McGill
Faculty of Engineering

Course Outline

ECSE 206

Course Title:	**Introduction to Signals and Systems**
Credits:	**3**
Contact Hours:	**(3-2-4)**
Course Prerequisite(s):	**ECSE 200**
Course Corequisite(s):	**N/A**
Course Description:	**Review of complex functions. Discrete-and continuous-time signals, basic system properties. Linear time-invariant systems, convolution. Fourier series and Fourier transforms, frequency-domain analysis, filtering, sampling. Laplace transforms and inversion, transfer functions, poles and zeros, solutions of linear constant-coefficient differential equations, transient and steady-state response. Z-transforms.**

Canadian Engineering Accreditation Board (CEAB) Curriculum Content

CEAB curriculum category content	Number of AU's	Description
Math	**26**	Mathematics include appropriate elements of linear algebra, differential and integral calculus, differential equations, probability, statistics, numerical analysis, and discrete mathematics.
Natural science	**0**	Natural science includes elements of physics and chemistry, as well as life sciences and earth sciences. The subjects are intended to impart an understanding of natural phenomena and relationships through the use of analytical and/or experimental techniques.
Complementary studies	**0**	Complementary studies include the following areas of study to complement the technical content of the curriculum: engineering economics and project management; the impact of technology on society; subject matter that deals with the arts, humanities and social sciences; management; oral and written communications; health and safety; professionalism, ethics, equity and law; and sustainable development and environmental stewardship.
Engineering science	**26**	Engineering science involves the application of mathematics and natural science to practical problems. They may involve the development of mathematical or numerical techniques, modeling, simulation, and experimental procedures. Such subjects include, among others, applied aspects of strength of materials, fluid mechanics, thermodynamics, electrical and electronic circuits, soil mechanics, automatic control, aerodynamics, transport phenomena, elements of materials science, geoscience, computer science, and environmental science.
Engineering design	**0**	Engineering design integrates mathematics, natural sciences, engineering sciences, and complementary studies in order to develop elements, systems, and processes to meet specific needs. It is a creative, iterative, and open-ended process, subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may also relate to economic, health, safety, environmental, societal or other interdisciplinary factors.

Accreditation units (AU's) are defined on an hourly basis for an activity which is granted academic credit and for which the associated number of hours corresponds to the actual contact time: one hour of lecture (corresponding to 50 minutes of activity) = 1 AU; one hour of laboratory or scheduled tutorial = 0.5 AU. Classes of other than the nominal 50-minute duration are treated proportionally. In assessing the time assigned to determine the AU's of various components of the curriculum, the actual instruction time exclusive of final examinations is used.

Graduate Attributes

This course contributes to the acquisition of graduate attributes as follows:

Graduate attribute	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
Level descriptor	I	I										

I = Introduced; D = Developed; A = Applied

KB *- Knowledge Base for Engineering: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.*

PA *- Problem Analysis: An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.*

IN *- Investigation: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.*

DE *- Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations.*

ET *- Use of Engineering Tools: An ability to create, select, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.*

IT *- Individual and Team Work: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.*

CS *- Communication Skills: An ability to communicate complex engineering concepts within the profession and with society at large. Such abilities include reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.*

PR *- Professionalism: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.*

IE *- Impact of Engineering on Society and the Environment: An ability to analyse social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.*

EE *- Ethics and Equity: An ability to apply professional ethics, accountability, and equity.*

EP *- Economics and Project Management: An ability to appropriately incorporate economics and business practices including project, risk and change management into the practice of engineering, and to understand their limitations.*

LL *- Life-Long Learning: An ability to identify and to address their own educational needs in a changing world, sufficiently to maintain their competence and contribute to the advancement of knowledge.*

Policies

Academic Integrity

McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures.
(see www.mcgill.ca/students/srr/honest/ for more information).
(approved by Senate on 29 January 2003)

In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.
(approved by Senate on 21 January 2009)

Grading Policy

In the Faculty of Engineering, letter grades are assigned according to the grading scheme adopted by the professor in charge of a particular course. This may not correspond to practices in other Faculty and Schools in the University.

In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

McGill
Faculty of Engineering

ECSE 206 Introduction to Signals and Systems

Winter 2023

Class Schedule

Lecture: CRN 2052, TR 11:35 – 12:55, EDUC 129, Jan 4 – Apr 13
*Tutorial: CRN 2053, M 13:35 – 15:25, ARTS W-120, Jan 4 – Apr 13

*See Important note in Instructional Methods

Instructor

Lawrence R. Chen
Email: lawrence.chen@mcgill.ca
Office hours: T 13:30 – 14:30, in-person and/or via Zoom (https://mcgill.zoom.us/j/4122615845)

Course Assistants

Hadi Hojjati, hadi.hojjati@mcgill.ca, **TA**
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Course Overview

Review of complex functions. Discrete and continuous time signals, basic system properties. Linear time-invariant systems, convolution. Fourier series and Fourier transforms, frequency-domain analysis, filtering, sampling. Laplace transforms and inversion, transfer functions, poles and zeros, solutions of linear constant-coefficient differential equations, transient and steady-state response. Z-transforms.

