

Course Outline: Biomedical Instrumentation

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COURSE TIMETABLE

General Information

Course Name	Biomedical Instrumentation
Course #	BMDE-503
Term	Fall
Year	2024
Course pre-requisite(s)	Basic understanding of linear algebra, calculus, differential equations (primarily Laplace Transform techniques) and basic complex numbers. Beginner-level experience writing computer programs is an asset.
Course co-requisite(s)	None
Course schedule (class day(s) and time)	Tuesday (T) & Thursday (R): 13h05-14h25
Number of credits	3
Contact Hours (Faculty Engineering)	(3-0-6) 3 hours of lecture per week 0 hours of tutorial per week 6 hours of personal study per week
Course Location	Duff Medical Building 321 (Lectures) 315D (Laboratory sessions; enter via room 316)

Instructor Information

Name and title	Ross Wagner, PhD (primary instructor)
Email	ross.wagner@mcgill.ca
Telephone	(514) 398-6740
Office location	Duff Medical Building , room 315C
Office hours	I am usually free after class. For other times please make an appointment. If circumstances warrant, I may institute fixed office hours.
Communication plan	Please contact me via email. I am usually on campus from 9AM to 5PM for in-person meetings. Alternatively, meetings may be held on-line. I strive to respond to email or posts in myCourses within the same work day.

Invited guest lecturers will give some lectures. See the [course timetable](#).

Course Overview

The principles and practice of making biological measurements in the laboratory, including theory of linear systems, data sampling, computer interfaces and electronic circuit design.

Learning Outcomes

By the end of this course students should:

- Understand how to characterize signals and systems in the frequency domain
- Be able to solve electronic circuits (electronics plays a central role in the course)
- Appreciate some of the issues involved in making electrical measurements on living organisms
- Have a general understanding of the signal processing chain of a typical data acquisition system

Instructional Methods

The course is taught via lectures, and [laboratory sessions](#) in lieu of lectures. Lectures will be synchronous. If more than 8 students are registered, the class will be divided into two groups for the laboratory sessions, also given synchronously.

Manner of Delivery

The course is primarily given in person, on campus. Some lectures may be offered remotely using the Zoom web conferencing tool integrated in [myCourses](#).

Course Structure

The course is scaffolded, building upon itself. As such,

- Subject matter covered in previous lectures is often referred to in subsequent ones
- Assignment questions may (i) draw upon the material presented in several lectures and (ii) build upon previous assignment questions
- Review assignment solutions as they are released – regardless of your assignment grade. Solutions may show a more efficient means of solving a problem.
- Discuss issues with the instructor as soon as possible (**this point cannot be overemphasized**)

Hardware / Software Requirements

Access to a personal computer with enough space to install the [application](#) used during the course.

One USB flash drive formatted to a FAT32 file system (2GB – 32GB, for [laboratory sessions](#)).

myCourses (Learning Technology)

myCourses is a web-based instructional management system used at McGill and will be used as a resource in this course to provide:

- Lecture notes
- Reference material
- Assignment releases

- Assignment hints, corrections, and clarifications
- Public announcements of course events
- Public discussion forum (with option to post anonymously)
- Private summary of marks and comments
- Final Assessment

You may access *myCourses* via the following link: <https://www.mcgill.ca/mycourses/>.

The [FAQs for students using myCourses](#) may also be useful.

You may download the [Brightspace Pulse mobile app](#) to stay connected and on track with your courses.

Learning Resources

The [Learning resources](#) page contains links to resources to help you stay on track and support your learning.

Expectations for Student Participation

Attendance is not mandatory for lectures given by the primary instructor.

Attendance is highly encouraged at guest-lecture presentations.

Participation is required in laboratory sessions if you are paired with a partner. (There are a finite number of lab kits, which may have to be synchronously shared with a partner. If you chose not to share a kit, and none is available for you, you will not be assessed on the laboratory work and will receive a grade of 0.)

Class Recordings

Lectures will not be recorded, nor should they be recorded without unanimous consent from attending students and the lecturer.

