

IBEHS 4QZ3
Modelling of Biological Systems
Fall 2021
Course Outline

COURSE DESCRIPTION

Introduction to experimental design and variance associated with biological systems and analysis of biological data, mathematical and engineering methods for describing and predicting the behaviour of biological systems, statistical models of biological functions as well as machine learning techniques.

COURSE SCHEDULE

Lectures: Online (IBEHS 4QZ3 Teams Lecture Channel)
Tutorials: BSB 137 Wednesdays 1:30-2:20

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): Registration in the Integrated Biomedical Engineering and Health Sciences (IBEHS) program
Antirequisite(s): ELECENG 4BC3

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Taylor deVet, MAsc.

McGill University/Shriners Hospital for Children Montreal
devett@mcmaster.ca

Office Hours:

Friday 10:30-12:30
Or by appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

Noor Abu Jarad

abujaran@mcmaster.ca

Andrew Lofts

loftsa@mcmaster.ca

Office Hours:

TBA

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

All course lecture and tutorial materials will be available on <http://avenue.mcmaster.ca>

COURSE OBJECTIVES

The purpose of this course is to understand mathematical approaches to modelling biological systems and the challenges associated with it. Linear time invariance (LTI) will be discussed as it applies to biological modelling. The short comings of LTI will be described and a thorough analysis using other approaches including short-time Fourier transform (STFT) wavelets, PCA/ICA and nonlinear dynamics (fractal and chaotic models). Real life examples will be presented using real data acquired from various imaging and physiological recording systems, and students will be able to identify which modelling systems work best for data types.

MATERIALS AND FEES

Required Texts:

There is no one book to cover all the material for this course. Necessary papers and readings to complement the course material will be posed to the course website as suggested readings. The following texts may be helpful:

Modeling and Simulation in Medicine and the Life Sciences 2nd Edition – Frank Hoppensteadt, Charles S. Peskin

Dynamic Systems, Biology Modeling and Simulation – Joseph DiStefano III

Bio signal and Medical Image Processing 3rd Edition - John L. Semmlow, Benjamin Griffel

Physiological Control Systems – Michael C.K. Khoo

Lecture Information: All lecture notes will be posted on the course web page the day before lecture.

NOTE: This course (this year) will run on a hybrid online format. Lectures will be presented synchronously, with subsequent lecture videos posted on the class Avenue page. Tutorials will be held in person, taught by Teaching Assistants.

Both Taylor and the TAs will often use a 'virtual white board' in lectures / tutorials. Students will also be responsible for understanding any such materials detailed on the board.

Calculator:

Only the McMaster Standard Calculator will be permitted in tests and examinations. This is available at the Campus Store.

Other Materials:

Throughout the course references to numerous texts and research review articles will be provided. All material is available in the McMaster Library system, or has been validated as open source.

COURSE OVERVIEW

Date/Week	Topic	Readings
1	Advantages and disadvantages of models, building models Variance and error in biological system	
2	Statistical analysis, Regression, Experimental Design	
3	CRD RCB, Post Hoc Testing	
4	Cardiac Modelling . introduction to pharmacokinetic modelling and drug delivery routes	

5	Midterm Recess
6	Indicator dilution, diffusion, contrast agents and other tracers used for assessing microvascular and metabolic kinetics.
7	Multivariate approaches to biological data analysis (e.g. PCA and ICA)
8	Chronobiology; cosinor analysis, LTI systems
9	Fourier Transforms vs short time FT vs Wavelets
10-11	Nonlinear dynamics, fractal processes, power law scaling, chaos, Logistic equations, phase space, attractors
12-13	Machine Learning in biological systems **Half lectures with half student presentations

ASSESSMENT

Component	Weight
Assignment #1 (due Oct 3 rd , 2021, at 11:59pm)	5%
Assignment #2 (due Oct 17 th , 2021, at 11:59pm)	5%
Midterm (October 19 – 22 nd , 2021) (open for 3 days, given 6 hrs to complete)	20%
Assignment #3 (due November 7 th , 2021 at 11:59 pm)	5%
Assignment #3 (due November 21 st 2021 at 11:59 pm)	5%
Analysis Project & Presentation (due Dec. 8 th , 2021 at 11:59pm)	25%
Weekly quizzes (0.5% each, drop 2)	5%
Final Exam (Similar format to midterm, date TBD)	30%
Total	100%

Assignments

Assignments will be done individually and will cover lecture and tutorial content. Assignments will require programming in Matlab or Python.

