MASTER OF APPLIED SCIENCE BIOMEDICAL ENGINEERING

Summary

• Degree offered: Master of Applied Science (MASc)
• Registration status options: Full-time; Part-time
• Language of instruction: English
• Program option (expected duration of the program):
  • within two years of full-time study
• Academic units: Faculty of Engineering (https://engineering.uottawa.ca/), School of Electrical Engineering and Computer Science (http://engineering.uottawa.ca/eecs/), Department of Mechanical Engineering (http://engineering.uottawa.ca/mechanical/), Department of Chemical Engineering (http://engineering.uottawa.ca/chemical/), Ottawa-Carleton Institute of Biomedical Engineering (http://www.ocibme.ca/).

Program Description

Ottawa-Carleton Joint Program

Established in 2006, the Ottawa-Carleton Institute of Biomedical Engineering (OCIBME) combines the teaching and research strengths of many academic units across the University of Ottawa and Carleton University.

Graduate education in biomedical engineering is multidisciplinary, and it combines the teaching and research input of seven primary participating academic units at:

University of Ottawa:

• Department of Mechanical Engineering (MCG)
• School of Electrical Engineering and Computer Science (EECS)
• Department of Chemical Engineering (CHG)

Carleton University:

• Department of Systems and Computer Engineering
• Department of Mechanical and Aerospace Engineering
• School of Computer Science
• Department of Physics

Research facilities are shared between the two campuses. Students have access to the professors, courses and facilities at both universities; however, they must enroll at the “home university” of their thesis supervisor if they are enrolled in the MASc option, or of their project supervisor if they are enrolled in the MEng with project/internship.

The Institute is a participating unit in the collaborative program in Bioinformatics (at the master’s level).

Main Areas of Research

The Institute benefits from the expertise of a number of prominent medical researchers and well established University of Ottawa medical research units including: the University of Ottawa Heart Institute and the University of Ottawa Eye Institute. In addition to the participating academic units listed above, a number of others are involved in the program through the research activities of some of their faculty members, or through graduate courses that may be taken as electives by students in the program.

Members of the Institute are engaged in five main research fields:

• Medical instrumentation
• Biomedical image processing
• Biomechanics and biomaterials
• Medical informatics
• Telemedecine

Other Programs Offered Within the Same Discipline or in a Related Area

• Master of Applied Science Biomedical Engineering Specialization in Bioinformatics (MASc)
• Master of Engineering Biomedical Engineering Concentration in Clinical Engineering (MEng)
• Master of Engineering Biomedical Engineering (MEng)

Fees and Funding

• Program fees:

The estimated amount for university fees (https://www.uottawa.ca/university-fees/) associated with this program are available under the section Finance your studies (http://www.uottawa.ca/graduate-studies/programs-admission/finance-studies/).

International students enrolled in a French-language program of study may be eligible for a differential tuition fee exemption (https://www.uottawa.ca/university-fees/differential-tuition-fee-exemption/).

• To learn about possibilities for financing your graduate studies, consult the Awards and financial support (https://www.uottawa.ca/graduate-studies/students/awards/) section.

Notes

• The program is governed by the regulations and procedures for Joint Graduate Programs and the general regulations (http://www.uottawa.ca/graduate-studies/students/general-regulations/) in effect for graduate studies at each of the two universities.
• In accordance with the University of Ottawa regulation, students have the right to complete their assignments, examinations, research papers, and theses in French or in English.
• Research activities can be conducted in English, French, or both depending on the language used by the professor and the members of the research group.

Program Contact Information

Graduate Studies Office, Faculty of Engineering (https://engineering.uottawa.ca/graduate-studies-office/)
STE 1024
800 King Edward Ave.
Ottawa ON Canada
K1N 6N5
Tel.: 613-562-5347
Fax.: 613-562-5129
Email: engineering.grad@uottawa.ca

Admission Requirements
For the most accurate and up to date information on application deadlines, language tests and other admission requirements, please visit the specific requirements webpage.

To be eligible, candidates must:
- Étre titulaire d’un baccalauréat spécialisé ou avec majeure (ou l’équivalent) en génie, en sciences, en informatique ou dans un domaine connexe avec une moyenne d’admission minimale de B+ (75%).
- Démontrer une bonne aptitude à la recherche que ce soit dans le contexte d’un projet de quatrième année au baccalauréat ou par la rédaction de rapports de recherche, de résumés ou d’autres documents démontrant des habiletés de recherche.