Required Course Materials

All course materials will be distributed by any of the following means:

- Primarily through [myCourses](#) (material intended to be downloaded prior to class will appear in [myCourses](#) no later than 5:00 PM the eve of the lecture day)
- During lectures by way of illustrations

Course Content

Biomedical instrumentation is a vast field, and the course title lends to differing interpretations. This course is not an exposition of various instruments used in healthcare. Rather, the course touches on the following topics:

- i) Electronics
- ii) The body/instrument interface (e.g. transducers, electrodes, ...)
- iii) Signal conditioning
- iv) Computer interfacing
- v) Electrical safety issues

- vi) Noise management

See the [course timetable](#) for a detailed list of topics.

Assessments

Assessment Criteria

Students will be assessed on their ability to:

- Apply one or more procedure(s) to a problem
- Analyze a problem and obtain a correct result
- Write computer programs to analyze a problem
- Interpret observations / results
- Provide short answers to questions
- Construct prototype electronic circuits (i.e., breadboard circuits)
- Use test equipment to measure circuit performance

It is neither necessary nor encouraged that you type your solutions, nor is it necessary to draw diagrams using a computer program – provided that your handwriting is legible, and sketches are neat.

Final Grade Structure

Course grades will be determined as follows.

Contribution to Final Grade	Type of Assessment
60%	Ten best ' Assignments ' out of twelve.
40%	Final Assessment – online
1-point bonus	A bonus will be awarded for completing the End-of-Course Evaluations in a timely manner: final course grades will be increased by one point if a minimum of 80% of the class completes the evaluation by midnight Dec. 12, 2024.
1-point bonus (prorated)	A bonus will be awarded for attending the guest-lecture presentations: your final course grades will be increased by a maximum of one point, prorated based on the number of lectures you attend.

Assignments

Types

Assignments come in the following forms:

- i) Traditional, consisting of a combination of analytical and [computer-based](#) problems to be completed outside of scheduled class time
- ii) Lab work, as [laboratory session](#), conducted in the department's electronics workshop. A lab session replaces a lecture. Typically, labs cannot be completed during the lecture timeslot. Work remaining to complete the lab experiments constitute that week's assignment time, and is to be completed outside of scheduled class time. The assignment submission is an informal lab report (submit your measurements, analysis and discussions).

Schedule

Twelve assignments will be released via [myCourses](#) on the following schedule.

Assessment Task Count	Name of Assessment Task	Due Date	% of Final Grade
1	Assignment 1	2024-09-10	6
2	Assignment 2	2024-09-17	6
3	Assignment 3	2024-09-24	6
4	Electronics Lab 1	2024-10-01	6
5	Assignment 4	2024-10-08	6
6	Electronics Lab 2	2024-10-22	6
7	Assignment 5	2024-10-29	6
8	Assignment 6	2024-11-05	6
9	Assignment 7	2024-11-12	6
10	Assignment 8	2024-11-19	6
11	Assignment 9	2024-11-26	6
12	Electronics Lab 3	2024-12-03	6

Length

Assignment work completed outside of scheduled class time should take no more than six hours to complete. This estimate presumes that you understand prior assignments. Please manage your time. If you get stuck on a question discuss it with the course instructor early.

Submission Instructions

An [assignment](#) is to be submitted in [myCourses](#) as a single, legible PDF document of contiguous pages (e.g., no attachments) by the due date indicated on the assignment. (See [Grading](#) below for grace period policy.)

The [FAQ for students using myCourses: Assignments](#) may be of value.

Grading

1. Assignments will be graded and returned to the student typically one week after being submitted.
2. Feedback on your performance on an assignment will primarily be made on the returned material. Supplemental ‘overall feedback’ may also be provided via [myCourses](#). (The latter typically occurs after assignment submissions have been returned.)
3. Late submissions will be subject to a penalty of 10% of the assignment worth, which grows cumulatively each 24-hour period post deadline.
4. Grace period: you are automatically granted a 24-hour extension on every assignment.

