Integrated Biomedical Engineering & Health Sciences Program
McMaster University

IBEHS 3A03
Biomedical Signals and Systems
Fall 2023
Course **Outline**

Calendar/Course Description

Linear systems, signals, input-output relations of linear systems; discrete and continuous time systems; transfer functions, Fourier transforms, Laplace transforms; sampling theory; stability.

Pre-Requisites and Anti-Requisites

Prerequisite(s): MATH 2Z03 and registration in the Integrated Biomedical Engineering and Health Sciences (IBEHS) program

Antirequisite(s): SFWRENG 3MX3, ELECENG 3TP3, ENGPHYS 3W04

Course Schedule

Lecture (in-person): Wed 7:00pm – 10:00pm (Location available on MOSAIC)

> Echo360 lecture capture will be used to stream lecture and will be posted automatically on Avenue. However, there are no guarantees about the quality of the audio or completeness of the video, for example, board work likely will not be captured by the system. Lecture videos are a backup for reference or clarification, not a replacement for regular lecture attendance.

Tutorial (in-person): T01 Wednesday 11:30 – 12:20pm; T02 Tuesday 1:30 – 2:20pm; T03 Wednesday 10:30 – 11:20am; T04 Tuesday 1:30 – 2:20pm (Location available on MOSAIC)

> Tutorials **will NOT** be streamed using Echo360 or posted on Avenue

Instructor Contact Information

Dr. Omar Boursalie
e-mail: ibio3a03@mcmaster.ca

Instructional Team Contact Information

TAs:
- Sean Clarke, ibio3a03@mcmaster.ca
- Ryan Singer, ibio3a03@mcmaster.ca
- Melih Yayli, ibio3a03@mcmaster.ca
- Calvin Zhu, ibio3a03@mcmaster.ca

Communicating with Instructor and TAs guide: https://libguides.mcmaster.ca/c.php?g=718526&p=5176620

Course Overview

Week	Topic	Readings
1	• Introduction to Signals and Systems	Ch. 1 in textbook
2–3	• Time Domain Models of Systems	Ch. 2 in textbook
4–6	• Fourier Series and Fourier Transforms	Ch. 3 in textbook
7–8	• Fourier Analysis of Signals and Systems	Ch. 4 and 5 in textbook
9	• The Laplace Transform and the Transfer Function Representation	Ch. 6 in textbook
10	• Analysis of Continuous-Time Systems Using the Transfer Function Representation	Ch. 8 in textbook
	• Filtering of Biomedical Signals	-
10–11	• Filtering of Biomedical Signals	-
12	• Non-Linear and Time-Domain Signal Analysis + Review	-
13	• Review	-

Materials and Fees

Textbooks

[Fundamentals of Signals and Systems (Third Edition), E. W. Kamen and B. S. Heck, Pearson, 2007. ISBN-10: 0131687379; ISBN-13: 978-0131687370](#)

Textbook companion website at: http://bonnie.ece.gatech.edu/book3/

Software
MATLAB + Signal Processing Toolbox

Assessments

The course is assessed as follows.

GRADING MODULE	WEIGHT
Lecture Class Exercise Participation (will be shifted to midterm & final exam if participation requirements not met)	5%
Assignments (4×10%)	40%
On-line Quizzes (4×2.5%)	10%
Midterm Exam	15%
Final Exam	30%

All submissions are in PDF format and/or MATLAB code. Handwritten assignments will receive a grade of 0.

Rubric feedback will be posted on Avenue, if after reviewing the guide you think that your assignment has a grading error, send an email to ibio3a03@mcmaster.ca detailing the error specifically and we will re-grade your work. Please keep in mind the following:

- Remember that we will re-grade the entire assignment, not just the criteria you have identified. If that re-grading yields a lower grade, we will not adjust your grade, but if it yields a higher one, we will.
- Questioning your grade will never result in a penalty for you.
- Regrading requests take longer to respond to than other emails because they are not as urgent as questions about work that has yet to be handed in. We appreciate your patience.

