

Course Outline (F2024)

BME772: Biomedical Signal Analysis

Instructor(s)	Dr. Sridhar Krishnan [Coordinator] Office: EPH 439 Phone: 554931 / 557548 Email: krishnan@torontomu.ca Office Hours: Mondays, 2pm to 3pm
Calendar Description	This is course will cover the different biomedical signals and the related signal modeling and analysis techniques. The topics covered in the course include an introduction to various physiological/biomedical signals such as the action potential, the electro-neurogram (ENG), the electromyogram (EMG), the electrocardiogram (ECG), the electroencephalogram (EEG), event-related potentials (ERPs), the electrogastrogram (EGG), the phonocardiogram (PCG), the carotid pulse (CP), signals from catheter-tip sensors, speech and oto-acoustic emission signals. The biomedical signal analysis portion of the course will deal with the analysis of concurrent, coupled and correlated processes, filtering for removal of artifact from biomedical signals, event detection techniques, analysis of wave-shape and waveform complexity associated with biomedical signals, mathematical modeling of biomedical systems, and medical decision support systems.
Prerequisites	BLG 601 and BME 632 and BLG 701 and BME 639
Antirequisites	ELE 772
Corerequisites	None
Compulsory Text(s):	1. Biomedical Signal Analysis, 3rd Edition, R.M. Rangayyan and S. Krishnan, IEEE Press Series in Biomedical Engineering, published by John Wiley and Sons Inc., 2024.
Reference Text(s):	1. Biomedical Signal Analysis for Connected Healthcare, S. Krishnan, Elsevier, 2021. 2. Technical articles and other relevant materials [to be posted if required]
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: <ol style="list-style-type: none"> 1. The students will be able to demonstrate their ability to apply different mathematical transforms and modeling techniques to physiological signals. (1c) 2. The students will build the knowledge base needed for data acquisition, signal pre-processing, analysis, and interpretation of various real-world physiological signals. (1d) 3. Solve design problems (4b) 4. Analyse data to make decisions. (5b) 5. Contribute to teamwork in an equitable and timely manner. (6a) 6. Use Technical vocabulary related to Biomedical Engineering accurately. (7a) 7. Make concise technical presentations to a peer group. (7b) 8. Use graphics to analyse and display data. (7c) 9. Understand how technological innovations can affect the well-being of those that use them. (8b) 10. Gains a working knowledge of the literature of biomedical engineering and how it effects the day to day life (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 2.0 hours of lab per week for 12 weeks 0.0 hours of tutorial per week for 12 weeks														
Teaching Assistants	TBA														
Course Evaluation	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <th colspan="2" style="text-align: left;">Theory</th> </tr> <tr> <td>Midterm Exam</td> <td style="text-align: right;">25 %</td> </tr> <tr> <td>Final Exam</td> <td style="text-align: right;">30 %</td> </tr> <tr> <th colspan="2" style="text-align: left;">Laboratory</th> </tr> <tr> <td>Lab Reports</td> <td style="text-align: right;">25 %</td> </tr> <tr> <td>Project</td> <td style="text-align: right;">20 %</td> </tr> <tr> <td>TOTAL:</td> <td style="text-align: right;">100 %</td> </tr> </table> <p>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).</p>	Theory		Midterm Exam	25 %	Final Exam	30 %	Laboratory		Lab Reports	25 %	Project	20 %	TOTAL:	100 %
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Examinations	Midterm exam in Week 8, two hours (covers Weeks 1-7). Final exam, during exam period, three hours (covers Weeks 1-13).														
Other Evaluation Information	<p>Course Project</p> <p>Project on state-of-the art biomedical analysis systems that may include implementation as well as a written report and presentation. The details will be discussed in class. The project will have to be done in groups of three students. A report including the problem statement, methodology, and results for each must be submitted by the date which will be provided later.</p> <p>The report should be in IEEE double column format, and should not be more than 6 double-column, single-spaced pages (IEEE templates for Word and Latex may be downloaded from the IEEE website). The presentation of the report will also be required, and a presentation schedule will be provided later in the course.</p>														
Teaching Methods	In-person lectures and labs														
Other Information	None														

Course Content

Week	Hours	Chapters / Section	Topic, description
1-2	4	Chapters 1 and 2	Biomedical signal analysis: Opportunities and Challenges. Nature of Biomedical Signals.
2-3	3	Chapter 3	Sources of noise, artifacts, and interferences in biomedical signals
3-5	8	Chapter 3	Filtering of biomedical signals
6-7	6	Chapters 4 and 5	Detection of events, waveshape analysis, and time-domain analysis Week 7: Project proposals due
8	2		Midterm
8-10	6	Chapter 6	Frequency-domain analysis of biomedical signals
10-11	3	Chapter 7	Mathematical modeling of biomedical signals
11-12	4	Chapter 10	Machine learning applications Week 12: Project reports due
13	3		Review and project presentations

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

Week	L/T/A	Description

2	Lab	Lab 0: Foundational aspects of biomedical signal analysis
3 and 4	Lab	Lab 1: Synchronized averaging
5 and 6	Lab	Lab 2: Filtering of the ECG for 60Hz removal
7 and 8	Lab	Lab 3: QRS Detection and ECG Rhythm Analysis
9 and 10	Lab	Lab 4: Frequency Domain Analysis
11 and 12	Lab	Open Lab for projects

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 further 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 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.