Example: An assignment marked due on Tuesday at 4:00 PM may be handed in on Wednesday at 4:00 PM without penalty. Should you miss the 4:00 PM grace deadline the assignment will be considered 24-hours late.

5. Assignments will be graded primarily on their content but must be presented in a clear, concise, and neat manner.
 - A penalty of 10% of the total assignment worth will be incurred for inadequate presentation.
 - No marks will be given for answers that are unjustified or appear to be miraculously obtained. (Show your work!)
6. Students are encouraged to collaborate on assignments but must hand in solutions independently. Any obvious copying between people will be considered plagiarism and implicated parties may be subjected to disciplinary measures. (See [Academic Integrity](#) below.)

Assignment Extensions

An assignment extension may be requested based on medical reasons or other extenuating circumstances. Note that having a heavy work load is not a reason to request an extension. You may be required to justify your request with official documentation (e.g., a doctor's note).

Solutions

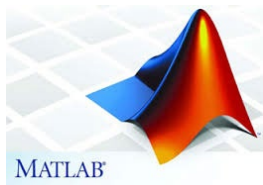
Assignment solutions are regularly released typically after an assignment has been graded. In some cases, solutions may be released sooner to help students for the following assignment.

Software / Application Restrictions

Use of symbolic math tools is prohibited unless otherwise indicated.

Computer-Based Problems

Computer-based problems will be done with Mathworks' MATLAB application (free for students).



MATLAB is a numeric computation and visualization software package used in many fields. Though MATLAB will be used often, only a modest level of proficiency in the application will be required, as this is not a course in computer science or programming. Example programs will be provided to help you get started.

Please refer to [IT Services](#) article KB0011460, [Create a Mathworks account and install MATLAB](#), for information on how to obtain MATLAB for your personal computer. You will need to install the following toolboxes:

- Signal Processing
- Control System
- Symbolic Math (Optional. Only to be used in rare occasions, when explicitly allowed.)

To confirm that the proper toolboxes are installed, type “ver” at the MATLAB command prompt and confirm that the above (mandatory) toolboxes are listed.

Refer to [System Requirements](#) for hardware requirements to install MATLAB.

A less-preferred alternative is MathWorks' [online version of MATLAB](#) that uses their MATLAB Drive cloud storage. Refer to the above-mentioned KB article on how to create a MathWorks account.

Final Assessment

Modality

The final assessment will be a synchronous, online, 3-hour, open-book examination hosted in [myCourses](#).

Format

Details of the final assessment will be provided in [myCourses](#) later in the term.

Scheduling

The scheduling of the final assessment is conducted by the Faculty of Engineering. Any conflicts should be reported to the scheduling office as instructors have no influence on the date chosen.

Laboratory Sessions

For lecture timeslots designated as laboratory sessions the class will be held in the electronics workshop.

- There are four experimental stations available for use.
- Due to limited resources work required to be done in the electronics lab will be done in groups of two, unless circumstances dictate otherwise. Each individual is to submit their own lab write up.
- Should there be more than 8 students registered in the course the class will be divided into sections. One section will work on their lab during normal class time. Students in other section(s) will have to find time in common with the primary instructor to meet in the workshop and make-up the session.
- Should you require time at a workstation outside of the class timeslot you will be able to reserve time in [myCourses](#).

The electronics lab is open 24/7. After the first lab session your McGill ID card will be programmed into the card reader system so that, during the semester, you will have access the department anytime.

Course Evaluations (Mercury Evaluations)

[Mercury course evaluations](#) are one of the ways that McGill works towards maintaining and improving the quality of courses and the student's learning experience. Instructors have no idea how well a course is received by students. The evaluations are usually an instructor's only feedback and are crucial for improving a course. You will be notified by e-mail when the evaluations are available. Please fill out the course evaluation. Written comments indicating what worked well in the course and what can be improved are much more helpful than just numerical evaluations. A bonus will be awarded if enough students complete the evaluation by a specified deadline. (See the [evaluation overview](#) for more detail.)

