Toronto Metropolitan University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Outline (F2023)

BME532: Signals And Systems I

Instructor(s)	Dr. Dafna Sussman [Coordinator] Office: Phone: (416) 979-5000 x 553767 Email: dafna.sussman@torontomu.ca Office Hours: Wednesday 12-1pm by appointment only
Calendar Description	This course deals with the analysis of continuous-time and discrete-time signals and systems. Topics include: representations of linear time-invariant systems, representations of signals, Laplace transform, transfer function, impulse response, step response, the convolution integral and its interpretation, Fourier analysis for continuous-time signals and systems and an introduction to sampling.
Prerequisites	CEN 199, BME 434
Antirequisites	ELE 532
Corerequisites	None
Compulsory Text(s):	1. B.P. Lathi, Linear Systems and Signals, 3rd edition, Oxford University Press, 2018. 2. Laboratory MATLAB assignment descriptions and procedures, and assignment problems are available from the course home page on D2L Brightspace via my.torontomu.ca.
Reference Text(s):	1. M. J. Roberts, Signals and Systems: Analysis Using Transform Methods and MATLAB, McGraw Hill, 2004. 2. Signals and Systems, A.V. Oppenheim, A.S. Willsky, S.H. Nawab, 2nd edition, Pearson, 1997.
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: 1. Review Complex Numbers, Euler's Equation, and Sinusoidal signals and tie those to signal decomposition. Learn linear signal operations and apply them to a variety of linear systems. Learn Fourier series and transforms and underlying math, and apply them in analyzing continuous time signals. Learn about Laplace transform and the underlying math, and use it to analyze solutions to differential equations. (**1c**) 2. Learn important signal and system classifications for further processing. For example if a system is Linear and Time invariant, then the output of the system to all inputs can be predicted using the impulse response and using convolution. (**3a**) 3. Learn frequency analysis of continuous-time signals and LTI systems and describe differences between Fourier transform and Fourier series analysis. Perform both Fourier transform and Fourier series in hypothetical design and analysis of signals and LTI systems. Analyze result of evaluation to detect if a continuous-time system is Linear Time-Invariant (LTI). To discern additional criteria. In case the system is LTI, additional characteristic of the system (impulse response of the system) is calculated to facilitate calculation and evaluation of the system's output. (**4b**) 4. Select and perform strategies to generate information about continuous-time signals (properties such as power or energy finiteness) and systems (properties such as linearity,

stability, causality) that may be used to modify, improve, or elaborate a design state. (**4c**)
5. Understanding system property and limitation, fundamental problems in sampling. Learning the role of important signals such as sinc and delta and role of them in system design and analysis. (**5a**)
6. Read and appropriately respond to technical and non-technical written instructions. Cites evidence to construct and support an argument. Produce four lab reports using appropriate format, grammar, and citation styles for technical and non-technical audiences. (**7a**)
7. Illustrate concepts of continuous-time signals and systems through graphical presentation of their properties. (**7c**)
8. Finding relationship between signals, building a signal based on other existing basis, signal modulation and its practical issues that can be well explained with the theory. (**12a**)

NOTE:*Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).*

Course Organization

3.0 hours of lecture per week for 13 weeks
2.0 hours of lab per week for 12 weeks
0.0 hours of tutorial per week for 12 weeks

Teaching Assistants

Karl Magtibay: karl.magtibay@torontomu.ca
Aayush Chakravartti: aayush.chakravartti@torontomu.ca
Alex Dunn: a1dunn@torontomu.ca

Lab section #	Day	Time	Location	TA Name
1	Thursday	10:00AM - 12:00PM	ENG409	Aayush Chakravartti
2	Wednesday	12:00PM - 2:00PM	ENG409	Aayush Chakravartti
3	Tuesday	2:00PM - 4:00PM	ENG408	Karl Magtibay
4	Tuesday	2:00PM - 4:00PM	ENG409	Alex Dunn
5	Monday	2:00PM - 4:00PM	ENG408	Karl Magtibay

Course Evaluation

Theory	
Quizzes (5 X 4%)	20 %
Midterm Examination	25 %
Final Examination	35 %
Laboratory	
Laboratory Assignments (4 X 5%)	20 %
TOTAL:	100 %

Note: In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both **"Theory and Laboratory"** components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the **"Course Evaluation"** section above for details on the Theory and Laboratory components (if applicable).

Examinations

- Bi-weekly 30-minute quizzes will be administered via D2L every 2 lecture-weeks.

- Midterm will be a 2-hour closed-book exam on Wednesday October 18th during the lecture session (10am-12pm), covering all material previously covered (lectures 1-6).

- Final exam, during exam period, will be a 3-hour closed-book exam, covering all course material with emphasis on the content covered after the midterm.

Other Evaluation Information	- The theoretical lecture material is provided ahead of each lecture in the form of PDF notes and recorded video modules. Students are required to view and download these lecture notes (viewing the recorded videos is not mandatory). - Lab marks are based on attendance, participation (showing your work, answering TA questions), successful completion of pre-lab problems, completion of experiment steps, lab reports and successful reply to your TA questions during submission. Students will have the responsibility to achieve a working knowledge of the software packages that will be used in the lab. - Students will complete their lab work in pairs and submit their individual reports through a D2L lab submission link. - Any concerns about the labs or quizzes should first be addressed to the TAs prior to contacting the course instructor.
Teaching Methods	- This course will be delivered using asynchronous teaching, aka flipped classroom approach, where the theoretical material will be posted online ahead of time and the lecture sessions will be dedicated to going over the theory, practicing hands-on problem solving, and discussing real-life applications.
Other Information	* Note that not all material covered during the lecture time will be posted online. Students are responsible for the material covered in class and in the labs. As such, students are encouraged to attend the lectures and not solely rely on the pre-recorded lectures. * Attendance in the lab is mandatory - work done at home independently will not be graded.

