Biomedical Engineering

- **M.A.Sc. Biomedical Engineering**

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About the Program

The Ottawa-Carleton Institute for Biomedical Engineering (OCIBME) offers a multi-disciplinary Masters of Applied Science degree (M.A.Sc.) in biomedical engineering. The main objective is to enhance students' abilities to solve biological and medical problems through the application of engineering principles. This objective is achieved through a combination of graduate course work, directed and individual study, research thesis work, and various forms of oral and written presentations. OCIBME welcomes applicants from a wide variety of academic backgrounds, including: engineering, science, computer science, biomedical sciences, health sciences, or a related discipline. Within biomedical engineering, the program has four main research areas: Medical Instrumentation, Biomedical Image Processing, Biomechanics and Biomaterials, and Medical Informatics and Telemedicine.

Academic Regulations

See the General Regulations section of this Calendar.

Admission Requirements

The normal requirement for admission is a four-year bachelor's degree in engineering, science, computer science, or a related discipline, with an average of at least B+.

Program Requirements

All master's students must successfully complete a total of 5.0 credits, which includes a 2.5 credit master's thesis. Courses must be selected with the approval of the student's supervisor. The specific requirements are:

M.A.Sc. Biomedical Engineering (5.0 credits)

1. 0.5 credit in compulsory:		0.5
BIOM 5010 [0.5]	Introduction to Biomedical Engineering	
2. 1.0 credit in two graduate level BIOM (BMG) courses (or equivalent)		1.0
3. 1.0 credit (or the equivalent) from graduate level courses offered at either Carleton University or University of Ottawa		1.0
4. 2.5 credits in:		2.5
BIOM 5909 [2.5]	M.A.Sc. Thesis	
4. 0.0 credit in:		0.0
BIOM 5800 [0.0]	Biomedical Engineering Seminar	
Total Credits		**5.0**

M.A.Sc. Biomedical Engineering with Specialization in Data Science (5.0 credits)

1. 0.5 credit in:		0.5
DATA 5000 [0.5]	Data Science Seminar	
2. 0.5 credit in compulsory:		0.5
BIOM 5010 [0.5]	Introduction to Biomedical Engineering	
3. 1.0 credit in two graduate-level BIOM (BMG) courses or equivalent		1.0
4. 0.5 credit (or the equivalent) from graduate-level courses offered at either Carleton University or University of Ottawa		0.5
5. 2.5 credits in:		2.5
BIOM 5909 [2.5]	M.A.Sc. Thesis	
6. 0.0 credit in:		0.0
BIOM 5800 [0.0]	Biomedical Engineering Seminar	
Total Credits		**5.0**

Note: for the course work **Item 3** and **Item 4** above, two 0.5 credit data science elective courses must be taken (two of BIOM 5400, BIOM 5405, COMP 5100, COMP 5101, COMP 5107, COMP 5108, COMP 5111, COMP 5112, COMP 5204, COMP 5209, COMP 5305, COMP 5306, COMP 5307, COMP 5308, COMP 5401, COMP 5703, COMP 5704, PHYS 5002, SYSC 5001, SYSC 5003, SYSC 5004, SYSC 5007, SYSC 5101, SYSC 5102, SYSC 5103, SYSC 5108, SYSC 5201, SYSC 5207, SYSC 5300, SYSC 5303, SYSC 5306, SYSC 5401, SYSC 5404, SYSC 5405, SYSC 5407, SYSC 5500, SYSC 5703, SYSC 5706).

Course Selection

Students in this program may choose elective graduate courses from either university, with the approval of their program advisor. All courses are 0.5 credit (one term's duration) with the exception of BIOM 5800 [0.0] Biomedical Engineering Seminar (and BIOM 5909 [2.5] M.A.Sc. Thesis (BMG 5909). Only a selection of courses listed is given in a particular academic year. For information on courses offered in a given year please consult the Institute's web site (www.ocibme.ca).

Notes:
University of Ottawa course numbers are in parentheses. Consult the Biomedical Engineering (BIOM) courses page for full course descriptions. The course descriptions for other courses are listed in the calendar under the department offering the course.
Given that the students admitted to this program are from different academic backgrounds, any elective course listed in this program can only be taken by qualified students who satisfy the prerequisites.

BIOM 5010 [0.5 credit]
Introduction to Biomedical Engineering
Research ethics and methods. Engineering systems approach to analysis and modelling of human anatomy and physiology. Introduction to topics including biomechanics, electrophysiology, and computational biology. Biomedical technologies. Impact of technology on society.

BIOM 5100 [0.5 credit] (BMG 5103)
Biomedical Instrumentation
Instrumentation designed to measure physiological variables related to the function of the heart,lungs, kidney, nervous and musculo-skeletal system; emergency, critical care, surgery and anaesthesia equipment.
Also listed as SYSC 5302 (ELG 6320).
Prerequisite(s): permission of the instructor.