Please note that a minimum number of responses must be received for results to be available to students.

McGill Policy Statements

As the primary instructor of this course, I endeavor to provide an inclusive learning environment. However, if you experience barriers to learning in this course, do not hesitate to discuss them with me and the [Office for Students with Disabilities](#), 514-398-6009.

Copyright

© Instructor-generated course materials (e.g., handouts, notes, summaries, assessment questions) are protected by law and may not be copied or distributed in any form or in any medium without explicit

permission of the instructor. Note that infringements of copyright can be subject to follow up by the University under the [Code of Student Conduct and Disciplinary Procedures](#).

Academic Integrity

McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the [Code of Student Conduct and Disciplinary Procedures](#).

See [McGill's guide to academic honesty](#) for more information.

Language Submission

In accord with McGill University's [Charter of Students' Rights](#), students in this course have the right to submit in English or in French any written work that is to be graded.

Student Assessment

The purpose of the [Policy on Assessment of Student Learning](#) (PASL) is to provide a set of common principles to guide the assessment of students' learning. Per PASL, assessment should be equitable and consistent, and promote effective learning experiences, a healthy learning environment, and academic integrity. Learn more on the [For Students](#) page of the PASL website.

Basic Needs

If you have difficulty affording food or if you lack a safe and stable place to live, and believe that these circumstances may affect your performance in this course, I encourage you to contact the [Dean of Students](#), who can connect you with support services. If you feel comfortable doing so, please let me know as well so we can discuss how I can best support your learning.

Wellness

Many students may face mental health challenges that can impact not only their academic success but also their ability to thrive in our campus community. Please reach out for support when you need it; [wellness resources](#) are available on campus, off campus, and online.

Extraordinary Circumstances

In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

Preparations for Next Lecture

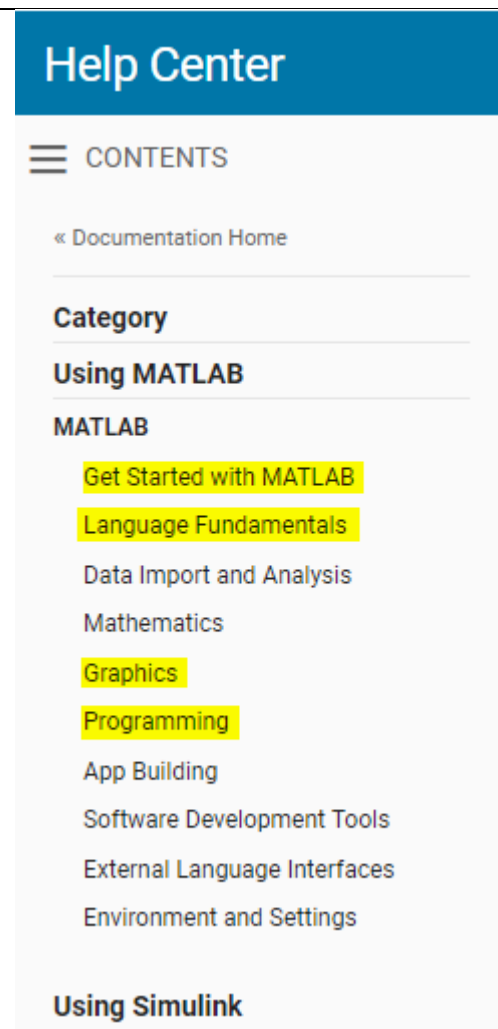
- Acquaint yourself with [myCourses](#)
- Download the class notes for lecture No. 2 and have them ready

Preparations for First Assignment

- Get access to MATLAB
- Confirm that the necessary [toolboxes](#) are installed
- Read the introduction to MATLAB available from The Mathworks web site at:
<https://www.mathworks.com/help/matlab/index.html>

In the left CONTENTS menu options, under the MATLAB section, consider working through the following topics:

- Get Started with MATLAB
- Language Fundamentals
 - Matrices and Arrays (*focus on arrays*)
- Graphics (focus on 2-D line plotting)
- Programming (focus on scripts and functions)



