Instructor:
Roshdy H. M. Hafez, PhD, P.Eng.
ME 4440 (T) +1 613 520 5731 (E) hafez@sce.carleton.ca
Office Hours: Wednesdays 2:20 – 4:30

Teaching Assistant:
Amirhossein Asgharnia Gourabjiri amirhosseinasgharnia@cmail.carleton.ca
TA office hours: TBD

Calendar Information:
**Signals and Systems**: SYSC 3500 [0.5 credit]
Signals: energy and power signals, discrete-time and continuous. Linear systems and convolution. Fourier Transform; complex Fourier series; signal spectral properties and bandwidth. Laplace transform and transient analysis. Transfer functions, block diagrams. Baseband and passband signals with applications to communications systems.

**Lectures**: three hours a week
**Problem analysis**: three hours alternate weeks.
**Includes**: Experiential Learning Activity
**Precludes**: additional credit for SYSC 3600 and SYSC 3610.
**Prerequisite(s)**: MATH 1005 and enrolment in Communications Engineering, and second-year status in Engineering.

“Students enrolled in this course are expected to know: elementary linear algebra, trigonometry, manipulation of vectors and complex numbers, formulating and solving first and second linear differential equations with constant coefficients”

**Students who have not satisfied the prerequisites for this course must either withdraw from the course or obtain a prerequisite waiver by visiting the Engineering Undergraduate Academic Support Office**

Course Objectives:
- Introduction to fundamental concepts of signals and systems.
- Definition and characteristics of deterministic signals, both analogue and digital
- Developing a thorough understanding of Fourier series and Fourier transforms for continuous and discrete time.
- Review of Laplace transform and system transient response
- Study of systems that manipulate signals focusing on Linear Time-Invariant (LTI) systems.
• Time domain analysis of systems, including impulse response and convolution. Frequency domain analysis and system frequency response will be discussed in details
• Applications of learned concepts on basic building blocks of communication systems: ADC, DAC, Multiplexing, Modulation etc.

Learning Outcomes:
1. By the end of this course, students should be familiar with the fundamental terminology and theory behind signals and systems analysis.
2. Students will develop the mathematical skills required to model and analyze signals and systems: including transforms, convolution, sampling, quantization and filtering
3. Students will acquire the necessary background for further study in fields such as communication theory, signal processing, and control systems
4. Students will be trained to design experiments that explore the mathematical foundation of signals and systems and verify them using computer simulations
5. Student will be trained to identify hypotheses that need to be verified experimentally. Study experimental procedures. Carry out experiments to produce measured data. Plot the experimental results.
6. Students will be trained to express their ideas in terms of sound technical writing, experimental documentation and oral presentation

Graduate Attributes:
The Canadian Engineering Accreditation Board requires graduates of engineering programs to possess 12 attributes at the time of graduation. Activities related to the learning outcomes listed above are measured throughout the course and are part of the department’s continual improvement process. Graduate attribute measurements will not be taken into consideration in determining a student’s grade in the course. For more information, please visit: https://engineerscanada.ca/

<table>
<thead>
<tr>
<th>Graduate Attributes</th>
<th>Learning Outcome(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6 S-Signals and systems</td>
<td>1</td>
</tr>
<tr>
<td>3.3 - Experimental procedure</td>
<td>2-4</td>
</tr>
<tr>
<td>4.4 - Design – Design solutions</td>
<td>3,4</td>
</tr>
<tr>
<td>5.3 - Engineering tools - Tools for design experimentations, simulations, visualization and analysis</td>
<td>5</td>
</tr>
<tr>
<td>7.2 - Communications skills - Professional documents, writing, design notes, drawings, attributions, and references</td>
<td>6</td>
</tr>
</tbody>
</table>

Text:
References:

Evaluation and Marking Scheme:
In-Class quizzes: 10%
Project: 10%
Short Assignments (3): 10%
Lab (5): 15%
Mid-term-1: 20%
Mid-term-2: 20%
Mid-term-3: 15%
- Class participation included: in-class quizzes, short assignments and project
- All exams are closed book without formula sheets
- Mid-term-3 will be carried out on the second last week

General Regulations:
Attendance: Students are expected to attend all lectures and lab periods. The University requires students to have a conflict-free timetable. For more information, see the current Undergraduate Calendar, Academic Regulations of the University, Section 2.1.3, Course Selection and Registration and Section 2.1.7, Deregistration.