The Accelerated Stream has four additional requirements:
- Must be completing or have completed an undergraduate degree offered by the Faculty of Engineering at the University of Ottawa.
- Completion of an undergraduate thesis course offered by the Faculty of Engineering with 80% (A-) or higher grade. The research completed within the undergraduate thesis course shall be relevant to the accelerated Master’s research and be under the same supervisor.
- Completion of two elective courses at the graduate level each with 70% (B) or higher grade. The choice of the two Master’s courses shall be approved by the thesis supervisor and by the program’s director.
- Have an admission average of A- (80%) or higher.

Language Requirements
Applicants must be able to understand and fluently speak and write the language of instruction (English) in the program to which they are applying. Proof of linguistic proficiency may be required.

Applicants whose first language is neither French nor English must provide proof of proficiency in the language of instruction.

Note: Candidates are responsible for any fees associated with the language tests.

Notes
- The choice of research supervisor will determine the primary campus location of the student. It will also determine which university awards the degree.
- The admission requirements listed above are minimum requirements and do not guarantee admission to the program.
- Admissions are governed by the general regulations in effect for graduate studies and by the general regulations of the Ottawa-Carleton Institute for Biomedical Engineering (OCIBME).

Program Requirements
Requirements for this program have been modified. Please consult the 2021-2022 calendars for the previous requirements.

Master’s with Thesis
Students must meet the following requirements:

Compulsory Courses:
- BMG 5112 Introduction to Biomedical Engineering 3 Units
- 6 optional course units from the list of biomedical engineering (BMG) courses at the graduate level
- 6 elective course units at the graduate level

Seminar:
- BMG 6996 Biomedical Engineering Seminar

Thesis:
- THM 7999 Master’s Thesis

Note(s)
1. The Department may require students to take additional courses, depending on their backgrounds.
2. The elective course units must be selected with the approval of the thesis supervisor and the director of the program. Courses taken in related disciplines must be previously approved by the Department.
3. Completion and successful oral defence of a research thesis in biomedical engineering.
4. Students are responsible for ensuring they have met all of the thesis requirements.

Master’s with Thesis, Accelerated Stream
Students must meet the following requirements:

Compulsory Courses:
- BMG 5112 Introduction to Biomedical Engineering 3 Units
- 6 optional course units from the list of biomedical engineering (BMG) courses at the graduate level

Seminar:
- BMG 6996 Biomedical Engineering Seminar

Thesis:
- THM 7999 Master’s Thesis

Note(s)
1. The Department may require students to take additional courses, depending on their backgrounds.
2. Completion and successful oral defence of a research thesis in biomedical engineering.
3. Students are responsible for ensuring they have met all of the thesis requirements.

List of Optional Courses
Courses specific to this program are designated BMG at the University of Ottawa and BIOM at Carleton University. The codes for the courses from other disciplines are CHG, CSI, ELG, EPI, MAT, MCG, and PHY (all at the
University of Ottawa) and COMP, EAJC, MAAJ, MECH, PHYS, SYSC, and STAT (all at Carleton University).

All courses, with the exception of the seminar and the thesis, are worth 3 credits at the University of Ottawa and 0.5 credits at Carleton University.

CHG 8121 Synthetic Membranes in Biomedical Engineering

CHG 8187 Introduction to Polymer Reaction Engineering

CHG 8188 Polymer Properties and Characterization

CHG 8195 Advanced Numerical Methods in Chemical and Biological Engineering

CHG 8196 Interfacial Phenomena in Engineering

CSI 5102 Topics in Medical Computing

CSI 5116 Authentication and Software Security

CSI 5131 Parallel Algorithms and Applications in Data Science

CSI 5164 Computational Geometry

CSI 5311 Distributed Databases and Transaction Processing

ELG 5104 Electromagnetic Waves Theory and Applications

ELG 5161 Robotics: Control, Sensing and Intelligence

ELG 5163 Machine Vision

ELG 5376 Digital Signal Processing

ELG 5378 Image Processing and Image Communications

ELG 6106 Design of Real-Time and Distributed Systems

ELG 6115 Software Quality Engineering and Management

ELG 6127 Distributed Systems Engineering

ELG 6136 Mobile Computing Systems

ELG 6142 Advanced Dynamics With Applications to Robotics

ELG 6152 Advanced Linear Systems

ELG 6160 Adaptive Signal Processing

ELG 6163 Digital Signal Processing Microprocessor, Software and Applications

ELG 6164 Advanced Topics in Digital Signal Processing: Speech Communications and Applications