Communication

myCourses (accessible via www.mcgill.ca/mycourses) will be used as the primary means for communication. In particular, it will be used to make important announcements related to the course, as well as to distribute all course materials, including class slides, class notes, worksheets and exercises (and their solutions), etc., as well as to administer quizzes, assignments, etc. ***It is your responsibility to consult the course webpage regularly and take note of all course matters, including due dates (e.g., for pre-class or in-class activities, reflective writings, quizzes, etc.).***

If you have a question regarding an assessment (e.g., clarifications on instructions, due dates, etc.), please feel free to post it on myCourses as other students may benefit from the response. If you need to reach me, please send an email to lawrence.chen@mcgill.ca. I will try to respond within 48 hours. If you do not receive a response and your question has not been answered via a posting on myCourses, please see me before/after class.

Learning Outcomes

LO1 Distinguish between and identify important properties of continuous time and discrete time signals and systems

LO2 Characterize continuous time and discrete time signals using appropriate mathematical tools (e.g., Fourier series and Fourier transforms)

LO3 Analyze the behavior and properties of continuous time and discrete time systems using appropriate mathematical tools (e.g., Laplace, Fourier, and Z-transforms) or determine the output of such systems subject to specified inputs

LO4 Apply technical knowledge to solve relevant problems

Course Materials and Textbooks

The following textbook will be used throughout the course:

B. P. Lathi, *Linear Systems and Signals*, 2nd Edition. New York: Oxford University Press, 2005. ISBN: 0-19-515833-4.

Available for loan (https://mcgill.on.worldcat.org/oclc/53476976) and on reserve (https://mcgill.on.worldcat.org/courseReserves/course/id/18987912)

Additional material will be posted on myCourses.

Instructional Methods

The course will adopt a flipped learning approach. **You are expected to learn the relevant material ahead of class, e.g., by watching instructional videos and/or reading assigned sections from the textbook, as well as to complete pre-class activities.** Class time will be devoted to reviewing key concepts, to test understanding of course content via quizzes and exercises/activities, as well as to solve problems individually and in groups.

Important Note: **There is NO distinction between 'lectures' and 'tutorials' and you are expected to attend both.** ***Failure to do so may impact negatively your grade.***

Group Work

As part of the flipped learning approach, this course relies heavily on active learning and peer instruction, including group work. Prior to or during the first class, you will form **groups of 6 students** (in myCourses). *You will then work in the same group for the entire semester*. For group assessments, e.g., some of the in-class activities, in-class quizzes, etc., each student in the group will receive the same grade.

Polling Questions

Polling questions will be used to encourage an environment of active learning. Your answers to these questions will not count towards the grading scheme in the course, but may be monitored. Some of these questions, or closely related questions, may appear on quizzes and assessments. Polling questions will be asked using Slido (see below).

Student Response System (Slido)

Logistical issues:

- You may respond to polling questions using any personal device (smartphone, tablet, or laptop).
- Simply go to www.slido.com and enter the code provided during class.
- If you have a hearing, visual, or other impairment, please contact me immediately in order for appropriate arrangements. If you do not have a suitable personal device to respond to polling questions, please contact me as soon as possible.
- To maintain a safe and respectful classroom environment, please ensure that any polling responses you submit are appropriate and relevant to the question asked. Please refer to the Code of Student Conduct and Disciplinary Procedures.

