/discussions</li> <li>• Online quizzes and interactive content</li> </ul>
Project and Placement Learning Methods	<ul style="list-style-type: none"> <li>• Group and individual project work</li> </ul>
<b>Assessment Strategy</b>	
Assessment Methods	<ul style="list-style-type: none"> <li>• Written examinations (open and closed book)</li> <li>• Oral presentations</li> <li>• Written reports, including a dissertation</li> <li>• Coursework including multiple choice progression tests, problem sheets, and quizzes</li> </ul>
<b>Academic Feedback Policy</b>	
<p>Feedback will be provided on coursework within two weeks of submission. Feedback may be provided in one of a number of formats, including:</p> <ul style="list-style-type: none"> <li>• Oral (during or after lectures)</li> <li>• Personal (discussion with academics during office hours)</li> <li>• Interactive (problem solving tutorials with GTAs &amp; study groups)</li> <li>• Written (solutions/model answers to coursework)</li> </ul> <p>In line with College policy, feedback will not be provided on written examinations.</p> <p>Preliminary results will be provided to students as alpha-grades. Numerical results will be published after the meeting of the final Board of Examiners.</p>	
<b>Re-sit Policy</b>	
<p>The College's Policy on Re-sits is available at: <a href="http://www.imperial.ac.uk/registry/exams/resit">www.imperial.ac.uk/registry/exams/resit</a></p>	

## Mitigating Circumstances Policy

The College's Policy on Mitigating Circumstances is available at: [www.imperial.ac.uk/registry/exams](http://www.imperial.ac.uk/registry/exams)

## Assessment Structure

### Marking Scheme

There are three elements, core subjects, stream specific and optional subjects, and the project.

The Pass Mark for postgraduate taught courses is 50%. Individual module marks may be below 50% but must be above 40% as long as the aggregate for each element is greater than 50%.

### Award of Merit and Distinction

Students who obtain a mark exceeding 60% in all three elements may be awarded the MSc degree with Merit, unless they are entitled to be awarded a Distinction. Where appropriate students who obtain a total aggregate mark exceeding 60% and a mark exceeding 60% in two elements and a mark no lower than 50% in a third element may, at the discretion of the Examiners<sup>1</sup>, be awarded the MSc degree with Merit.

Students who obtain a mark of greater than 70% in all three elements may be awarded the MSc degree with Distinction. Where appropriate students who obtain a total aggregate mark of greater than 70% and a mark of greater than 70% in two elements and a mark no lower than 60% in a third element may, at the discretion of the Examiners<sup>1</sup>, be awarded the MSc degree with Distinction.

Note 1 : Examiners' discretion will only normally be used if the mark in the lowest element is within 2.5% of the grade boundary and if there is compelling information of substantial performance above the mark in that element in other areas of contribution.

## MSc Biomedical Engineering (*Biomechanics Stream*)\*

Element (and weighting)	Module	% Module Weighting
Core (30%)	Biomedical Imaging	25%
	Journal Club	12.5%
	Medical Device Certification	12.5%
	Systems Physiology	25%
	Statistics and Data Analysis	25%
Specialist (30%)	Biomechanics	20%
	4 x modules from elective group (A)	20% each
Project (40%)	Individual Project	100%

\*Note that not all combinations of elective modules may be possible due to timetabling constraints

<b>MSc Biomedical Engineering (<i>Biomaterials Stream</i>)*</b>		
Element (and weighting)	Module	% Module Weighting
Core (30%)	Biomedical Imaging	25%
	Journal Club	12.5%
	Medical Device Certification	12.5%
	Systems Physiology	25%
	Statistics and Data Analysis	25%
Specialist (30%)	Biomaterials	20%
	Advanced Biomaterials	20%
	Advanced Tissue Engineering	20%
	2 x modules from elective group (B)	20% each
Project (40%)	Individual Project	100%

*\*Note that not all combinations of elective modules may be possible due to timetabling constraints*

<b>MSc Biomedical Engineering (<i>Medical Physics Stream</i>)*</b>		
Element (and weighting)	Module	% Module Weighting
Core (30%)	Biomedical Imaging	25%
	Journal Club	12.5%
	Medical Device Certification	12.5%
	Systems Physiology	25%
	Statistics and Data Analysis	25%
Specialist (30%)	Advanced Physiological Monitoring and Data Analysis	20%
	4 x modules from elective group (C)	20% each
Project (40%)	Individual Project	100%