Course Content

Week	Hours	Chapters / Section	Topic, description
1 & 2	6		Signals and Systems Representations Size of a signal: signal energy and power useful signal operations: time-shifting, time scaling, time reversal, combined operations, classification of signals: linear systems, time-invariant systems, linear and time-invariant continuous-time (LTIC) systems, useful signal models: unit step function, unit impulse function, exponential function, even and odd functions, continuous-time systems, classification of systems, internal and external descriptions of a system. (Reference: Chapter 1 Sections 1.1-1.7)
3-5	9		Time-Domain Analysis of Continuous-Time Systems System response to internal conditions: the zero-input response, the unit impulse response, system response to external response: zero-state response, the convolution integral, interconnected systems, total system response, classical solution to differential equations: forced response, the method of undetermined coefficients, system stability: internal (asymptotic) stability, BIBO stability, criterion relationship between BIBO and asymptotic stability, intuitive insights into system behavior. (Reference: Chapter 2 Sections 2.1-2.6 and 2.8-2.9)

6 & 7	4		Continuous-Time Signal Analysis: The Fourier Series Periodic signal representation by trigonometric Fourier series existence and convergence of Fourier series exponential Fourier series LTIC system response to periodic inputs. (Reference: Chapter 6 Sections: 6.1-6.4)
7	2		Midterm Exam
8 & 9	6		Continuous-Time Signal Analysis: The Fourier Transform Aperiodic signal representation by Fourier integral Fourier transforms of some useful functions properties of the Fourier transform signal transmission through LTIC systems ideal and practical filters signal energy application to communications. (Reference: Chapter 7 Sections 7.1-7.9)
10 & 11	6		Sampling: Discrete-Time Signals Introduction to Sampling theorem signal reconstruction. (Reference: Chapter 8 Sections 8.1-8.2)
12	2		Introduction to Sampling theorem signal reconstruction. (Reference: Chapter 8 Sections 8.1-8.2)
12 & 13	7		The Laplace Transform The Laplace transforms, properties of the Laplace transform, solution of differential equations: zero-state response, stability, inverse systems, analysis of electric networks, block diagrams, system realizations, application to feedback and control, the frequency response of an LTIC system. (Reference: Chapter 4 Sections 4.1-4.2 4.4 and 4.6)

Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
2	T	Tutorial 1: Introduction to MATLAB It is very important to attend the MATLAB tutorial scheduled for Week 2 and inform your TA of your lab partner.
3 & 4	L	Lab 1: Signals and Systems Representation

		In this experiment, you will work with simple MATLAB functions and will explore some signal properties.
5 & 6	L	Lab 2: Time-Domain Analysis of CT Systems In this experiment, you will learn how to use m-files in MATLAB and exercise convolution and system properties.
8	T	Tutorial 2: Midterm Review Examples Problems from the course textbook and quizzes will be discussed
10 & 11	L	Lab 3: The Fourier Series The purpose of this experiment is to investigate the Fourier Series while continuing to learn how to use MATLAB effectively. General Fourier series characteristics will be investigated and MATLAB functions that work with Fourier series will be developed. Also, the effects on the Fourier series coefficients due to changing the period of a periodic signal will be investigated along with the effects of series truncation on signal reconstruction.
12 & 13	L	Lab 4: The Fourier Transform In this experiment, you will investigate the properties of the Fourier transform. You will use Fourier Transform to analyze dual-tone multi-frequency (DTMF) signals used in telephone signaling.
14	T	Tutorial 3: Final Exam Review Examples Problems from the course textbook and quizzes will be discussed

University Policies

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the Senate website

Important Resources Available at Toronto Metropolitan University

- The Library provides research workshops and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or students can use the Library's virtual research help service to speak with a librarian.
- Student Life and Learning Support offers group-based and individual help with writing, math, study skills, and transition support, as well as resources and checklists to support students as online learners.

- You can submit an Academic Consideration Request when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the Senate website and select the blue radio button on the top right hand side entitled: Academic Consideration Request (ACR) to submit this request.

  For Extenuating Circumstances, Policy 167: Academic Consideration allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences

more than 3 days in duration and those that involve a final exam/final assessment, require documentation. Students must notify their instructor once a request for academic consideration is submitted. See Senate Policy 167: Academic Consideration.

- If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The Remote Learning Guide for students includes guides to completing quizzes or exams in D2L Brightspace, with or without Respondus LockDown Browser and Monitor, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
- Information on Copyright for Faculty and students.

Accessibility

- Similar to an accessibility statement, use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic accommodation regardless of program or course load.

- Learn more about Academic Accommodation Support.
- Learn how to register with AAS.

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about Academic Accommodations versus Academic Consideration and how to access each.

Wellbeing Support

At Toronto Metropolitan University, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:

- **Distress Line:**24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk:**24/7-hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via My SSP app or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- **Centre for Student Development and Counselling:** 416-979-5195 or email csdc@torontomu.ca
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email osvse@torontomu.ca
- **Medical Centre:** call (416) 979-5070 to book an appointment

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the Toronto Metropolitan University Mental Health and Wellbeing website.