NOTE 1: assignments are due digitally (i.e., upload to Avenue) at 11:59pm on the due date. Late assignments will be deducted **0.01389% per minute**.

NOTE 2: No make-up assignments will be granted. The entire weight of missed material will be transferred to the final exam.

Midterm and Final Exam

The exams will cover everything up to the end of the lecture 1 week prior. The final exam will cover all course materials after the midterm. Both the final and midterm exams will be open book. These will be a combination of multiple choice, short answer, and coding problems. They will be delivered as quizzes on avenue. Once started the midterm should take ~2.5 hours but students will be given 6 hours to complete all quiz questions and submit their quiz, as well as a pdf of any rough work they wish to be included for any of the sections. If a multiple choice or short answer question is incorrect, it may be possible to gain part marks from this. A teams channel will be used to answer questions during the midterm period.

Weekly Quizzes

Weekly quizzes will cover the previous weeks lecture content to ensure students are keeping up with and understanding content. The two lowest marked quizzes will be dropped, making each quiz worth 0.5%.

Analysis Project

Students will be required to complete a major data modeling and analysis project. These will be done in *groups of up to 3 students*, but can be done individually if desired. The data can be anything physiological/biological in nature. There are numerous sites on the internet that are repositories of biological/medical data. It is suggested data from one of these sites be downloaded and used. The report will include an introduction about the data and why it might be important. Analysis will include modeling of some form of response and how this was determined as appropriate, proper statistical analysis from multiple subjects and error analysis where appropriate. The report should end with interpretations, conclusions, and possible future directions. The report should be 2000-3000 words and include figures, program code, etc. It should look like a journal paper. To conclude the project each group will do a 15 minute presentation on their project for the class in lecture in week 12 or 13 (November 29 or Dec 3). The project is mandatory and cannot have its weight transferred to the exam via an MSAF form.

ACCREDITATION LEARNING OUTCOMES
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The Learning Outcomes 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.

Outcomes	Indicators
To be able to design a mathematical model for a biomedical or biological problem. To understand how to test the model using computational approaches, mock systems and real-life scenarios	2.1
To be able to decide upon best mathematical models to investigate a real biological or biomedical problem. Be able to identify ways to simplify model by way of logical choices of assumptions. To know when to use model or data driven approaches.	3.2
To be able to classify and characterize sources of error in biological models. Understand error propagation and sources of error in bio systems.	3.3
Students will be required to complete a major data modeling and analysis project. These will be done in groups of up to 4 students.	6.3
To understand complex systems (chaos theory, temporal and spatial fractals) and how they relate to biological modeling. To understand how complex systems relate to biomedical and environmental problems. Viral/bacterial spreading sustainability of herds/food sources- epidemiology.	9.1

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

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all 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., the submission of work that is not one’s own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g., A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic**

integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to <https://www.mcmaster.ca/academicintegrity/>.

ACADEMIC ACCOMMODATION OF 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 OBSERVANCES (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 their 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 TERM 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. In most cases an extension will be granted in lieu of moving the weight to the examination. The research project is **mandatory** and can not have its weight moved to the exam.

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 us of this preference early in the semester.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g., e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names 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 a course that uses on-line elements 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.

For Standard Operating Procedures (SOPs), Health and Safety videos and other resources, follow [this link](#).

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

TA	The first point of contact for lab supervision	
IBEHS Lab Technician	Leela Pilli	pillil@mcmaster.ca
IBEHS Instructional Assistant	Parmveer Bola	bolap1@mcmaster.ca
IBEHS Wet Lab Tech	Andrej Rusin	rusina@mcmaster.ca
IBEHS Co-Directors	Dr. Greg Wohl Dr. Michelle MacDonald	wohlg@mcmaster.ca macdonml@mcmaster.ca
IBEHS Program Manager	Alexa Behar-Bannelier	alexa.behar@mcmaster.ca
IBEHS Course Instructor	Please contact your specific course instructor directly	