Course Delivery

Avenue-to-Learn will be the online management system for the course. Through **Avenue**, you will be able to:
- Find all course materials (lecture slides, assignment instructions, etc.)
- View course-related announcements
- Complete online quizzes
- Submit course work (assignment deliverables) for grading
- View your gradebook

Through **Microsoft Teams,** you will be able to:
- Attend virtual office hours and lecture backup in case of instructor illness

Communication Policy

All official class announcements and materials will be posted on the course Avenue site, not Teams. We will endeavour to provide extra reminders in lectures and on MS Teams. Please contact the instructor and TAs via their respective email addresses or by sending them a message in MS Teams via the corresponding MACID.

Office Hours

Please complete https://forms.office.com/r/MV1Jx7stKq by noon on Friday, September 8th, to help us determine office hours. Our goal is to offer office hours each day. You do not have to specifically come to the office hours of your tutorial section's TA.

"Office hours" are when the TAs and I plan to be available to work with students. You can come to get help with your assignment before you submit it, ask questions about something covered in the lecture, get advice on problems with your group, or anything else that you would like our help with.

Contact Guidelines

- Dr. Boursalie will be present at lecture
- A TA will be present at tutorials
- During the workday, we are fast with email, but slower in the evenings and on weekends. You can expect that email will generally be replied to within 24h, but please include the course code (IBEHS 3A03) in the subject line for the fastest response

- If you need to speak with Dr. Boursalie directly, you can talk to me in class, go to office hours in MDCL-3515/E, or make an appointment via email. Appointments outside office hours are very limited due to my heavy teaching schedule this term. Please use office hours as much as you can.
- We cannot "check" individual homework during office hours or by email because we can't do it for the whole class,it would be unfair. However, we are always happy to answer specific technical questions via email/Teams or during office hours.

Completion and Submission of Work

It is the student's responsibility to ensure assessments are correctly submitted to the correct location, on time, and in the specified format. DO NOT EMAIL work to Dr. Boursalie or the TAs, even if you miss the deadline. Out of fairness to the class, we never accept work via email or Teams, only via Avenue.

Assignments 1-3 Grace Period
Assignments 1-3 Grace period ends: 11:59 pm EST the following Friday (1 week)

Assignment 1-3 Grace period: no penalty, no need to email or MSAF; the Avenue dropbox will remain open.
- In general, I recommend that you try to complete the work as it is assigned. This is intended to help you keep a schedule and past students have indicated that handing in as scheduled is important to their success in the course.
- I implemented this policy because I want to grade your best work and care about your stress level.
- Use the grace period for any reason, no questions asked. If you think it's a good reason to hand in late, it probably is.
- This is intended for the big and little things that happen in all our lives from time to time: you have a minor illness, you don't want to miss your mom's birthday, you have to work at your job, your varsity team has a game, you have a midterm in another class, your laptop breaks, your internet is slow etc.
- Things that affect our ability to hand in work happen to all of us at some point, so I am extending you a bit of "grace" with this policy. In return, I ask that you do the same to your teammates and treat each other kindly as you work together.
- Please note: **At the end of the grace period, the dropbox will close, and any assignment not submitted will be considered late and will receive a zero**. If your internet breaks as you are handing in at the end of the grace period, that is unfortunate, but the end of the grace period is the end. Please hand in sooner to allow for that kind of problem; that's what the grace period is for.
- Any work handed in is eligible to be graded immediately. If multiple submissions are present, the most recent will be graded. However, no new submissions will be considered once work has been graded, even within the grace period.
- A MSAF results in an additional one week to complete your assignment, not cancellation of that work.

NO GRACE PERIOD on Lecture Participation, Assignment 4, Quizzes, Midterm and Final Exam.

All coursework MUST be handed in by 11:59 pm EST on December 6, 2023, no extensions.

Inclusive Environment Statement

We consider this classroom to be a place where you will be treated with respect, and we welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

We will gladly honour your request to address you by an alternate name or gender pronoun. Please advise of this preference early in the semester so that we may make appropriate changes to our records.

