

## Course Outline (W2024)

### BME809: Biomedical Systems Modelling

<b>Instructor(s)</b>	Dr. Dafna Sussman [Coordinator] Office: Phone: (416) 979-5000 x 553767 Email: dafna.sussman@torontomu.ca Office Hours: Monday 12-1pm By appointment
<b>Calendar Description</b>	Mathematical modeling of biomedical systems. Lumped and distributed models of electrical, mechanical, and chemical processes applied to cells, tissues, and organ systems.
<b>Prerequisites</b>	BLG 601 and BLG 701 and BME 229 and BME 639
<b>Antirequisites</b>	None
<b>Corerequisites</b>	None
<b>Compulsory Text(s):</b>	1. Signals and Systems in Biomedical Engineering: Physiological Systems Modeling and Signal Processing (Third Edition), Suresh R. Devasahayam. Springer Singapore, 2019 (ebook ISBN 978-981-13-3531-0, hardcover book ISBN 978-981-13-3530-3)
<b>Reference Text(s):</b>	1. Modeling and Simulation in Biomedical Engineering, Applications in Cardiorespiratory Physiology, Willem Van Meurs, McGrawHill, 2011 2. Cardiac Electrophysiology Methods and Models, Daniel C. Sigg, Paul A. Laizzo, Yong-Fu Xiao and Bin He (Editors), Springer, 2010
<b>Learning Objectives (Indicators)</b>	At the end of this course, the successful student will be able to: <ul style="list-style-type: none"> <li>1. Apply principles from control systems (e.g. block diagrams, feedback loops), Electrical Engineering (e.g. LCR circuits), and Physics/Kinematics in combination with ordinary and partial differential equations to model physiological systems and processes. <b>(1d)</b></li> <li>2. Apply and evaluate the suitability of various signal processing techniques to different types of physiological measurements (e.g. action potentials, ECG, EMG) for analysing signal characteristics and improving signal quality using Matlab. <b>(2b), (3b), (5a)</b></li> <li>3. Apply numerical and analytical methods to generate computational models of physiological systems and simulate physiological signals (using Simulink and Matlab) to address biomedical problems (e.g. effect of pathologies or drugs on a system). <b>(4b)</b></li> <li>4. Learn to identify and evaluate the implications of different approaches to addressing/modelling a biomedical problem and develop decision making criteria to determine the optimal solution under different conditions. <b>(8b)</b></li> <li>5. Understand the underlying physiological, electrical, mechanical and chemical processes of human cells, tissues and organ systems that result in physiological signal generation and their role in generating biophysical models. <b>(12b)</b></li> </ul> <p><b>NOTE:</b> Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).</p>

