IBEHS 3A03

Biomedical Signals and Systems

Fall 2025

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: Monday 11:30 am – 12:20 pm, Wednesday 11:30 am – 12:20 pm, & Friday 1:30 – 2:20 pm

Echo360 lecture capture will be used to stream lectures, and recordings will be linked automatically on Avenue. However, regular in-person attendance is highly recommended for the best learning opportunity.

Tutorial: T01 – Monday 10:30 – 11:20 am; T02 – Thursday 11:30 am – 12:20 pm; T03 – Tuesday 10:30 – 11:20 am; T04 – Wednesday 9:30 – 10:20 am

Tutorials will NOT be streamed or recorded. Please attend tutorials regularly.

[See Avenue to Learn site or MOSAIC for classroom locations]

Instructor Office Hours and Contact Information

Dr. Ian C. Bruce
brucei@mcmaster.ca

Office Hours:

- In-person or on-line, by appointment

Instructional Team

TA contact details will be provided on Avenue to Learn site

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, lab materials, project documents, etc.)
- View course-related announcements
- Complete online quizzes
- Submit course work (assignment, project deliverables) for grading
- View your gradebook

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

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

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%**

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. ***Failure to correctly submit an assignment will result in a mark deduction***.

MSAF Policy

Midterm Exam – If a student applies an MSAF to the Midterm Exam, then the assessment weight will be shifted to the Final Exam and Class Participation Exercises.

On-Line Quizzes – If a student applies an MSAF to an On-Line Quiz, then the assessment weight will be shifted to the other On-Line Quizzes.

Assignments – If a student applies an MSAF to an Assignment, then a 5-day deadline extension will be granted for that Assignment. Only one student per group needs to submit an MSAF for it to be applied to the entire group.

Use of AI tools in the course.

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.

Important Dates

Fall Term	
Tuesday, September 2	Fall Classes Begin!
Tuesday, September 30	**National Day for Truth and Reconciliation (no classes)**
October 13 – 19	**Fall Reading Week (no classes)**
Thursday, December 4	Fall Classes End
December 6 – 19	**Fall Term Examinations**

Course Overview

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

Communication Policy

All official class announcements will be made on the course Avenue site. We will also 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.

Please see the *Communicating with Professors* document for guidelines on how to communicate appropriately with the instructional team: https://libguides.mcmaster.ca/c.php?g=718526&p=5176620

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.

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

CEAB Accreditation Units: Engineering Science 100%

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.

On all work submitted for credit by students at McMaster University, the following pledge is either required or implied: *"I understand and believe the main purpose of McMaster and of a university to be the pursuit of knowledge and scholarship. This pursuit requires my academic integrity; I do not take credit that I have not earned. I believe that academic dishonesty, in whatever form, is ultimately destructive to the values of McMaster, and unfair to those students who pursue their studies honestly. I pledge that I completed this assessment following the guidelines of McMaster's academic integrity policy."*

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.

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 brucei@mcmaster.ca. Sending to another email address will delay processing.
- It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in his/her course.
    - See the subsection *MSAF Policy* on p. 3 of this course outline for details of how MSAFs will be applied in this course.

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.

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. At McMaster University, HR maintains Health & Safety information that is also available at https://hr.mcmaster.ca/employees/health_safety_well-being/our-safety/lab-safety/.

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