ELG 6168 Wireless Communication Systems Engineering

ELG 6171 Operating System Methods for Real-Time Applications

ELG 6173 Integrated Database Systems

ELG 6180 Network Computing

ELG 6377 Microsensors and Mems

ELG 7171 Topics in Signal Processing I

ELG 7173 Topics in Signal Processing II

MAT 5190 Mathematical Statistics I

MAT 5191 Mathematical Statistics II

MAT 5198 Stochastic Models

MAT 5317 Analysis of Categorical Data

MAT 5992 Seminar in Biostatistics

MCG 5152 Theory of Turbulence

MCG 5173 Systems Engineering and Integration

MCG 5177 Robot Mechanics

MCG 5332 Instrumentation Techniques

PHY 5112 Physics of Medical Imaging

**Minimum Requirements**

The passing grade in all courses is B.

Students who fail six units, or the thesis proposal, or whose research progress report is deemed unsatisfactory will be withdrawn from the program.

**Research**

**Research Fields & Facilities**

Located in the heart of Canada’s capital, a few steps away from Parliament Hill, the University of Ottawa is among Canada’s top 10 research universities.

uOttawa focuses research strengths and efforts in four Strategic Areas of Development in Research (SADRs):

- Canada and the World
- Health
- e-Society
- Molecular and Environmental Sciences

With cutting-edge research, our graduate students, researchers and educators strongly influence national and international priorities.

**Research at the Faculty of Engineering**

**Areas of research:**

- Chemical and Biological Engineering
- Civil Engineering
- Electrical Engineering and Computer Science
- Mechanical Engineering

For more information, refer to the list of faculty members and their research fields on Uniweb.

**IMPORTANT:** Candidates and students looking for professors to supervise their thesis or research project can also consult the website of the faculty or department (https://www.uottawa.ca/graduate-studies/students/academic-unit-contact-information/) of their program of choice. Uniweb does not list all professors authorized to supervise research projects at the University of Ottawa.

**Courses**

Courses specific to this program are designated BMG at the University of Ottawa and BIOM at Carleton University. The codes for courses from other disciplines are CHG, CSI, ELG, EPI, MAT, MCG, and PHY (all at the University of Ottawa) and COMP, EAJC, MAAJ, MECH, PHYS, SYSC, and STAT (all at Carleton University).

All courses, with the exception of the seminar and the thesis, are worth 3 units at the University of Ottawa and 0.5 units at Carleton University.
BMG 5001 Stage en génie clinique / Clinical Engineering Internship (6 crédits / 6 units)
Stage en génie clinique dans un établissement extérieur à l'université. Rédaction d'un rapport ayant trait aux activités menées durant l'internat. Noté S (satisfaisant) ou NS (non satisfaisant) par le superviseur et un professeur nommé par le directeur du programme. / Internship in an institutional setting outside the university. Requires a formal written paper relating to the internship activities. Graded S (Satisfactory) / NS (Not satisfactory) by the supervisor and a professor appointed by the program director. Préalable : approbation du directeur du programme. / Prerequisite: approval of the program director. Ce cours est équivalent à BIOM 5801 à la Carleton University. / This course is equivalent to BIOM 5801 at Carleton University.
Volet / Course Component: Stage / Work Term
Préalable: approbation du directeur du programme. / Prerequisite: approval of the program director.

BMG 5103 Biomedical Instrumentation (3 units)
Instrumentation designed to measure physiological variables related to the function of the heart, lungs, kidney, nervous and musculo-skeletal systems; emergency, critical care, surgery and anesthesia equipment. This course is equivalent to BIOM 5100 at Carleton University.
Course Component: Lecture
Courses BMG 5103, ELG 6320 cannot be combined for units.