*\*Note that not all combinations of elective modules may be possible due to timetabling constraints*

<b>MSc Biomedical Engineering (<i>Neurotechnology Stream</i>)*</b>		
<b>Element (and weighting)</b>	<b>Module</b>	<b>% Module Weighting</b>
Core (30%)	Biomedical Imaging	25%
	Journal Club	12.5%
	Medical Device Certification	12.5%
	Systems Physiology	25%
	Statistics and Data Analysis	25%
Specialist (30%)	Computational Neuroscience	20%
	Brain Machine Interfaces	20%
	3 x modules from elective group (D)	20% each
Project (40%)	Individual Project	100%

*\*Note that not all combinations of elective modules may be possible due to timetabling constraints*



**Indicative Module List (*Biomechanics Stream*)**

Code	Title	Core/ Elective	L&T Hours	Ind. Study Hours	Place- ment Hours	Total Hours	% Written Exam	% Course- work	% Practical	FHEQ Level	ECTS
BE9-MBIMG	Biomedical Imaging	CORE	28	122	0	150	100%	0%	0%	7	6
BE9-MJCLUB	Journal Club	CORE	10	90	0	100	0%	100%	0%	7	4
BE9-MMDC	Medical Device Certification	CORE	22	78	0	100	0%	100%	0%	7	4
BE9-MSPHYS	Systems Physiology	CORE	30	120	0	150	100%	0%	0%	7	6
BE9-MSTDA	Statistics and Data Analysis	CORE	28	122	0	150	100%	0%	0%	7	6
BE4-MBMX	Biomechanics	CORE	28	122	0	150	95%	5%	0%	7	6
MSE315	Biomaterials	ELECTIVE (A)	24	126	0	150	100%	0%	0%	7	6
BE9-MHASP	Hearing and Speech Processing	ELECTIVE (A)	27	123	0	150	100%	0%	0%	7	6
BE3-HPFM	Physiological Fluid Mechanics	ELECTIVE (A)	26	124	0	150	70%	30%	0%	7	6
BE9-MCBMX	Cellular Biomechanics	ELECTIVE (A)	28	122	0	150	80%	20%	0%	7	6
BE9-MHNCL	Human Neuromechanical Control and Learning	ELECTIVE (A)	28	122	0	150	80%	20%	0%	7	6
BE9-MOBBMX	Orthopaedic Biomechanics	ELECTIVE (A)	28	122	0	150	60%	40%	0%	7	6
BE9-MBMIME	Biomimetics	ELECTIVE (A)	26	124	0	150	100%	0%	0%	7	6
BE9-MITR	Introduction to Robotics	ELECTIVE (A)	30	120	0	150	80%	20%	0%	7	6

**Indicative Module List (*Biomechanics Stream*)**

Code	Title	Core/ Elective	L&T Hours	Ind. Study Hours	Place- ment Hours	Total Hours	% Written Exam	% Course- work	% Practical	FHEQ Level	ECTS
BE9-MHEDM	Health Economics and Decision Making	ELECTIVE (A)	27	123	0	150	100%	0%	0%	7	6
BE9-MMIP	Individual Project	CORE	40	810	0	850	0%	90%	10%	7	34