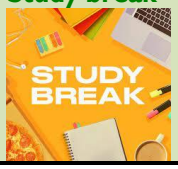
Evaluation and Assessment

Reflective writing Throughout the semester, I will be asking you to write about your learning process and how you are engaging with the course. These reflective writing exercises will take place on average every other week. You will receive full credit for each writing exercise you complete, provided that your response is pertinent. The reflections will be reviewed, but due to the volume of responses, I may not provide you with specific/individual feedback. These exercises should help you identify concepts that you have difficulty understanding and how you will go about resolving any difficulties, as well as allow you to develop a broader appreciation for the course material. CEAB attributes: LL	**3%**
Pre-class activities Pre-class activities will be administered regularly throughout the semester. These may involve simple calculation questions, inquires, or online quizzes and should not take more than 15 minutes to complete. The pre-class activities will be described in the 'Class plans and objectives' document (see 'Class plans and objectives' in the *Content* tab) as well as appear on the calendar in myCourses. **Please check myCourses regularly for updates or revisions.** As long as you complete the pre-class activity, you will receive full credit, i.e., **these are completion-based activities**. If you do not complete a pre-class activity, you will receive a grade of 0 for that activity. You can miss two pre-class activities without penalty. **Late submissions/completion of pre-class activities will not be allowed.** Learning outcomes: LO1, LO2, LO3 CEAB attributes: KB	**10%**
In-class activities and quizzes A number of problems will be distributed on a regular basis. You will be given time to work on these during class. Some of the problems (or similar types of problems) will be collected for grading at the end of class or a few days after class. In some cases, you will work on the problems in groups, but will submit your responses individually; in other	**40%**

cases, there will be group submissions. For group submissions, all students in the group receive the same grade (one submission per group). There will be several 'formal' quizzes which are announced in the 'Class plans and objectives' document and will involve individual and/or group work. All in-class activities and quizzes will be equally weighed. Your two lowest scores will be dropped; alternatively, this means that you can 'miss' two in-class activities or quizzes without penalty. **Late submissions: For in-class activities,** a penalty of 15% / day will be applied and no submissions will be accepted 48 hours after the due date**. For quizzes,** no late submissions will be allowed. Learning outcomes: LO1, LO2, LO3, LO4 CEAB attributes: KB, PA, IN	
Midterm assessment The midterm assessment will be distributed on Thu, Feb 18; you will have about 48 hours to complete and submit your work. Each student must submit the assignment individually through myCourses. While I encourage you to work individually, you may consult with other students, but only from your group. Learning outcomes: LO1, LO2, LO3, LO4 CEAB attributes: KB, PA, IN	**20%**
Final assessment The final assessment will be held during the formal exam period from Apr 14 – Apr 28. The assessment will be comprehensive in nature and cover all course material. The final assessment will be 3 hours in duration and run in two parts. The first part will involve individual work and last about 115 minutes. In the second part, you will work in your groups to answer additional questions. Solutions to these questions are submitted as a group (students must reach a consensus on their answer and will receive the same grade for their responses). This second part will last about 55 minutes. The remaining time will be for setup. The individual and group portions will count for 75% and 25%, respectively, of the overall assessment grade. Learning outcomes: LO1, LO2, LO3, LO4 CEAB attributes: KB, PA, IN	**27%**

COURSE CONTENT AND SCHEDULE

Week	Class	Date	Lecture Topic
1	1	Jan 5	**Introduction to the course** ➢ Teaching approach and methodology ➢ What is the course about? What will you get out of the course? **Fundamental concepts** ➢ What are signals and systems? Classification of signals and systems, tools used to analyze signals and systems
2	2	Jan 9	**Quick review of mathematical tools** ➢ Complex variables, partial fraction expansions
	3	Jan 10	**Continuous time signals** ➢ Classification of signals and signal operations ➢ Important signals and their properties: complex exponential signals, delta function (impulse), step function
	4	Jan 12	**Continuous time systems** ➢ Definition and classification ➢ Formulation of system representation from physical problems
3	5	Jan 16	**Representation of continuous time signals: Fourier series** ➢ Motivation ➢ Fourier series representations
	6	Jan 17	➢ Fourier spectrum and interpretation ➢ Properties of Fourier series ➢ Relationships between Fourier series representations
	7	Jan 19	**Application and catch-up**
4	8	Jan 23	**Representation of continuous time signals: Fourier transforms** ➢ Motivation, definition, and convergence
	9	Jan 24	➢ Properties (convergence, symmetry) ➢ Transforms of important CT signals
	10	Jan 26	**Application and consolidation**
5	**Continuous time systems: time domain analysis**		
	11	Jan 30	➢ Representation of LTIC systems by ODEs ➢ Zero-input response, impulse response
	12	Jan 31	➢ Convolution of signals and zero-state response ➢ Total output response ➢ System responses: natural, forced, transient, steady-state
	13	Feb 2	➢ Stability of LTIC systems: BIBO stability, asymptotic stability, and marginal stability

