Toronto Metropolitan University

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

Course Outline (W2024)

BME674: Biomedical Instrumentation

Instructor(s)	Dr. M. Ali Tavallaei [Coordinator] Office: ENG466 Phone: (416) 979-5000 x 556078 Email: ali.tavallaei@torontomu.ca Office Hours: Mondays 1-2 pm
Calendar Description	This course deals with the application and design of medical instrumentation systems for which the source of the signals is living tissue or energy applied to living tissues. The major emphasis will be on, transduction principles, sensors, detectors, electronic signal conditioning and processing techniques, and electrical safety standards for medical instrumentation. Some of the major topics include: sensors and transducers - e.g. displacement, resistive, inductive, capacitive, piezoelectric, temperature, radiation thermometry, optical etc.; special-purpose amplification and signal processing techniques; ECG-EMG-EEG biopotential electrodes and amplifiers; non-invasive blood pressure, flow-rate and volume sensing and measurement techniques; respiratory plethysmography; electrochemical biosensors and laboratory instruments; medical imaging systems; and designs for electrical safety. Important instrumentation design concepts are illustrated through design labs, a final design project, and use of circuit simulation tools.
Prerequisites	BLG 601, BLG 701, BME 506, BME 538, CEN 199
Antirequisites	None
Corerequisites	BME 532
Compulsory Text(s):	1. Medical Instrumentation: Application and Design, John G. Webster, 5 th edition, John Wiley and Sons, Inc, 2020.
Reference Text(s):	1. Bioinstrumentation, John G. Webster (Editor), John Wiley & Sons, Inc, 2004.
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: 1. Demonstrate in-depth understanding of key concepts and principles of biomedical instrumentation. Demonstrate, integrate and apply specialized inter-disciplinary engineering principles for design and development of biomedical instrumentation systems. (**1d**) 2. Describe differences between methods and components and then perform a specific method and component integration in a hypothetical design situation. Subsequently integrate the generated ideas into a design plan for a simple biomedical instrumentation system, generating ideas creatively or ad-hoc where established methods fail. (**4b**) 3. Describe iterative process models of design and modify, improve or elaborate a design state using feedback (from expert or system performance results) to achieve specified targets. (**4c**) 4. Demonstrate the ability to use the knowledge on biomedical instrumentation and measurement equipment for obtaining valid data. (**5a**) 5. Produce formal lab and project reports using appropriate format, grammar, and citation styles for technical and non-technical audiences. Cites evidence (e.g. data sheets, literature) to support the design considerations. (**7a**)

6. Know the role of the biomedical engineer in society. Including responsibility for protecting, specifically, patient safety, and, generally, the broader public interest. (**8b**)
7. Describe interactions between biomedical instrumentation system design and economic and environmental factors. (**9b**)
8. Demonstrate the ability to source and use technical information related to biomedical instrumentation. (**12a**)

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
2.0 hours of lab per week for 12 weeks
0.0 hours of tutorial per week for 12 weeks

Teaching Assistants

Sina Keshavarz: mkeshavarz@torontomu.ca
Mohammad Khoobani: mohammad.khoobani@torontomu.ca
Robnier Reyes Perez: rreyespe@torontomu.ca

Course Evaluation

Theory	
Midterm Exam	25 %
Final Exam	45 %
Laboratory	
Labs	15 %
Project	15 %
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

The midterm exam is in Week 6, two hours, closed book (covers up to the prior week of the midterm exam), formula sheet permitted.
Final exam, during the exam period, three hours, closed book (covers all material), formula sheet permitted.

Other Evaluation Information

None

Teaching Methods

In-person lectures, laboratories, and pre-recorded videos.

Other Information

Major Design Lab Project
In the course project, students will design a biomedical signal acquisition and processing system based on LabView-Microprocessor/Microcontroller interface. The project is open-ended, and the student can choose the measurand, appropriate transduction principle, components, and quantification approaches for their design while adhering to the general design process for medical instrumentation. The project groups will be the same as the lab groups. The last four weeks of the lab sessions will be used for the project work. The students can do the groundwork

	for the project from the start of the course and will submit a proposal outlining their design plan with proper justifications of their design considerations by Week 8 and should get it evaluated and approved by the Instructor/TA. From week 9 to 13, students will engage in the implementation phase. During this phase, students will consult with the instructor/TA to discuss their weekly progress and incorporate feedback to improve their design. In the last week of their respective lab sessions, the students will demonstrate their projects to the Instructor/TA and submit a report with the following sections: problem definition, literature survey (pertaining to the justification for their design), methodology, implementation details, and performance analysis. The project reports should be written in a manner that the main theme of the project can be understood by a non-technical reader. Individual student contributions are to be highlighted with consent from all the group members. The project will be evaluated based on the proposed design considerations incorporating the following four factors: (i) Signal, (ii) Medical, (iii) Environmental, and (iv) Economic (Refer to Figure 1.8 in the Text Book for more details). The report should clearly justify the design choices with respect to the above four factors.

Course Content

Week	Hours	Chapters / Section	Topic, description
1	3	Chapter 1 and 14 Sections 1.1-1.10, 1.25-1.27 14.1-14.9	Basic Concepts of Medical Instruments & Electrical Safety
2-3	6	Chapter 1 Sections 1.11-1.24	Amplifiers and Signal Processing
4-6	6	Chapter 2 and 10 Sections 2.1-2.14, 10.1-10.2 and 10.9	Basic Sensors & Principles
7-8	3	Chapter 3	Microcontrollers in Medical Instrumentation
8-10	9	Chapter 4-6 Sections 4.1-4.2, 5.1-5.8 6.1-6.7, 6.10 (Self Study Sections 4.3-4.9)	Midterm Test, The Origin of Biopotentials, Electrodes, and Amplifiers
11-12	6	Chapters 7-9 and 11, Sections 7.1 7.9, 7.10 7.13,	Applications: Measurements of Blood Pressure Flow Volume and Respiratory System. Overview of Laboratory Instrumentation

		8.4,8.5-8.7,8.8 9.7, 11.1, 11.4	
12-13	4	Chapter 12 Sections 12.5, 12.7, 12.8, 12.12	Medical Imaging: Radiography Ultrasonography Computed Tomography Magnetic Resonance Imaging

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

Week	L/T/A	Description
1	L	Design Lab 0: Introduction & Review
2-4	L	Design Lab 1: Amplifiers and Signal Processing
5-6	L	Design Lab 2: Sensors
7-9	L	Design Lab3: ECG - Measurement and Monitoring
9-13	L	Project (Major Design Lab): Biomedical Signal Acquisition - Microcontroller-LabviewInterface-Based System.

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.