**Indicative Module List (*Biomaterials Stream*)**

Code	Title	Core/ Elective	L&T Hours	Ind. Study Hours	Place- ment Hours	Total Hours	% Written Exam	% Course- work	% Practical	FHEQ Level	ECTS
BE9-MBIMG	Biomedical Imaging	CORE	28	122	0	150	100%	0%	0%	7	6
BE9-MJCLUB	Journal Club	CORE	10	90	0	100	0%	100%	0%	7	4
BE9-MMDC	Medical Device Certification	CORE	22	78	0	100	0%	100%	0%	7	4
BE9-MSPHYS	Systems Physiology	CORE	30	120	0	150	100%	0%	0%	7	6
BE9-MSTDA	Statistics and Data Analysis	CORE	28	122	0	150	100%	0%	0%	7	6
MSE315	Biomaterials	CORE	24	126	0	150	100%	0%	0%	7	6
MSE417	Advanced Biomaterials	CORE	24	126	0	150	100%	0%	0%	7	6
MSE418	Advanced Tissue Engineering	CORE	24	126	0	150	100%	0%	0%	7	6
BE4-MBMX	Biomechanics	ELECTIVE (B)	28	122	0	150	95%	5%	0%	7	6
BE9-MAPMDA	Advanced Physiological Monitoring and Data Analysis	ELECTIVE (B)	30	120	0	150	100%	0%	0%	7	6
BE9-MHASP	Hearing and Speech Processing	ELECTIVE (B)	27	123	0	150	100%	0%	0%	7	6
BE3-HIPR	Image Processing	ELECTIVE (B)	38	112	0	150	100%	0%	0%	7	6
BE9-MAMI	Advanced Medical Imaging	ELECTIVE (B)	30	120	0	150	100%	0%	0%	7	6
BE9-MHEDM	Health Economics and Decision Making	ELECTIVE (B)	27	123	0	150	100%	0%	0%	7	6

**Indicative Module List (*Biomaterials Stream*)**

Code	Title	Core/ Elective	L&T Hours	Ind. Study Hours	Place- ment Hours	Total Hours	% Written Exam	% Course- work	% Practical	FHEQ Level	ECTS
BE9-MOBMX	Orthopaedic Biomechanics	ELECTIVE (B)	28	122	0	150	60%	40%	0%	7	6
BE9-MBMIME	Biomimetics	ELECTIVE (B)	26	124	0	150	100%	0%	0%	7	6
BE9-MITR	Introduction to Robotics	ELECTIVE (B)	30	120	0	0	80%	20%	0%	7	6
BE9-MMIP	Individual Project	CORE	40	810	0	850	0%	90%	10%	7	34

**Indicative Module List** (*Medical Physics Stream*)

Code	Title	Core/ Elective	L&T Hours	Ind. Study Hours	Place- ment Hours	Total Hours	% Written Exam	% Course- work	% Practical	FHEQ Level	ECTS
BE9-MBIMG	Biomedical Imaging	CORE	28	122	0	150	100%	0%	0%	7	6
BE9-MJCLUB	Journal Club	CORE	10	90	0	100	0%	100%	0%	7	4
BE9-MMDC	Medical Device Certification	CORE	22	78	0	100	0%	100%	0%	7	4
BE9-MSPHYS	Systems Physiology	CORE	30	120	0	150	100%	0%	0%	7	6
BE9-MSTDA	Statistics and Data Analysis	CORE	28	122	0	150	100%	0%	0%	7	6
BE9-MAPMDA	Advanced Physiological Monitoring and Data Analysis	CORE	30	120	0	150	100%	0%	0%	7	6
BE3-HIPR	Image Processing <sup>+</sup>	ELECTIVE (C)	38	112	0	150	100%	0%	0%	7	6
BE4-MCNS	Computational Neuroscience**	ELECTIVE (C)	28	122	0	150	100%	0%	0%	7	6
BE9-MAMI	Advanced Medical Imaging <sup>+</sup>	ELECTIVE (C)	30	120	0	150	100%	0%	0%	7	6
BE9-MNMED	Nuclear Medicine	ELECTIVE (C)	30	120	0	150	100%	0%	0%	7	6
BE9-MRADP	Radiotherapy Physics and Radiobiology <sup>+</sup>	ELECTIVE (C)	30	120	0	150	100%	0%	0%	7	6
BE4-MBMX	Biomechanics	ELECTIVE (C)	28	122	0	150	95%	5%	0%	7	6
BE9-MHASP	Hearing and Speech Processing	ELECTIVE (C)	27	123	0	150	100%	0%	0%	7	6
MSE315	Biomaterials	ELECTIVE (C)	24	126	0	150	100%	0%	0%	7	6

**Indicative Module List (*Medical Physics Stream*)**

Code	Title	Core/ Elective	L&T Hours	Ind. Study Hours	Place- ment Hours	Total Hours	% Written Exam	% Course- work	% Practical	FHEQ Level	ECTS
BE9-MHEDM	Health Economics and Decision Making**	ELECTIVE (C)	27	123	0	150	100%	0%	0%	7	6
BE9-MBMIME	Biomimetics	ELECTIVE (C)	26	124	0	150	100%	0%	0%	7	6
BE9-MITR	Introduction to Robotics	ELECTIVE (C)	30	120	0	150	80%	20%	0%	7	6
BE9-MMIP	Individual Project	CORE	40	810	0	850	0%	90%	10%	7	34