BIOM 5101 [0.5 credit] (BMG 5104)
Biological Signals
Modeling of neuromuscular biological signals, including subthreshold phenomena, active behaviour of cell membranes, and innervation processes. Measurement of biological signals, including electrode effects. Time domain, frequency domain, and adaptive filtering techniques for noise reduction.
Also listed as SYSC 5307 (ELG 6307).

BIOM 5106 [0.5 credit] (BMG 5109)
Advanced Topics in Medical Instrumentation
Recent and advanced topics in the field of medical instrumentation and its related areas.

BIOM 5200 [0.5 credit] (BMG 5105)
Medical Image Processing
Mathematical models of image formation based on the image modality and tissue properties. Linear models of image degradation and reconstruction. Inverse problems, regularization for image reconstruction. Image formation in radiology, computed tomography, MRI, nuclear medicine, ultrasound, positron emission tomography, electrical impedance tomography.
Precludes additional credit for SYSC 5304 (ELG 5127).
Prerequisite(s): permission of the instructor.

BIOM 5201 [0.5 credit] (BMG 5106)
Introduction to Medical Imaging Principles and Technology
Basic principles and technological implementation of x-ray, nuclear medicine, magnetic resonance imaging (MRI), and other imaging modalities used in medicine. Contrast, resolution, storage requirements for digital images. Applications outside medicine, future trends.
Also listed as PHYS 5201.
Prerequisite(s): permission of the Physics department.

BIOM 5202 [0.5 credit] (BMG 5107)
Wavelet Applications in Biomedical Image Processing
Introduction to wavelet analysis and processing techniques for the quantification of biomedical images and signals. Topics include: multiresolution algorithms for denoising and image restoration, multiscale segmentation and classification for computer aided diagnosis and compression.
Prerequisite(s): SYSC 5602/ELG 5376 and BIOM 5200/ BMG 5105, or permission of the instructor.

BIOM 5203 [0.5 credit] (BMG 5108)
Advanced Topics in Biomedical Image Processing
Recent and advanced topics in the field of biomedical image processing and its related areas.
Prerequisite(s): permission of the instructor.

BIOM 5300 [0.5 credit] (BMG 5300)
Biological and Engineering Materials
Properties of structural biological materials (bone, tendon, ligament, skin, cartilage, muscle, and blood vessels) from an engineering materials viewpoint. Selection of engineering materials as biomaterials. Introduction to biocompatibility. Histology of soft tissues. Viscoelasticity, mechanical properties and models of muscles, ligaments and tendons.
Prerequisite(s): permission of the instructor.

BIOM 5301 [0.5 credit] (BMG 5301)
Biomechanics of Skeletal System, Motion and Tissue
Analysis of human motion. Kinematics and kinetics of various activities. Engineering analysis and modeling techniques applied to human motion. Injury mechanics, treatment, prosthetic replacements. Fracture behaviour and healing processes.
Prerequisite(s): permission of the instructor.

BIOM 5302 [0.5 credit] (BMG 5302)
Biofluid Mechanics
Properties of blood. Blood flow models for vessels, circulation systems and the heart. Artificial blood vessels. Kidney flow and exchange. Modeling of perfused tissues and cells. Transport phenomena across membranes. Molecular and ionic transport. Other body fluids.
Prerequisite(s): permission of the instructor.

BIOM 5303 [0.5 credit] (BMG 5303)
Ergonomics and Design
Review of ergonomic issues encountered in engineering design, including biomechanical, physical and physiological issues. Strategies for human interaction with complex systems, such as aircraft cockpits, equipment control consoles, human-robotic interactions, and tele-operated equipment.
Prerequisite(s): permission of the instructor.

BIOM 5304 [0.5 credit] (BMG 5110)
Advanced Topics in Biomechanics and Biomaterials
Recent and advanced topics in the field of biomechanics and biomaterials and its related areas.

BIOM 5306 [0.5 credit] (BMG 5306)
Special Topics in Mechanical and Aerospace Engineering: Biomechanics
Overview of human anatomy and physiology with emphasis on artificial organ and prosthetic device design requirement. Application of engineering principles to cells and tissues, biofluid mechanics, human body energetics, measurement techniques, mechanics of human body systems, with emphasis on the artificial heart.
Also listed as MECH 5801 (MCG 5489).
Precludes additional credit for MCG 5489/MECH 5801.
Also offered at the undergraduate level, with different requirements, as MAAE 4906, for which additional credit is precluded.

BIOM 5311 [0.5 credit] (BMG 5311)
Design of Medical Devices and Implants
Solutions to clinical problems through the use of implants and medical devices. Pathology of organ failure and bioengineering and clinical aspects of artificial organs. Examples: blood substitutes, oxygenators, cardiac support, vascular substitutes, pacemakers, ventricular assist devices, artificial hearts and heart valves.
Prerequisite(s): permission of the instructor.

BIOM 5312 [0.5 credit] (BMG 5312)
Design of Orthopaedic Implants and Prostheses
Anatomy of the musculo-skeletal system. Electromyography. Static and dynamic analysis of the human skeleton. Materials and manufacturing considerations for orthopaedic devices. Strength and failure theories. Implant fatigue, fracture and corrosion.
Prerequisite(s): permission of the instructor.

