

# MASTER OF ENGINEERING BIOMEDICAL ENGINEERING AND CONCENTRATION CLINICAL ENGINEERING

## Summary

- Degree offered: Master of Engineering (MEng)
- 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
- For immigration purposes, the summer term (May to August) for this program is considered a regularly scheduled break approved by the University. Students should resume full-time studies in September.
- 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.

## 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 four main research fields:

- Medical instrumentation
- Biomedical image processing
- Biomechanics and biomaterials
- Medical informatics
- Telemedicine

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

- Master of Applied Science Biomedical Engineering (MASc)
- Master of Applied Science Biomedical Engineering Specialization in Bioinformatics (MASc)

## 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](mailto:engineering.grad@uottawa.ca)

Twitter | Faculty of Engineering (<https://twitter.com/uOttawaGenie/?lang=en>)

Facebook | Faculty of Engineer (<https://www.facebook.com/uottawa.engineering/>)

## 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 (<https://www.uottawa.ca/graduate-studies/programs-admission/apply/specific-requirements/>) webpage.

## To be eligible, candidates must:

- Have a bachelor's degree with a specialization or a major (or equivalent) in engineering, science, computer science, or a related discipline, with a minimum admission average of 75% (B+).
- Note: International candidates must check the admission equivalencies (<https://www.uottawa.ca/graduate-studies/international/study-uottawa/admission-equivalencies/>) for the diploma they received in their country of origin.
- Demonstrate a good academic performance in previous studies as shown by official transcripts, research reports, abstracts or any other documents demonstrating research skills.
- In the case of applicants to project option or the concentration in Clinical Engineering, identify at least one professor who is willing to supervise your project. We recommend that you contact potential project supervisors as soon as possible.

## 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 project 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 (<http://www.uottawa.ca/graduate-studies/students/general-regulations/>) in effect for graduate studies and by the general regulations of the Ottawa-Carleton Institute of Civil Engineering (OCICE).

## Program Requirements

### Master's with Concentration

To receive this Master's degree, a student enrolled in the program must successfully complete 27 course units.

Students in the concentration in Clinical Engineering must meet the following requirements:<sup>1</sup>

#### Compulsory Courses:<sup>2</sup>

BMG 5103	Biomedical Instrumentation	3 Units
BMG 5105	Medical Imaging Modalities	3 Units
BMG 5112	Introduction to Biomedical Engineering	3 Units
BMG 5113	Clinical Engineering	3 Units
BMG 5130	Fundamentals of Policy I: Policy Analysis	3 Units

#### Seminar:

BMG 6996	Biomedical Engineering Seminar	
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#### Internship:

BMG 5001	Clinical Engineering Internship	6 Units
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#### Project:

BMG 6001	Clinical Engineering Project	6 Units
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Note(s)

1

At least 50% of the units must be obtained from the student's home university.

2

The Admissions Committee may require students to take additional courses, depending on their backgrounds.

## 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 de 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

Permission of the Department is required.

### **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 biomechanics and biomaterials 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 biomedical 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)**

Properties of blood. Blood flow models for vessels, circulation systems and the heart. Man-made blood vessels. Kidney flow and exchange. Modeling of perfused tissues and cells. Transport phenomena across membranes. Molecular and ionic transport. Other body fluids. This course is equivalent to BIOM 5302 at Carleton University.

**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

Courses BMG 5304 and ELG 6133 cannot be combined for units.

**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 rehabilitators, 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

Prerequisite: knowledge of electromagnetic theory.

**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

**BMG 5502 Éthiques, normes et méthodes de recherche (3 crédits)**

Théories éthiques, prise de décision, codes de déontologie; expérimentation sur des animaux et des êtres humains, consentement, comités de déontologie; méthodes de recherche et règlements concernant la conception, la fabrication et la certification d'appareils médicaux; collecte, contrôle et analyse des données, y compris la protection de la confidentialité, dilemmes bioéthiques, effets (sociaux, politiques, financiers) de la technologie et de la recherche. Les cours ELG 7514/EACJ 5300, BMG 5502 ne peuvent être combinés pour l'obtention de crédits. Ce cours est équivalent à BIOM 5002 à la Carleton University.

**Volet :** Cours magistral

**BMG 6000 Projet en génie biomédical / Biomedical Engineering Project (6 crédits / 6 units)**

Projet en génie biomédical supervisé par un professeur approuvé par le directeur du programme. Rédaction d'un rapport approfondi, qui doit être présenté oralement. Noté S (satisfaisant) ou NS (non satisfaisant) par le superviseur du projet et un autre professeur nommé par le directeur du programme. Le projet peut normalement être complété en une session d'études à temps complet. Ce cours est équivalent à BIOM 5900 à la Carleton University. / Project in biomedical engineering supervised by a professor approved by the program director. Requires an in-depth report that must be presented orally. Graded S (Satisfactory) or NS (Not satisfactory) by the supervisor and by another professor appointed by the program director. The project can normally be completed in one session of full-time study. This course is equivalent to BIOM 5900 at Carleton University.

**Volet / Course Component:** Recherche / Research

Permission of the Department is required.

**BMG 6001 Projet en génie clinique / Clinical Engineering Project (6 crédits / 6 units)**

Projet en génie clinique supervisé par un professeur du programme et un ingénieur clinique. Rédaction et présentation orale d'un rapport approfondi. Noté S (satisfaisant) ou NS (non satisfaisant) par les superviseurs du projet et un autre professeur nommé par le directeur du programme. Le projet peut normalement être complété en une session d'études à temps complet. Ce cours est équivalent à BIOM 5901 à la Carleton University. / Project in clinical engineering supervised by a professor in the program and a clinical engineer. Requires an in-depth report that must be presented orally. Graded S (Satisfactory) or NS (Not satisfactory) by the co-supervisors and by another professor appointed by the program director. The project can normally be completed in one session of full-time study. This course is equivalent to BIOM 5901 at Carleton University.

**Volet / Course Component:** Recherche / Research

Permission of the Department is required.

**BMG 6996 Séminaire en génie biomédical / Biomedical Engineering Seminar**

Cours composé d'une série de séminaires présentés par des étudiants de deuxième cycle et des chercheurs en génie biomédical. En plus d'avoir à animer un séminaire, tous les étudiants doivent assister à au moins dix séances. Ce cours est équivalent à BIOM 5800 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 ten seminars and make one presentation in the context of this seminar series. This course is equivalent to BIOM 5800 at Carleton University.

**Volet / Course Component:** Séminaire / Seminar

**BMG 7199 Directed Studies in Biomedical Engineering (3 units)**

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. This course is equivalent to BIOM 5906 at Carleton University.

**Course Component:** Recherche

**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