<p><b>Course Organization</b></p>	<p>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</p>																
<p><b>Teaching Assistants</b></p>	<p>TBA</p>																
<p><b>Course Evaluation</b></p>	<table border="1"> <thead> <tr> <th colspan="2"><b>Theory</b></th> </tr> </thead> <tbody> <tr> <td>Midterm Exam</td> <td>25 %</td> </tr> <tr> <td>Quizzes (2*7.5%)</td> <td>15 %</td> </tr> <tr> <td>Final Exam</td> <td>30 %</td> </tr> <tr> <th colspan="2"><b>Laboratory</b></th> </tr> <tr> <td>Lab (4 x 5%)</td> <td>20 %</td> </tr> <tr> <td>In-Class Assignments and Participation</td> <td>10 %</td> </tr> <tr> <td>TOTAL:</td> <td>100 %</td> </tr> </tbody> </table> <p><b>Note:</b> 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 "<b>Theory and Laboratory</b>" 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 "<b>Course Evaluation</b>" section above for details on the Theory and Laboratory components (if applicable).</p>	<b>Theory</b>		Midterm Exam	25 %	Quizzes (2*7.5%)	15 %	Final Exam	30 %	<b>Laboratory</b>		Lab (4 x 5%)	20 %	In-Class Assignments and Participation	10 %	TOTAL:	100 %
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<p><b>Examinations</b></p>	<p>Midterm Exam: The midterm exam will be in week 9 of the course (on March 11th). It will be a 2-hour, closed book test that will cover material from weeks 1-8.</p> <p>Quizzes: In week 7 (week of Feb. 26th) and week 11 (week of March 25th) of the course, will be of 30 minute duration at the start of tutorials 2 and 3, respectively. Quizzes are closed book and will cover lecture material from the previous 2-4 weeks.</p> <p>The final exam will be during the exam period, and will be 3 hours, closed book, and will cover all course material.</p>																
<p><b>Other Evaluation Information</b></p>	<p>Laboratory manuals will be posted on the course shell on D2L. The lab will run every week beginning week 2. All labs will involve simulating and/or processing physiological signals and systems using Matlab and/or Simulink software.</p> <p>Each lab is worth 5%, and will be marked based on completion of the lab report and answering TA questions during and at the end of the lab session. A lab report must be submitted for each of the four labs, one lab report per group, submitted within 1 week of completing the lab (emailed to the TA before the start of the next lab). Late submissions will be penalized over the first 3 days, after which a grade of zero will be assigned.</p> <p>Lab reports will Not be accepted from students who did not attend a lab session.</p> <p>Lectures will involve in-class assignments that are to be submitted through D2L.</p> <p>** Laboratory attendance and lecture attendance are both mandatory. Attendance will be taken within the first 15min of the lecture / lab start time. Late admission will not count towards one's attendance grade.</p>																

	The TAs are responsible for managing all quizzes and labs; kindly direct any related inquiries to them.
<b>Other Information</b>	Lecture Time: Mondays 9AM -12PM, Location: DCC 350

## Course Content

Week	Hours	Chapters / Section	Topic, description
1	3	part I: 1	Lecture topics: Introduction to systems and modeling and physiological signals and noise. Review of signals and systems basics statistical description of a random process, continuous and discrete signals and digitization.
2	3	part I: 4	Lecture topics: Review of frequency decomposition of signals. Fourier series, Fourier Transform (discrete-time discrete fast short-time), wavelet transform, Laplace transform, filtering
3	3	part I: 1-2	Lecture topics: Differential equations and numerical methods, Modeling of the cardio-respiratory system
4	3	part I: 5, part II:1	Lecture topics: Modelling nerve action potentials, Stimulation of excitable tissue, Windkessel model
5	3	part I: 3,8, part II:3	Lecture topics: Feedback systems, control systems, system stability, sensory receptors
6	3	part II: 8	Lecture topics: Model validation, FEM, Immune System
7	3	part II: 7	Lecture topics: Linear model of blood flow, mechanical and electrical analogies
8	1		Lecture topics: Review for midterm exam (material from weeks 1-6)

8	2	(supplement)	Lecture topics: Modelling healthy and diseased ocular system
9	3		Midterm exam (in class, closed book) + 1hr to review solutions in the lecture
10	3	(supplemental lecture notes)	Lecture topics: Computational modelling of placental vasculature
11	3	part II: 4	Lecture topics: Modelling skeletal muscle contraction
12	3	part II: 4-5	Lecture topics: Modelling skeletal muscle contraction, Myoelectric activity
13	3	part II: 5-6	Lecture topics: EMG data acquisition and processing
14	3	(supplement)	Practice modelling a variety of physiological systems: Cellular iron regulation, fructose intolerance (through an exam mock-up)

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

Week	L/T/A	Description
2-3	1	Lab 1: Wavelet transformation applied to EEG
4	T1	Tutorial 1: Introduction to Simulink
5,6	3	Lab 2: Windkessel model of blood circulation
7	T2	Tutorial 2: Review of course concepts problem solving
8-9	T1	Lab 3: System Identification

10-11	4	Lab 4: Immune System
12	T3	Tutorial 3: Skeletal Muscles
13	T4	Tutorial 4: Real-time data acquisition and signal processing

## 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 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](mailto:csdc@torontomu.ca)
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email [osvse@torontomu.ca](mailto: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.