Instructor Information and Office hours
Prof. Ian Marsland, Office: 4442 ME, email: ianm@sce.carleton.ca
Office Hours: Wednesdays, 1-2pm, or by appointment.

TA Information and Office hours
Monirosharieh (Monireh) Vameghestahbanati

Course Number and Calendar Description
Precludes additional credit for SYSC 3501 or SYSC 4600.
Lectures three hours a week, laboratory, three hours alternate weeks.

Prerequisites
Prerequisite: SYSC 3500 and (STAT 2605 or SYSC 2510).

Course Objectives
This course provides an introduction to the fundamental principles of communication theory. The basic components of a communication system will be outlined and the concept of modulation will be explained, pointing out the differences between analogue and digital modulation. Important techniques for representing signals in the time and frequency domains will be presented, including signal-space diagrams. Analogue amplitude modulation and frequency modulation will be studied, including their performance in the presence of noise. Amplitude shift keying (ASK), frequency shift keying (FSK), and phase shift keying (PSK), three digital modulation techniques, will be defined, and the fundamental concepts of optimal reception of digitally modulated signals transmitted over an additive white Gaussian noise (AWGN) channel will be emphasized. Techniques for calculating the expected probability of error at the receiver output will be covered.

Learning Outcomes
By the end of this course, students will be familiar with the fundamental terminology and theory behind communication systems, including modulation, signal space representation, optimal reception, and error probability analysis. Students will further develop their understanding of the mathematical tools, including calculus, probability theory, and Fourier transforms, that are required for the course material. Students will also improve their software development skills by simulating communication systems in the lab. Students will acquire the necessary background to study more advanced material in communication theory, as offered in SYSC 4604 – Digital Communication Theory, SYSC 4607 – Wireless Communications, and SYSC 4700 – Telecommunications Engineering.

Graduate Attributes (GA’s)
The Canadian Engineering Accreditation Board requires graduates of engineering programs to possess 12 attributes. Activities related to the learning outcomes listed here are intended to develop students' competence in the following GAs:

1.6.S Knowledge Base: Signals and systems
2.2 Problem Analysis: Approach to the problem
3.3 Investigation: Experimental procedure
5.3 Use of Engineering Tools: Tools for design, experimentation, simulation, visualization, and analysis
7.3 Communication Skills: Oral and written presentations

**Textbooks (or other resources) if applicable**

Lectures: Mondays and Wednesdays, 10:00-1:30 in 4332 ME.

TA: The TA will supervise the labs, and mark the lab reports and assignments.

Instructor: I will be available for discussion during my scheduled office hours (Wednesdays 1-2pm), but feel free to drop by my office at any time. Appointments at other times can be arranged if you have trouble finding me. I can also be reached by email, but for help with difficult problems it is usually more productive to meet in person.


References:

**Evaluation and Grading Scheme**

To pass the course, students must attend all the labs. For these students, the final grade will be calculated by weighting the course components according to whichever of the following schemes yields the highest grade:

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<tr>
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<th>Scheme #1</th>
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<td>Assignments:</td>
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<td>Lab Reports:</td>
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<td>Term Project:</td>
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<td>Mid-term Exam:</td>
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<td>Final Exam:</td>
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The final examination is for evaluation purposes only and will not be returned to students. You will be able to make arrangements with the instructor or with the department office to see your marked final examination after the final grades have been made available.
Week-by-Week breakdown

The following week-by-week outline is a preliminary guideline only and is subject to change:

Week 1: January 7th – January 11th:
Introduction and overview of communication theory and systems: General model of a communication system. Examples of communication systems. Analogue vs. digital modulation.


Review of systems: Classification of systems: Linear vs. nonlinear, time invariant vs. time-variant, realizable vs. non-realizable. Impulse and frequency response of linear time-invariant systems. Transmission of signals through linear time-invariant systems. Convolution.

Week 2: January 14th – January 18th:
Digital transmission: Baseband and bandpass signalling. Bandlimited signals, sampling theorem for bandlimited signals, pulse amplitude modulation (PAM), quantization, pulse code modulation (PCM), line codes. Binary and M-ary signalling. Amplitude shift keying (ASK), phase shift keying (PSK), and frequency shift keying (FSK).

Week 3: January 21st – January 25th:
Geometric representation of signals: signal space diagrams, Gram-Schmidt orthogonalization

Week 4: January 28th – February 1st:

Week 5-6: February 4th – February 15th:
Spectral characteristics of baseband and bandpass signals: Spectral analysis, pulse shaping, Nyquist criterion for no intersymbol interference (ISI).

Week 7-8: February 25th – March 8th:
Optimal receivers: Matched filters (to maximize output SNR). Optimal detection in the presence of AWGN: Maximum a posteriori (MAP) and maximum likelihood (ML) decision rules to minimize the probability of error.

Weeks 9-10: March 11th – March 22nd:
Probability of error analysis: Probability of symbol and bit errors for digital communication systems in the presence of AWGN.

Week 11: March 25th – March 29th:
Analogue modulation schemes: Amplitude modulation (AM): definition, time domain waveform, modulation index and modulation efficiency, spectrum, bandwidth, envelope detection and coherent demodulation, superheterodyne receiver. Double-sideband suppressed carrier (DSB-SC) AM. Quadrature AM. Frequency modulation (FM).

Week 12: April 1st – April 9th:
Review: Review and oral presentations.
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 1.2, Course Selection and Registration and Section 1.5, 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 2.6, 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 2.7, Informal Appeal of Grade and Section 2.8, 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/. 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 Accommodation: 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/For an accommodation request, the processes are as follows:

- Pregnancy obligation: write to me 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
- Religious obligation: write to me 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
- 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 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). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult https://carleton.ca/pmc/students/dates-and-deadlines/ 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/.

- **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

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