BIOM 5314 [0.5 credit] (BMG 5314)
Biocontrols
Application of traditional control system principles to the human body. Functionality of sample actuators and sensors. Characterization of human body control loops with emphasis on system stability, robustness, and effect of adverse external disturbance.
Prerequisite(s): permission of the instructor.

BIOM 5315 [0.5 credit] (BMG 5315)
Biorobotics
Interpretation of physical laws as applied to human motion, kinematics and dynamics of humanoid robots, modeling of biological sensors and actuators, artificial muscles, tele-manipulation, robot assisted surgery, and multi-fingered end-effectors. Design of mechatronic devices including rehabilitators, extenders, haptic devices, and minimally invasive surgery systems.
Prerequisite(s): permission of the instructor.

BIOM 5316 [0.5 credit] (BMG 5316)
Biotransport Processes
Application of chemical engineering principles to medicine and biology. Principles of mass transfer and fluid dynamics in topics such as hemodialysis, artificial kidney, diffusion in blood, mass transfer in the eye, drug distribution in the body, and advanced life support systems.
Prerequisite(s): permission of the instructor.

BIOM 5323 [0.5 credit] (BMG 5323)
Rehabilitation Engineering
Multidisciplinary approach to assistive-device design. Biomechanics applied to rehabilitation. Gait, neurological disorders, pathological gait, prosthetics, orthotics, seating, and mobility. Transducers, bio-instrumentation, EMG, FES. Augmentive communication and sensory aids. Human-assistive device interfaces, human-robot interfaces, computer-vision-guided rehabilitation aids, telerehabilitation.
Prerequisite(s): permission of the instructor.

BIOM 5330 [0.5 credit] (BMG 5330)
Electromagnetic Fields and Biological Systems
Review of electromagnetic waves at radio and microwave frequencies. Electrical and magnetic properties of tissue. Impact of electromagnetic waves on tissue. Cellular effects.
Prerequisite(s): permission of the instructor.

BIOM 5400 [0.5 credit] (BMG 5317)
Medical Computing
Introduction to information technology research used in the medically related fields such as biotechnology, cancer treatment, and biometric. Topics may include: medical imaging, telemedicine, telesurgery, DNA analysis, and medical information systems.
Prerequisite(s): permission of the instructor.

BIOM 5401 [0.5 credit] (BMG 5318)
Advanced Health Care Engineering
Healthcare and technology; overview of medical devices and sensors; safe and effective use and management of technology; telemedicine; medical databases, data collection, storage, retrieval and computers in medicine; electronic patient records, PACS; clinical decision-support systems.
Also listed as SYSC 5300 (ELG 6130), EACJ 5303 (ELG 5123).
Prerequisite(s): permission of the instructor.

BIOM 5402 [0.5 credit] (BMG 5402)
Interactive Networked Systems and Telemedicine
Telemanipulator; human motoring and sensory capabilities; typical interface devices; mathematical model of haptic interfaces; haptic rendering; stability and transparency; remote control schemes; time delay compensation; networking and real-time protocols, history and challenges of telemedicine; telemedicine applications: telesurgery, tele-monitoring, tele-diagnosis and tele-homecare.
Also listed as SYSC 5303 (ELG 6133).
Prerequisite(s): permission of the instructor.

BIOM 5403 [0.5 credit] (BMG 5111)
Advanced Topics in Medical Informatics and Telemedicine
Recent and advanced topics in the field of medical informatics and telemedicine and its related areas.

BIOM 5405 [0.5 credit] (BMG 5111)
Pattern Classification and Experiment Design
Introduction to a variety of supervised and unsupervised pattern classification techniques with emphasis on correct application. Statistically rigorous experimental design and reporting of performance results. Case studies will be drawn from various fields including biomedical informatics.
Also listed as SYSC 5405 (ELG 6102).
Prerequisite(s): undergraduate introductory probability and statistics.

BIOM 5800 [0.0 credit] (BMG 5800)
Biomedical Engineering Seminar
This course is in the form of seminars presented by graduate students and other researchers in the area of Biomedical Engineering. To complete this course, a student must attend at least ten seminars and make one presentation in the context of this seminar series.

BIOM 5906 [0.5 credit] (BMG 7199)
Directed Studies in Biomedical Engineering
Various possibilities exist for pursuing directed studies on topics approved by a course supervisor, including the above-listed course topics where they are not offered on a formal basis.

BIOM 5909 [2.5 credits]
M.A.Sc. Thesis

Summer session: some of the courses listed in this Calendar are offered during the summer. Hours and scheduling for summer session courses will differ significantly from those reported in the fall/winter Calendar. To determine the scheduling and hours for summer session classes, consult the class schedule at central.carleton.ca

Not all courses listed are offered in a given year. For an up-to-date statement of course offerings for the current session and to determine the term of offering, consult the class schedule at central.carleton.ca