6	**Continuous time systems: transform domain analysis**		
	14	Feb 6	**Laplace transforms** ➢ Bilateral and unilateral Laplace transforms, properties ➢ Region of convergence and time domain representation ➢ Inverse transform
	15	Feb 7	**LTIC systems in the transform domain** ➢ Solutions of linear systems described by ODEs using transform techniques ➢ System transfer function and impulse response ➢ Poles and zeros
	16	Feb 9	**Stability and causality** ➢ Implications of region of convergence on impulse response of a system ➢ Stability, causality, and region of convergence ➢ Connection between Laplace and Fourier transforms
7	17	Feb 13	**Application**
	18	Feb 14	**Review and consolidation**
	19	Feb 16	**Midterm assessment** 
8	20	Feb 20	**Catch-up and reflection**
	21	Feb 21	**Discrete time signals** ➢ Definition, classification, and signal operations ➢ Properties, important discrete time signals (harmonic and complex exponential signals)
	22	Feb 23	**Representation of discrete time signals: discrete time Fourier series** ➢ Linear space of periodic discrete time signals ➢ DTFS: definition, properties, and examples
9		Feb 27 – Mar 3	**Study break** 
10	23	Mar 6	**Representation of discrete time signals: discrete time Fourier transforms** ➢ DTFT: definition, inverse DTFT, properties, transforms of important DT signals
	24	Mar 7	**Discrete time systems: time-domain analysis** ➢ Representation of LTID systems by linear difference equations ➢ Classification and examples
	25	Mar 9	➢ Recursive solution ➢ Zero-input response, impulse response, zero-state response, total response ➢ Properties of LTID systems, including stability

11	26	Mar 13	**Application and consolidation**
	27	Mar 14	**Z transform** ➢ Z transform: definition (unilateral, bilateral), properties, inverse transform ➢ Characteristics of signals and region of convergence
	28	Mar 16	**LTID systems in the transform domain** ➢ Systems represented by linear difference equations in the transform domain ➢ Solution of linear difference equations using transform techniques ➢ Transfer functions and system realizations ➢ Properties of LTID systems
12	**Discrete time systems: transform domain analysis (con't)**		
	29	Mar 20	**LTID systems in the transform domain** ➢ Poles and zeros, implications on time-domain response ➢ Stability, causality, and region of convergence
	30	Mar 21	**Digital filters** ➢ Connection between Z and discrete time Fourier transforms
	31	Mar 23	➢ Frequency response ➢ Introduction to digital filter design ➢ Design and signal processing
13	32	Mar 27	**Application and consolidation**
	33	Mar 28	**Review and catch-up**
	34	Mar 30	**Flex**
14	**Sampling: connecting the continuous time and discrete time worlds**		
	35	Apr 3	**Sampling systems** ➢ Impulse train sampling and the sampling theorem ➢ Interpolation
	36	Apr 4	**Discrete time processing of continuous time signals**
	37	Apr 6	**Catch-up**
15		Apr 10	**Easter Monday** 
	38	Apr 11	**Application and consolidation**
	39	Apr 12	**Review**

Health and Wellness Resources at McGill

Student well-being is a priority for the University. Below are some suggested resources that all students have access to for free. We highly encourage students to investigate and make use of the services available.

Student Wellness Hub - All of McGill's health and wellness resources, integrated into a single hub; includes urgent care, self-help, various events and workshops, and more.
Visit www.mcgill.ca/wellness-hub or drop by the Brown Student Services Building (downtown) or Centennial Centre (Macdonald campus).

Student Accessibility & Achievement (SAA) - Works with students who have documented disabilities, mental health issues, chronic health conditions, or other impairments to determine what resources or accommodations will help ensure a successful learning experience.
Visit https://www.mcgill.ca/access-achieve/ or drop by 1010 Sherbrooke Street West, Suite 410.

McGill Engineering Student Centre (MESC) - Provides academic and career advising, wellness support, and peer tutoring services.
Visit www.mcgill.ca/engineering/students/undergraduate/mesc or drop by FDA 22.

Local Wellness Advisor (LWA, Virginie Yeba) - Trained clinicians here to orient and connect you with the appropriate resource(s) for your unique situation.
To make an appointment, visit https://www.mcgill.ca/wellness-hub/hub-clinical-services/hub-clinicians/local-wellness-advisors/local-wellness-advisor-engineering or look for Virginie in FDA 22.

Additional Policies

The *University Student Assessment Policy* includes all disparate policies with regard to multiple aspects and methods of student assessments. A copy of this policy can be found here: https://www.mcgill.ca/secretariat/files/secretariat/2016-04_student_assessment_policy.pdf

Language of Submission

In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded. This does not apply to courses in which acquiring proficiency in a language is one of the objectives.

Academic Integrity

McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures.

Course Materials

OTHER

In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

As the instructor of this course I endeavor to provide an inclusive learning environment. However, if you experience barriers to learning in this course, do not hesitate to discuss them with me and/or with McGill Student Accessibility & Achievement, 514 398 6009 (option #1 or #2).

McGill University is on land which has long served as a site of meeting and exchange amongst Indigenous peoples, including the Haudenosaunee and Anishinabeg nations. We acknowledge and thank the diverse Indigenous people whose footsteps have marked this territory on which peoples of the world now gather.