Course Objectives and Learning Outcomes (LO)

Upon successful completion of the course, the student should be able to:

LO.01	understand the concepts underlying analysis and visualisation of systems and signals commonly encountered in biomedical engineering
LO.02	derive mathematical expressions for the convolution of simple discrete time and continuous time signals
LO.03	apply mathematical operations such as the Fourier and Laplace transforms to signals and systems
LO.04	understand the properties of linear time-invariant (LTI) systems
LO.05	understand the frequency domain descriptions/analysis of continuous time signals and systems both periodic and non-periodic, e.g., working knowledge of Fourier series and Fourier transform analysis including their properties
LO.06	understand the Laplace transform and analysis of continuous-time systems using the transfer function representation
LO.07	use MATLAB to conduct basic analysis and visualisation of biomedical signals and systems

Accreditation

The Graduate Attributes defined in this section are measured for Accreditation purposes only and will not be directly taken into consideration in determining a student's actual grade in the course. For more information on Accreditation, please visit: https://www.engineerscanada.ca. Mapping of the course **Learning Outcomes (LO)** to the Canadian Engineering Accreditation Board (CEAB) **Graduate Attributes (GA)** are outlined in the table below:

GRADUATE ATTRIBUTE	LEARNING OUTCOME(S)
GA01 - Knowledge Base for Engineering	
1.1 – Competence in mathematics	able to derive mathematical expressions for the convolution of simple discrete time and continuous time signals
1.3 – Competence in Engineering Fundamentals	able to assess the properties of a discrete-time system through testing of responses to a range of system inputs
1.4 – Competence in Specialized Engineering knowledge	able to design digital filters to be applied for specific uses with real biomedical (physiological) signals
GA02 Problem Analysis	
2.2 – Proposes problem solutions supported by substantiated reasoning, recognizing the limitations of the solutions.	able to perform Fourier analysis on the frequency content of biomedical signals and interpret the results
GA05 Use of Tools	

5.2 – Successfully uses engineering tools.	able to use Matlab to conduct basic analysis and visualisation of biomedical signals and systems
GA12 Life-Long Learning	
12.2 – Seeks and acquires appropriate external information as required, including showing awareness of sources of information and ability to critically evaluate them.	able to learn about several different digital filter design methods through MATLAB help documentation and on-line tutorials

For more information on Accreditation, please visit: https://www.engineerscanada.ca

McMaster Approved Policy Statements

Conduct Expectations

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g., use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

Academic Integrity

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/

The following illustrates only three forms of academic dishonesty:
- Plagiarism, e.g., submission of work not one's own or which other credit been obtained.
- Improper collaboration in group work.
- Copying or using unauthorized aids in tests and examinations.

Authenticity / Plagiarism Detection

In this course we will be using a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. Students will be expected to submit their work electronically either directly to Turnitin.com or via Avenue to Learn (A2L) plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish to submit their work through A2L and/or Turnitin.com must still submit an electronic and/or hardcopy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com or A2L. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). To see the Turnitin.com Policy, please go to the following website: www.mcmaster.ca/academicintegrity.

Generative AI Use Prohibited

Students are not permitted to use generative AI in this course. In alignment with McMaster academic integrity policy, it "shall be an offence knowingly to … submit academic work for assessment that was purchased or acquired from another source". This includes work created by generative AI tools. Also state in the policy is the following, "Contract Cheating is the act of "outsourcing of student work to third parties" (Lancaster & Clarke, 2016, p. 639) with or without payment." Using Generative AI tools is a form of contract cheating. Charges of academic dishonesty will be brought forward to the Office of Academic Integrity.