Health and Safety: Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: http://sce.carleton.ca/courses/health-and-safety.pdf

Deferred Term Work: Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. For more information, see the current Undergraduate Calendar, Academic Regulations of the University, Section 4.4, Deferred Term Work.

Appeal of Grades: The processes for dealing with questions or concerns regarding grades assigned during the term and final grades is described in the Undergraduate Calendar, Academic Regulations of the University, Section 3.3.4, Informal Appeal of Grade and Section 3.3.5 Formal Appeal of Grade.
**Academic Integrity:** Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at: [https://carleton.ca/registrar/academic-integrity/](https://carleton.ca/registrar/academic-integrity/) This site also contains a link to the complete Academic Integrity Policy that was approved by the University's Senate.

**Plagiarism:** Plagiarism (copying and handing in for credit someone else's work) is a serious instructional offense that will not be tolerated.

**Academic Accommodations:** You may need special arrangements to meet your academic obligations during the term. You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at [http://www.carleton.ca/equity/](http://www.carleton.ca/equity/) For an accommodation request, the processes are as follows:

- **Pregnancy or Religious obligation:** Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see [https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf](https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf)

- **Academic Accommodations for Students with Disabilities:** The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or [pmc@carleton.ca](mailto:pmc@carleton.ca) for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your **Letter of Accommodation** at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (*if applicable*). **Requests made within two weeks will be reviewed on a case-by-case basis.** After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website ([www.carleton.ca/pmc](http://www.carleton.ca/pmc)) for the deadline to request accommodations for the formally-scheduled exam (*if applicable*).

- **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton’s Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: [https://carleton.ca/sexual-violence-support/](https://carleton.ca/sexual-violence-support/).

- **Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation...
during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf

*Copyright on Course Materials:* The materials created for this course (including course outline, slides, posted notes, labs, project, assignments, quizzes, exams and solutions) are intended for personal use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).

**Week-By-Week Schedule**

**Weeks 1-2:**
- Overview of a communication system.
- Introduction to signals:
  - Classifications of signals: continuous-time vs. discrete-time, continuous amplitude vs. discrete amplitude, energy vs. power, deterministic vs. random, periodic vs. aperiodic.
  - Commonly used signals: Unit step function, rectangular pulses, triangular pulses, ramp functions, the Dirac delta (impulse function), and complex sinusoids.
  - Time shifted signals.
- Introduction to systems:
  - Classification of systems: Linear vs. nonlinear, time invariant vs. time-variant, realizable vs. non-realizable, memoryless vs. with memory.

**Weeks 3-4:**
- Linear time-invariant systems
- Transmission of signals through linear time-invariant systems.
- Impulse response.
- Convolution sum and convolution integral.
- Difference equations and differential equations.

**Weeks 5-8:**
- Frequency domain representation of continuous-time signals:
  - Complex Fourier series.
  - Line spectrum representation.
  - Fourier transforms and inverse Fourier transforms.
  - Fourier transforms of common signals.
  - Energy/power spectrum. Bandwidth.
  - Parseval’s Theorem.
  - Properties of the Fourier transform and transform pairs.
- Frequency domain representation of discrete-time signals:
  - Discrete-time Fourier transforms.
  - Discrete Fourier transforms and Fast Fourier Transform (FFT).
  - Spectrum of discrete-time signals.

**Week 9:**
- Fourier analysis of Systems:
  - Continuous-time signals – frequency response.
Discrete-time signals.
- Analysis of ideal filters. Lowpass, bandpass, highpass filters.

**Week 10:**
- Sampling and Quantization:
  o Nyquist’s sampling theorem.
  o Sampling frequency.
  o Signal reconstruction.
  o Aliasing.

**Week 11:**
- Applications:
  o Amplitude Modulation
  o Filtering: Lowpass and bandpass signals.
  o Multiplexing and demultiplexing
  o Up and Down converters
  o Modulation & demodulation.

**Week 12:**
- Review of Laplace Transforms
- Course review