Toronto Metropolitan University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Outline (W2024)

BME804: Design of Bio-MEMS

Instructor(s)	Dr. Virgilio Valente [Coordinator] Office: ENG450 Phone: (416) 979-5000 x 553728 Email: vvalente@torontomu.ca Office Hours: Tue 1pm-3pm (weeks 2-13)
Calendar Description	Biophysical and chemical principles of biomedical microelectromechanical systems (bioMEMS) for the measurement of biological phenomena and clinical applications. micro-and nano-scale devices for the manipulation of cells and biomolecules. Topics include solid-state transducers, optical transducers, electrochemical transducers, biomedical microelectronics, microfluidics, and hybrid integration of microfabrication technology.
Prerequisites	BME 423 and BME 674 and BME 634
Antirequisites	None
Corerequisites	None
Compulsory Text(s):	1. No compulsory text. BME804 Lecture notes- V.Valente
Reference Text(s):	1. Fundamentals of BioMEMS and Medical Microdevices, 1st Edition, by Steven S. Saliterman, 2006. 2. BioMEMS: Science and Engineering Perspectives, 1st Edition, by Simona Badilescu and Muthukumaran Packirisamy, 2011. 3. Bio-MEMS: technologies and applications, 1st Edition, by Wanjun Wang and Steven A. Soper, 2007. 4. BioMEMS, 1st Edition, by Gerald A. Urban, 2007 5. MEMS for Biomedical Applications Edited by: Shekhar Bhansali and Abhay Vasudev, 2012
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: 1. Understand the biophysical and chemical principles to design biomedical micorelectromechanical systems (BioMEMS) for measurement of biological phenomena and to design solutions to biomedical problems. (**1c**) 2. Adopt biophysical and chemical principles to conceptualize the modeling and the design of BioMEMS devices. (**1d**) 3. Model and test BioMEMS components and devices through software simulations (using Coventorware software) and critically evaluate the implications of component/device parameters modifications on overall design, independently and in lab/project teams. (**2b**), (**3a**), (**5a**), (**6a**) 4. Understand, apply and critically evaluate the design, fabrication, and operation of BioMEMS components (e.g. optical transducers, electrochemical transducers, biomedical electronics, microfluids, hybrid integration of micofabrication technology) to address medical issues and applications. (**4b**)

5. Communicate an understanding of fundamental theoretical and practical principles and critical evaluation of BioMEMS designs through written laboratory reports, written assignments and oral project presentations evaluated on grammar, completeness, clarity and design innovation. (**7a**), (**7b**), (**7c**)
6. Understand, apply and critically evaluate the design, fabrication, and operation of BioMEMS components (e.g. optical transducers, electrochemical transducers, biomedical electronics, microfluids, hybrid integration of microfabrication technology) to address medical issues and applications. (**12b**)

NOTE:*Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).*

Course Organization

3.0 hours of lecture per week for 13 weeks
1.0 hours of lab per week for 12 weeks
1.0 hours of tutorial per week for 12 weeks

Teaching Assistants

Sima Darbasi (sima.darbasi@torontomu.ca)
Irene Miah (irene.miah@torontomu.ca)

Course Evaluation

Theory	
Midterm Exam	25 %
Final Exam	35 %
Course Projects	20 %
Laboratory	
3 Labs (5%, 7.5%, 7.5%)	20 %
TOTAL:	100 %

Note: In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both **"Theory and Laboratory"** components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the **"Course Evaluation"** section above for details on the Theory and Laboratory components (if applicable).

Examinations

Midterm exam will be held in Week 7 of the course on Mar 1 at 11am, lasting for 2 hours, closed book and will cover all material from Weeks 1-6.
Final exam during exam period will be three hours, closed-book and will cover all material from Weeks 8-11.

Other Evaluation Information

Labs will start in week 3. All labs will be related to the design and simulation of bioMEMS components/devices using the software package of Coventorware. The laboratory manuals will be posted on course shell on D2L. The introductory lab will be worth 5%. Labs 1 and 2 will worth 7.5% each.

Course Project: Students will complete a course project on a topic of their choosing. Students will work in groups of 4 members (where applicable). Groups must be formed and group topic selected by week 4 of the term and must be approved by the course instructor (topics entered in the provided spreadsheet by 5pm Friday week 4). Details of the term project will be given during class and posted on the BME804 course shell.