The screenshot shows the MATLAB Help Center interface. At the top is a blue header with the text "Help Center". Below this is a grey bar with a hamburger menu icon and the word "CONTENTS". Underneath is a link "« Documentation Home". The main content area is titled "Category" and lists various topics. The "Using MATLAB" section is expanded, showing a list of topics: "MATLAB", "Get Started with MATLAB", "Language Fundamentals", "Data Import and Analysis", "Mathematics", "Graphics", "Programming", "App Building", "Software Development Tools", "External Language Interfaces", and "Environment and Settings". The "Using Simulink" section is partially visible at the bottom.

Course Timetable

<i>Date</i> <small>Day</small>	<i>Lecture</i> <i>No.</i>	<i>Topic(s)</i>	<i>Lecturer</i>
Aug 29 <small>R</small>	1	Orientation Session (+ Medical Instrumentation System)	Dr. Wagner
Sep 03 <small>T</small>	2	Frequency-Domain Representations and Linear Time-Invariant Systems	Dr. Wagner
Sep 05 <small>R</small>	3	Electronic Circuits (Kirchoff's laws, Superposition theorem, 1 st -order ODE, Laplace methods and Thevenin/Norton theorems, modulation, etc.)	Dr. Wagner
Sep 10 <small>T</small>	4	Electronic Circuits (continued)	Dr. Wagner
Sep 12 <small>R</small>	5	Electronic Circuits (conclusion)	Dr. Wagner
Sep 17 <small>T</small>	6	Transfer functions, higher-order ordinary differential equations, and frequency responses	Dr. Wagner
Sep 19 <small>R</small>	7	Bode Plots	Dr. Wagner
Sep 24 <small>T</small>	8	<i>Electronics lab 1 (Introduction to equipment)</i>	Dr. Wagner
Sep 26 <small>R</small>	9	Operational Amplifiers	Dr. Wagner
Oct 01 <small>T</small>	10	Operational Amplifiers (conclusion)	Dr. Wagner
Oct 03 <small>R</small>	11	Basic Sensors and Principles	Dr. Wagner
Oct 08 <small>T</small>	12	<i>Electronics lab 2 (Op Amps)</i>	Dr. Wagner
Oct 10 <small>R</small>	13	Sensor Interfacing	Dr. Wagner
Oct 22 <small>T</small>	14	(Solving multi op-amp circuits tutorial) or (Analog Filtering)	Dr. Wagner
Oct 24 <small>R</small>	15	Signal Digitization	Dr. Wagner
Oct 29 <small>T</small>	16	Electrical Safety and Isolation	Dr. Wagner
Oct 31 <small>R</small>	17(*)	Electrodes and Electromyography (EMG)	Prof. Kearney
Nov 05 <small>T</small>	18	Electroencephalography (EEG)	Dr. Gotman
Nov 07 <small>R</small>	19	Measuring Eye Movements and Electrocardiography (ECG)	Dr. Wagner
Nov 12 <small>T</small>	20	Biopotential Amplifiers / Tutorial	Dr. Wagner
Nov 14 <small>R</small>	21	Digital Electronics	Dr. Wagner
Nov 19 <small>T</small>	22	Data Conversion (A/D, D/A and acquisition)	Dr. Wagner
Nov 21 <small>R</small>	23	Noise Management	Dr. Wagner
Nov 26 <small>T</small>	24	<i>Electronics lab 3 (Sampling and measuring the ECG)</i>	Dr. Wagner
Nov 28 <small>R</small>	25	<i>Electronics lab 3 (Measuring the ECG, continued)</i>	Dr. Wagner
Dec 03 <small>T</small>	26	<i>Electronics lab 3 (Measuring the ECG, conclusion)</i>	Dr. Wagner

Fall Reading Break: Oct 15 – 18, inclusive.

*: Lecture delivered remotely

Last day of lectures Dec 04 – **No assignment submissions allowed beyond this date**