<sup>+</sup>Students must take at least two of these subjects

**\*\***Students may only take one of BE9-MHEDM and BE9-MCNS

**Indicative Module List *(Neurotechnology Stream)***

Code	Title	Core/ Elective	L&T Hours	Ind. Study Hours	Place- ment Hours	Total Hours	% Written Exam	% Course- work	% Practical	FHEQ Level	ECTS
BE9-MBIMG	Biomedical Imaging	CORE	28	122	0	150	100%	0%	0%	7	6
BE9-MJCLUB	Journal Club	CORE	10	90	0	100	0%	100%	0%	7	4
BE9-MMDC	Medical Device Certification	CORE	22	78	0	100	0%	100%	0%	7	4
BE9-MSPHYS	Systems Physiology	CORE	30	120	0	150	100%	0%	0%	7	6
BE9-MSTDA	Statistics and Data Analysis	CORE	28	122	0	150	100%	0%	0%	7	6
BE4-MCNS	Computational Neuroscience	CORE	28	122	0	150	100%	0%	0%	7	6
BE9-MBMI	Brain Machine Interfaces	CORE	27	123	0	150	80%	20%	0%	7	6
BE9-MAPMDA	Advanced Physiological Monitoring and Data Analysis	ELECTIVE (D)	30	120	0	150	100%	0%	0%	7	6
BE9-MHASP	Hearing and Speech Processing	ELECTIVE (D)	27	123	0	150	100%	0%	0%	7	6
BE3-HIPR	Image Processing	ELECTIVE (D)	38	112	0	150	100%	0%	0%	7	6
BE9-MAMI	Advanced Medical Imaging	ELECTIVE (D)	30	120	0	150	100%	0%	0%	7	6
BE9-MHNCL	Human Neuromechanical Control and Learning	ELECTIVE (D)	28	122	0	150	80%	20%	0%	7	6
BE9-MBMIME	Biomimetics	ELECTIVE (D)	26	124	0	150	100%	0%	0%	7	6

**Indicative Module List (*Neurotechnology Stream*)**

Code	Title	Core/ Elective	L&T Hours	Ind. Study Hours	Place- ment Hours	Total Hours	% Written Exam	% Course- work	% Practical	FHEQ Level	ECTS
BE9-MMLNC	Machine Learning and Neural Computation	ELECTIVE (D)	30	120	0	150	80%	20%	0%	7	6
BE9-MITR	Introduction to Robotics	ELECTIVE (D)	30	120	0	150	80%	20%	0%	7	6
BE9-MMIP	Individual Project	CORE	40	810	0	850	0%	90%	10%	7	34



## Supporting Information

The Programme Handbook is available at: <http://www.imperial.ac.uk/bioengineering/admin/msc/>

The Module Handbook is available at: <http://www.imperial.ac.uk/bioengineering/admin/msc/>

The College's entry requirements for postgraduate programmes can be found at:  
[www.imperial.ac.uk/study/pg/apply/requirements](http://www.imperial.ac.uk/study/pg/apply/requirements)

The College's Quality & Enhancement Framework is available at:  
[www.imperial.ac.uk/registry/proceduresandregulations/qualityassurance](http://www.imperial.ac.uk/registry/proceduresandregulations/qualityassurance)

The College's Academic and Examination Regulations can be found at:  
<http://www3.imperial.ac.uk/registry/proceduresandregulations/regulations>

Imperial College is an independent corporation whose legal status derives from a Royal Charter granted under Letters Patent in 1907. In 2007 a Supplemental Charter and Statutes was granted by HM Queen Elizabeth II. This Supplemental Charter, which came into force on the date of the College's Centenary, 8th July 2007, established the College as a University with the name and style of "The Imperial College of Science, Technology and Medicine".  
<http://www.imperial.ac.uk/admin-services/secretariat/college-governance/charters-statutes-ordinances-and-regulations/>

Imperial College London is regulated by the Higher Education Funding Council for England (HEFCE)  
<http://www.hefce.ac.uk/reg/of/>