Academic Accommodations for Students with Disabilities

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

Academic Accommodation for Religious, Indigenous, or Spiritual Observations (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation *or* to the Registrar's Office prior to examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Academic Accommodations for Relief for Missed Academic Work: McMaster Student Absence Form (MSAF)

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

- All MSAFs are to be directed to ibio3a03@mcmaster.ca. Sending to another email address will delay processing. **You will receive an MSAF flag on avenue grade section to verify your MSAF has been processed.**
- It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in his/her course.
    - An MSAF applied to a quiz result in an additional week to complete the quiz
    - An MSAF applied to an assignment result in an additional week to complete the assignment
    - An MSAF applied to the midterm the grade is shifted to the final exam
    - If an MSAF is applied to either the **Graphics Design Final Assessment** or **Computing Final Assessment**, they **will be rescheduled**.

Courses with an On-Line Element

In this course, we will be using **Avenue-to-Learn** and **Microsoft Teams**. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, usernames for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same

course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

Online Proctoring

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

Copyright and Recording

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

Reference to Research Ethics

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to https://reo.mcmaster.ca/.

Extreme Circumstances

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

Notice Regarding Possible Course Modification

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.

Integrated Biomedical Engineering & Health Sciences (IBEHS) Labs/Design Studio Safety

Information for Laboratory Safety and Important Contacts

This document is for users of IBEHS instructional laboratories at the following locations:
- ABB C104 (Design Studio)
- ETB 533 (Medical Imaging/Biomaterials Lab)
- ETB 534 (Medical Instrumentation/Robotics Lab)
- HSC 4N72 (Genetic Engineering Lab)

This document provides essential information for the healthy and safe operation of IBEHS instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in IBEHS. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

Details on Standard Operating Procedures (SOPs), Health and Safety videos and other resources can be found online at the iBioMed Health and Safety webpage.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:
- Food and beverages are not permitted in the instructional laboratories.
- A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
- Laboratory equipment should only be used for its designed purpose.
- Proper and safe use of lab equipment should be known before using it.
- The lab tech or course TA leading the lab should be informed of any unsafe conditions.
- The location and correct use of all available safety equipment should be known.
- Potential hazards and appropriate safety precautions should be determined, and the sufficiency of existing safety equipment should be confirmed before beginning new operations.
- Proper waste disposal procedures should be followed.
- Personal ergonomics should be practiced when conducting lab work.
- Current University health and safety issues and protocols should be known.

Location of Safety Equipment

Fire Extinguisher: on walls in halls outside of labs or within labs

First Aid Kit: ABB C104, ETB 533, ETB 534, HSC 4N72 or dial "88" after 4:30 p.m.

Telephone: on the wall of every lab near the door

Fire Alarm Pulls: Near all building exit doors on all floors

Who to Contact?

Emergency Medical / Security:

On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.

Hospital Emergency Medical / Security:

For McMaster HSC, call Security at extension **5555** or **905-521-2100** from a cell phone.

Non-Emergency Accident or Incident: Immediately inform the Lab Tech, TA on duty or Course Instructor.

University Security (Enquiries / Non-Emergency):

Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.

See Lab Tech, TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs.

Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.

IBEHS Specific Instructional Laboratory Concerns: For non-emergency questions specific to the IBEHS laboratories, please contact appropriate personnel below from a McMaster phone:

- Leela Pilli, Laboratory Technician – 26888
- Parmveer Bola, Instructional Assistant – 23521
- Andrej Rusin, Wet Laboratory Technician – 28347
- Alexa Behar-Bannelier, Program Manager – 24548

In Case of a Fire (Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people.
1. Douse with water from safety shower immediately or
2. Roll on the floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if a blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents. Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:
1. Immediately discontinue use of the equipment.
2. In Power Lab, press the wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you are not sure, ask!

Defined Roles

IBEHS Lab Technician	Leela Pilli, pillil@mcmaster.ca
IBEHS Instructional Assistant	Parmveer Bola, bolap1@mcmaster.ca
IBEHS Wet Lab Technician	Andrej Rusin, rusina@mcmaster.ca
IBEHS Co-Directors	Dr. Colin McDonald, cmcdona@mcmaster.ca Dr. Michelle MacDonald, macdonml@mcmaster.ca
IBEHS Program Manager	Alexa Behar-Bannelier, alexa.behar@mcmaster.ca
IBEHS Course Instructor	Please contact your specific course instructor directly