

Course Outline (F2025)

BME532: Signals And Systems I

Instructor(s)	Dr. Dafna Sussman [Coordinator] Office: ENG317 Phone: (416) 979-5000 x 553767 Email: dafna.sussman@torontomu.ca Office Hours: Monday 12-1pm By appointment
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	EES 604, CEN 199
Antirequisites	ELE 532
Corerequisites	None
Compulsory Text(s):	<ol style="list-style-type: none"> 1. P. P. Vaidyanathan - Signals, Systems, and Signal Processing - California Institute of Technology, ISBN: 9781009412292 (Hard Cover: \$97.95 from Amazon.ca) or 9781009412285 (eBook: \$94.62 from VitalSource) Published 2024 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):	<ol style="list-style-type: none"> 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)	<p>At the end of this course, the successful student will be able to:</p> <ol style="list-style-type: none"> 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
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Teaching Assistants	TBA
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Course Evaluation	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: left;">Theory</th> </tr> </thead> <tbody> <tr> <td>Quizzes (3 X 5%)</td> <td style="text-align: right;">15 %</td> </tr> <tr> <td>Midterm Examination</td> <td style="text-align: right;">25 %</td> </tr> <tr> <td>Final Examination</td> <td style="text-align: right;">40 %</td> </tr> <tr> <th colspan="2" style="text-align: left;">Laboratory</th> </tr> <tr> <td>Laboratory Projects (4 X 5%)</td> <td style="text-align: right;">20 %</td> </tr> <tr> <td>TOTAL:</td> <td style="text-align: right;">100 %</td> </tr> </tbody> </table> <p>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).</p>	Theory		Quizzes (3 X 5%)	15 %	Midterm Examination	25 %	Final Examination	40 %	Laboratory		Laboratory Projects (4 X 5%)	20 %	TOTAL:	100 %
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Examinations	<ul style="list-style-type: none"> - Quizzes are scheduled on Week 4, 9, and 13, approximately 20-30 minutes, during the last 30min of the lab. - Midterm Exam is in Week 8, two and half hours, problem-solving, during the regular lecture hours (covers Weeks 1-7 of lecture notes). - Final Exam is scheduled during the undergraduate exam period (covers all course material with emphasis on the material not covered on the midterm).
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Other Evaluation Information	- The lab marks are based on attendance, successful completion of pre-lab problems, participation, and completion of experiment steps, lab interviews, and lab reports. Students will have the responsibility to achieve a working knowledge of the software packages that will be used in the lab. Students will work in groups of two.
Other Information	None

Course Content

Week	Hours	Chapters / Section	Topic, description
1 & 2	6	1.1-1.4, 2.1-2.7	<p>This course introduces fundamental concepts in signal processing, starting with the basic definition and characteristics of signals. The size of a signal is quantified by its energy and power, which helps classify it. We can also manipulate signals using operations like time-shifting, time scaling, and time reversal. Signals can be classified into different categories, such as continuous-time vs. discrete-time, and periodic vs. aperiodic. Other classifications include causal, non-causal, and anti-causal signals. The course also introduces useful signal models, including the unit step function, unit impulse function, and exponential functions, which serve as building blocks for more complex signal analysis.</p> <p>(Homework Problems: 2.3-2.6,2.9-2.10)</p>
3-5	9	2.8-2.15, 3.1-3.7	<p>Time-domain analysis of continuous-time systems involves several key concepts. The zero-input response is the system's output due to its initial internal conditions, while the zero-state response is the system's output to external inputs. The total system response is the sum of these two. The convolution integral is a fundamental tool used to find the zero-state response, and it relies on the system's unique unit impulse response, which is its output when the input is a unit impulse. The analysis of linear time-invariant (LTI) systems is a core focus because their properties of linearity and time-invariance simplify calculations and predictions. Finally, the course also addresses system stability, distinguishing between internal (asymptotic) stability and BIBO (bounded-input bounded-output) stability and exploring the important relationships between them.</p> <p>(Homework Problems: 2.13-2.14, 2.16)</p>
6 & 7	6	3.8-3.14, 9.1-9.4	<p>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.</p> <p>(Homework Problems: 3.21,3.24,9.1-9.4)</p>

8	3		Midterm Exam
9 & 10	6	11.1-11.13	<p>The Fourier transform is a powerful tool for analyzing aperiodic signals, which are represented by the Fourier integral. This analysis involves understanding the Fourier transforms of some useful functions and the key properties of the Fourier transform. The Fourier transform is also used to study signal transmission through LTIC systems and to design ideal and practical filters. A signal's energy can be determined in the frequency domain using the Fourier transform, which has important applications in communications.</p> <p>(Homework Problems: 11.1-11.21)</p>
11	3	10.1-10.4	<p>Applications of Fourier transform properties, including how they are used to analyze signals and design systems like bandpass filters, which selectively allow a certain range of frequencies to pass through. The module also introduces the Laplace transform, which extends the Fourier transform's capabilities to a broader class of signals. A key concept for the Laplace transform is the Region of Convergence (ROC), which defines the set of complex numbers for which the transform integral exists and converges.</p> <p>(Homework Problems: 10.1,10.3-10.12)</p>
12 & 13	6	13.1-13.4	<p>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.</p>

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

Week	L/T/A	Description
2	T	<p>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.</p>
3 & 4	L	<p>Lab 1: Signals and Systems Representation In this experiment, you will work with simple MATLAB functions and will explore some signal properties.</p>

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.
7 / 8 (Monday section)	T	Tutorial 2: Midterm Review Examples Problems from the course textbook and quizzes will be discussed
9 & 10	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.
11 & 12	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.
13	T	Tutorial 3: Final Exam Review Examples Problems from the course textbook and quizzes will be discussed

University Policies & Important Information

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](#)

Refer to the [Departmental FAQ page](#) for further information on common questions.

Important Resources Available at Toronto Metropolitan University

- [The University Libraries](#) provide research [workshops](#) and individual consultation appointments. There is a drop-in Research Help desk on the second floor of the library, and students can use the [Library's virtual research help service](#) to speak with a librarian, or [book an appointment](#) to meet in person or online.
- [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, always require documentation. Students must

notify their faculty/contract lecturer once a request for academic consideration is submitted. See Senate [Policy 167: Academic Consideration](#).

Longer absences are not addressed through Policy 167 and should be discussed with your Chair/Director/Program to be advised on next steps.

- [FAQs Academic Considerations and Appeals](#)
- Information on Copyright for [Faculty/Contract Lecturers](#) and [students](#).

Lab Safety (if applicable)

Students are to strictly adhere and follow:

- a. The Lab Safety information/guidelines posted in the respective labs,
- b. provided in their respective lab handouts, and
- c. instructions provided by the Teaching Assistants/Course instructors/Technical Staff.

During the lab sessions, to avoid tripping hazards, the area around the lab stations should not be surrounded by bags, backpacks etc, students should place their bags, backpacks etc against the walls of the labs and/or away from their lab stations in such a way that it avoids tripping hazards.

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](#).
- Learn about [Policy 159: Academic Accommodation of Students with Disabilities](#)

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.