BMG 5104 Biological Signals (3 units)
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. This course is equivalent to BIOM 5101 at Carleton University.
Course Component: Lecture

BMG 5105 Medical Imaging Modalities (3 units)
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. This course is equivalent to BIOM 5200 at Carleton University.
Course Component: Lecture
Courses BMG 5105, ELG 5127 cannot be combined for units.

BMG 5106 Introduction to Medical Imaging Principles and Technology (3 units)
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. This course is equivalent to BIOM 5201 at Carleton University.
Course Component: Lecture

BMG 5107 Applications in Biomedical Image Processing (3 units)
Image processing methods applied to biomedical images. Overview of medical imaging modalities. Image enhancement, segmentation, registration, and fusion. Image quality metrics. Image formats. Application examples. Includes: Experiential Learning Activity This course is equivalent to BIOM 5202 at Carleton University.
Course Component: Lecture

BMG 5108 Advanced Topics in Biomedical Image Processing (3 units)
Recent and advanced topics in the field of biomedical image processing and its related areas. Prerequisite: permission of the program director. This course is equivalent to BIOM 5203 at Carleton University.
Course Component: Lecture
Permission of the Department is required.

BMG 5109 Advanced Topics in Medical Instrumentation (3 units)
Recent and advanced topics in the field of medical instrumentation and its related areas. This course is equivalent to BIOM 5106 at Carleton University.
Course Component: Lecture

BMG 5110 Advanced Topics in Biomechanics and Biomaterials (3 units)
Recent and advanced topics in the field of biomaterials and biomedical imaging modalities and its related areas. This course is equivalent to BIOM 5304 at Carleton University.
Course Component: Lecture

BMG 5111 Advanced Topics II Medical Informatics and Telemedicine (3 units)
Recent and advanced topics in the field of medical informatics and telemedicine and its related areas. This course is equivalent to BIOM 5403 at Carleton University.
Course Component: Lecture

BMG 5112 Introduction to Biomedical Engineering (3 units)
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. This course is equivalent to BIOM 5010 at Carleton University.
Course Component: Lecture

BMG 5113 Clinical Engineering (3 units)
Overview of the Canadian health care system; brief examples from other countries; clinical engineering and the management of technologies in industrialized and in developing countries; safety, reliability, quality assurance; introduction to biomedical sensor technologies; applications of telemedicine; impact of technology on health care. This course is equivalent to BIOM 5406 at Carleton University.
Course Component: Lecture

BMG 5120 Biomechanics of Movement (3 units)
Human and animal movement examined through the lens of mechanics. Biological, mechanical, and neurological processes by which muscles produce movement. Experimental, mathematical, and computational tools. Clinical and sports applications. Recent advances in biomechanical research. Assignments, computer simulations, and a small research project.
Course Component: Lecture
The courses BMG 5120, MCG 4153, and MCG 4553 cannot be combined for units.

BMG 5122 Biomaterials and Tissue Engineering: Theories and Applications (3 units)
This course covers principles of materials science and cell biology that apply to biomaterials and tissue engineering. Polymers, ceramics, metals, biomaterial surface modifications, molecular and cellular interactions with biomaterials, immune response, tissue engineering principles, ethical considerations and regulatory overview. Technical analysis of a biomaterial-based medical device.
Course Component: Lecture
The courses BMG 5122, MCG 4154, and MCG 4554 cannot be combined for units.
BMG 5130 Fundamentals of Policy I: Policy Analysis (3 units)
Policy analysis and policy processes with an emphasis on the stages of the policy process, as well as the influences of institutions, ideas and interests. This course is equivalent to HLTH 5201 at Carleton University.
Course Component: Lecture

BMG 5300 Biological and Engineering Materials (3 units)
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. This course is equivalent to BIOM 5300 at Carleton University.
Course Component: Lecture
Permission of the Department is required.

BMG 5301 Biomechanics of Skeletal System, Motion and Tissue (3 units)
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. This course is equivalent to BIOM 5301 at Carleton University.
Course Component: Lecture
Permission of the Department is required.

BMG 5302 Biofluid Mechanics (3 units)
Course Component: Lecture
Permission of the Department is required.

BMG 5304 Interactive Networked Systems and Telemedicine (3 units)
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. This course is equivalent to BIOM 5402 at Carleton University.
Course Component: Lecture
Permission of the Department is required.

