

## **IBEHS 4A03**

### **Biomedical Control Systems**

Winter 2021 Course Outline (WIP)

#### **FORMAL CALENDAR DESCRIPTION**

IBEHS 4A03 focuses on the modelling of control systems in the continuous-time domain; state space representations; model linearization; performance of control systems in time and frequency domains; stability; control design. Particular emphasis will be given to biomedical and engineering applications.

#### **INFORMAL COURSE DESCRIPTION**

Control systems are everywhere, from the furnace in your home, to cruise control in a commercial airliner, to the pressure and temperature regulation of a pharmaceutical bioreactor, to the many control systems working to achieve homeostasis in the human body. This course will investigate how these systems work, and how this understanding will allow us to engineer solutions for industries, patients, and everything in-between.

#### **PRE-REQUISITES AND ANTI-REQUISITES**

Prerequisite(s): IBEHS 3A03

Antirequisite(s): ELECENG 3CL4, MECHENG 4R03, CHEMENG 3P04

#### **INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION**

**Dr. Jake Nease**  
BSB B105  
[neasej@mcmaster.ca](mailto:neasej@mcmaster.ca)  
ext. 27337

**Office Hours:**  
TBD (Dedicated to 4A03)  
TBD (Open to all courses)  
Or by appointment (If the door is open, I'm available!)

#### **TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION**

**TBD**  
JHE TBD  
[someone@mcmaster.ca](mailto:someone@mcmaster.ca)  
ext. >9000

**TBD**  
JHE TBD  
[someone@mcmaster.ca](mailto:someone@mcmaster.ca)  
ext. >9000

**TBD**  
JHE TBD  
[someone@mcmaster.ca](mailto:someone@mcmaster.ca)  
ext. >9000

**Office Hours:**  
TBD

#### **COURSE WEBSITE**

IBEHS 4A03 will use Avenue to Learn as the primary repository for notes, assignments, tutorial activities, and grades. Grades posted on Avenue to Learn are unofficial until posted on MOSAIC. Students can log in via the link:

<http://avenue.mcmaster.ca/>

## COURSE LEARNING OBJECTIVES

By the end of this course, students should be able to:

- Identify the fundamental components of linear and nonlinear dynamic models with biomedical and industrial applications.
- Apply linearization methods to achieve locally linear dynamic models.
- Apply Laplace and Inverse-Laplace transforms to convert between time-domain and frequency-domain models as appropriate.
- Perform fundamental open-loop analyses of dynamic systems to assess stability, damping effects, disturbances, and time delays.
- Build closed-loop block diagrams of dynamic systems.
- Design and implement controllers for a variety of biomedical and industrial systems.
- Assess the performance of common control methods such as proportional, proportional-integral, and proportional-integral-derivative and comment on their appropriateness given the application.
- Perform stability analyses on closed-loop systems and comment on an appropriate control structure to optimize performance.
- Convert a linear(ized) time-domain model to state-space representation.
- Identify the parameters of linear models in state-space form using appropriate model fitting techniques.

## MATERIALS AND FEES

### Required Texts:

There is no required textbook for this course.

### Calculator:

Students are welcome to use any calculator desired.

### Other Materials:

This course will require the use of MATLAB and SIMULINK. A full version of MATLAB with SIMULINK is available to McMaster students from the Mathworks website: <https://www.mathworks.com/products/matlab/student.html>

## COURSE OVERVIEW

IBEHS 4A03 will follow the following list of topics as closely as possible. Note that the instructor reserves the right to change the order and coverage of topics as they feel appropriate and possibly even at the request of the class.

Date/Week	Topics covered (subject to change!)
<b>Week 01</b>	Introduction; Review of biomedical control applications; math review
<b>Week 02</b>	Model building from first principles; Linearization; Introduction to Laplace transforms
<b>Week 03</b>	Laplace transforms; Transfer functions; Inverse Laplace Transforms; Partial fractions review
<b>Week 04</b>	Transfer function characteristics; Damping; Stability analyses; Poles and zeros
<b>Week 05</b>	Block diagram representations; Block diagram algebra; Closed loop systems
<b>Week 06</b>	Stability of closed loops; Introduction to feedback control
<b>Week 07</b>	Feedback controller performance; P, PI, and PID control

<b>Week 08</b>	Closed loop stability of controlled systems; Routh-Hurwitz test; Pole placement
<b>Week 09</b>	Controller tuning and performance; Introduction to feed-forward control
<b>Week 10</b>	Feedforward control; Model identification
<b>Week 11</b>	State space representation; Multi-input/Multi-output systems
<b>Week 12</b>	Model identification using state space notation; Loop pairing; Interacting systems
<b>Week 13</b>	Review and wrapup

#### ASSESSMENT

Component	Weight
TBD (C19 Dependent)	#%
TBD (C19 Dependent)	#%
TBD (C19 Dependent)	#%
Total	100%

#### ACCREDITATION LEARNING OUTCOMES

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
<b>1: Engineering Knowledge Base</b>	1.1: Knowledge of engineering mathematics 1.3: Knowledge of fundamental engineering sciences
<b>7: Use of Engineering Tools</b>	

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 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. 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 [www.mcmaster.ca/academicintegrity](http://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](mailto: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

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.

#### 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.

The instructor is certified with the McMaster Professor Hippo on Campus Program for mental health awareness and aid to students in need. My office (or online video portal) is a **safe space** to discuss issues both academic and otherwise, and you are welcome to contact me at any time to chat. If I reach out to you at any time, be aware that it is not to embarrass or penalize you; it is because I care.



#### 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.

#### REQUESTS 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”.

#### 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.