Project assessment:

	1 - Project description due in week 10 in D2L (30%) 2 - Final presentations: Each group will present their course project in a 30-min presentation. Each member of the group must present (approx 7-8 min each). (70%)
Other Information	Lectures: Friday 11:00 AM - 2:00 PM, DSQ12 Lectures in general consist of: - Lecture material (course topics, examples etc.) - Group activities (discussions, project work) - Offline coursework (reading material, assignments, watch prerecoded videos (where applicable), self-organized group meetings etc.)

Course Content

Week	Hours	Chapters / Section	Topic, description
1	3		Lecture Topic 1: Introduction to MEMS and BioMEMS. Introduction to MEMS and their applications.
2	3		Lecture Topic 2: Silicon Microfabrication Part I. Mask creation, silicon wafer preparation, photolithography, photoresist (positive or negative), UV exposure and development, etching methods, resist stripping.
3	3		Lecture Topic 3 : Silicon Microfabrication Part II. Thin films, thin film processes, deposition, micromachining, bonding.
4	3		Lecture Topic 4: Soft Fabrication and Polymers. Soft lithography - micromolding, photo polymerization, Smart polymers and hydrogels, thick-film technologies. Course Project: Group members and Project topic selection should be finalized.
5	3		Lecture Topic 5: Microfluidic Principles Part I. Microfluidics lab-on-a-chip - silicon, glass and polymer material.
6	3		Lecture Topic 6: Microfluidic Principles Part II. Electro-osmosis, electorphoresis, streaming potential, fluid dynamic principles.

7	2		Midterm Exam (2 hours closed book on material covered in weeks 1-6)
8	3		Lecture Topic 7: Sensor Principles and Microsensors. Thermal, mechanical, flow, magnetic and optical sensors.
9	3		Lecture Topic 8: Microactuators and Drug Delivery. Applications, role of actuators, activation methods, drug delivery systems.
10	3		Lecture Topic 9: Biosensors
11	3		No Class - Easter Good Friday
12	3		Lecture Topic 10: Packaging power and safety. System integration, RF safety, power transfer and data transmission, energy-harvesting.
13	3		Project Presentations & Review

Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
3-4	1	Lab 1- Introduction to ConventorWare & design example. Reports due in week 4, by Friday at 11.50PM
5-9	2	Lab 2 - Electrostatic 2D micro-mirror design and simulation. Reports due in week 9, by Friday at 11.50PM
10-12	3	Lab 3 - Electro-thermal micro-gripper Simulation.

		Reports due in week 12, by Friday at 11.50PM

University Policies & Important Information

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the Senate website

Refer to the Departmental FAQ page for furhter information on common questions.

Important Resources Available at Toronto Metropolitan University

- The Library provides research workshops and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or students can use the Library's virtual research help service to speak with a librarian.
- Student Life and Learning Support offers group-based and individual help with writing, math, study skills, and transition support, as well as resources and checklists to support students as online learners.

- You can submit an Academic Consideration Request when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the Senate website and select the blue radio button on the top right hand side entitled: **Academic Consideration Request (ACR)** to submit this request.

  For Extenuating Circumstances, Policy 167: Academic Consideration allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences more than 3 days in duration and those that involve a final exam/final assessment, require documentation. Students must notify their instructor once a request for academic consideration is submitted. See Senate Policy 167: Academic Consideration.

- If a student is requesting accommodation due to a religious, Aboriginal and/or spiritual observance, they must submit their request via the online Academic Consideration Request (ACR) system **within the first two weeks of the class or, for a final examination, within two weeks of the posting of the examination schedule**. If the required absence occurs within the first two weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these requests should be submitted with as much lead time as possible in advance of the required absence.

- If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The Remote Learning Guide for students includes guides to completing quizzes or exams in D2L Brightspace, with or without Respondus LockDown Browser and Monitor, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
- Information on Copyright for Faculty and students.

Accessibility

- Similar to an accessibility statement, use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic accommodation regardless of program or course load.

- Learn more about Academic Accommodation Support.
- Learn how to register with AAS.

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about Academic Accommodations versus Academic Consideration and how to access each.

Wellbeing Support

At Toronto Metropolitan University, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:

- **Distress Line:**24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk:**24/7-hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via My SSP app or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- **Centre for Student Development and Counselling:** 416-979-5195 or email csdc@torontomu.ca
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email osvse@torontomu.ca
- **Medical Centre:** call (416) 979-5070 to book an appointment

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the Toronto Metropolitan University Mental Health and Wellbeing website.