BMG 5305 Pattern Classification and Experiment Design (3 units)
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. This course is equivalent to BIOM 5405 at Carleton University.
Course Component: Lecture
Courses BMG 5305 and ELG 6102 cannot be combined for units.

BMG 5306 Special Topics in Mechanical and Aerospace Engineering: Biomechanics (3 units)
Overview of human anatomy and physiology with emphasis on artificial organ and prosthetic device design requirements. 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. This course is equivalent to BIOM 5306 at Carleton University.
Course Component: Lecture
The courses BMG 5306 and MCG 5489 cannot be combined for units.

BMG 5311 Design of Medical Devices and Implants (3 units)
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, pacemakers, ventricular assist devices, artificial hearts and heart valves. This course is equivalent to BIOM 5311 at Carleton University.
Course Component: Lecture
Permission of the Department is required.

BMG 5312 Design of Orthopaedic Implants and Prostheses (3 units)
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. This course is equivalent to BIOM 5312 at Carleton University.
Course Component: Lecture
Permission of the Department is required.

BMG 5315 Biorobotics (3 units)
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, dual arm robots, robot-assisted surgery, and multi-fingered end-effectors. Approaches to design of mechatronic devices to support and enhance human movement including rehabilitation, extenders, haptic devices, and minimally invasive surgery systems. This course is equivalent to BIOM 5315 at Carleton University.
Course Component: Lecture
Permission of the Department is required.

BMG 5319 Introduction to Microfluidics (3 units)
Physics of liquid transport in micro-fabricated systems including physics at the microscale, hydrodynamics of microfluidic systems, diffusion mixing, introduction to microfabrication, examples of microfluidics devices and Micro PIV techniques, project.
Course Component: Lecture
The courses BMG 5319, MCG 4112, and MCG 4512 cannot be combined for units.

BMG 5330 Electromagnetic Fields and Biological Systems (3 units)
Review of electromagnetic waves at radio and microwave frequencies. Electrical and magnetic properties of tissue. Impact of electromagnetic waves on tissue. Cellular effects. This course is equivalent to BIOM 5330 at Carleton University.
Course Component: Lecture

BMG 5501 Étude technique et modélisation de l'anatomie et de la physiologie du corps humain (3 crédits)
Méthodes de systèmes d’ingénierie pour analyser et modéliser les systèmes anatomiques et physiologiques du corps humain. Propriétés mécaniques et électriques des tissus. Systèmes musculosquelettiques, cardiovasculaires et pulmonaires. Ce cours est équivalent à BIOM 5001 à la Carleton University.
Volet : Cours magistral
Volet / Course Component: Études supérieures et des chercheurs invités. En plus d’avoir à présenter deux séminaires, les étudiants doivent assister et participer à au moins 20 séminaires. Noté S (satisfaisant) ou NS (non satisfaisant). Ce cours est équivalent à BIOM 6800 à Carleton University. / 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 20 seminars and make two presentations in the context of this seminar series. This course is equivalent to BIOM 6800 at Carleton University.

Volet / Course Component: Séminaire / Seminar

BMG 9901 Séminaire de doctorat en génie biomédical / Biomedical Engineering PhD Seminar

Une série de séminaires présentés par des étudiants aux cycles supérieurs et des chercheurs invités. En plus d’avoir à présenter deux séminaires, les étudiants doivent assister et participer à au moins 20 séminaires. Noté S (satisfaisant) ou NS (non satisfaisant). Ce cours est équivalent à BIOM 6800 à Carleton University. / 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 20 seminars and make two presentations in the context of this seminar series. This course is equivalent to BIOM 6800 at Carleton University.

Volet / Course Component: Séminaire / Seminar

BMG 9997 Rapport et soutenance du projet de thèse / Report and Defence of Thesis Proposal

Inscription requise de tous les candidats au doctorat jusqu’à la réussite à l’examen de synthèse. / Following completion of the comprehensive examination, registration required for all PhD candidates until the thesis proposal is accepted by the Advisory Committee.

Volet / Course Component: Recherche / Research

BMG 9998 Examen de synthèse / PhD Comprehensive Exam

À la suite de la réussite à l’examen de synthèse, inscription requise de tous les candidats au doctorat jusqu’à ce que le projet de thèse soit accepté par le Comité consultatif. / Registration required for all PhD candidates until the comprehensive examination is passed.

Volet / Course Component: Recherche / Research