**Western University**
**Faculty of Engineering**
**Department of Electrical and Computer Engineering**

# ECE 4437a – Communication Theory
## *Course Outline for 2023 – 2024*

**Description:** The objective of the course is to provide the students an in-depth understanding of the fundamental principles and theories related to communication systems. The course aims to develop students' analytical and design skills through the study of communication processes/ theories and the completion of design-oriented assignments. At the end of the course, the students will be able to use appropriate method and tools in analyzing communication signal, channel and system in achieving specific design goals including system capacity and bit error rate performance.

**Academic Calendar Copy:** Introduction to communication systems and information theory. Classification of signals and systems. Communication channel modeling. Fourier series and transform applications. Modulation techniques. Sampling theory and digital transmission. Digital modulation, optimum receiver design, performance analysis. Error control. Selected topics.

**Contact Hours:** 3 lecture hours, 1 tutorial hours, 0.5 course.

**Prerequisites:** ECE 3330A/B, ECE 3331A/B, ECE 3375A/B, Statistical Sciences 2141A/B or Statistical Sciences 2143A/B, Applied Mathematics 2276A/B or the former Applied Mathematics 2415.

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

**CEAB Academic Units:** Engineering Science 100%

**Course Materials:**

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J.G. Proakis & Masoud Salehi, Fundamentals of Communication Systems (2 edition), Prentice Hall, 2014, ISBN-13: 978-0-13-335485-0. 1edition available at Taylor Library: TK5101.P755 2005

- Class notes.
- MATLAB, SIMULINK software and online tutorials

**Reference Materials:**

- S. Haykin, Communication Systems, 4th Edition, John Wiley and Sons, 2001, ISBN: 0-471-1786-4. Available at Taylor Library: TK5101.H37 2001
- Related published journal and conference papers.
- MATLAB, student version with Simulink, Release 12 or later, www.mathworks.com/store

**General Learning Objectives (CEAB Graduate Attributes)**

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|---|---|---|---|---|---|
| Knowledge Base | A | Use of Engineering Tools | A | Impact on Society and the Environment | |
| Problem Analysis | A | Individual and Team Work | D | Ethics and Equity | |
| Investigation | D | Communication Skills | | Economics and Project Management | |
| Design | D | Professionalism | | Life-Long Learning | |

[**I** – The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. **D** – There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. **A** – It is expected that the student can apply the knowledge without prompting (e.g. no review).

## Course Topics:

- Overview of communication system
- Classification and representation of communications signals
- Analysis of communication signals in time and frequency domain. Notion of carrier frequency, bandwidth and modulation
- Fourier series and Fourier transformation (online review)
- Probability theory (online review), PDF, CDF, correlation function
- Information, information rate vs transmission rate. representation of information in binary form, entropy, introduction to source coding. Shannon's capacity and fundamental limits of communications.
- Sampling theory (online review), A/D, D/A conversion. Common sources of information: sensory data, voice video, aggregated data
- Complex representation of signals. Digital amplitude, phase, frequency modulations
- Noise in communications Systems (online review), AWGN. Errors due to noise. Idea of error correction.
- Optimum receiver design and communication system performance analysis. Performance matrices and optimization.
- Communication channel.
- Channel impairment and impact on quality of information.
- Selected topics.

**Specific Learning Objectives:**

- Understand the basic architecture and components of a communication system **PA1, PA2**
- Use different ways of representing communication signals **KB3**, **ET2**
- Analyze communication signals in time/frequency domain **PA1, PA2, PA3, PA4, PA5, ET2**
- Understand and analyze signals in the frame of probabilistic theory P**A1, PA2, PA3, ET2.**
- Understand and use concept of information, information rate, coding K**B1, KB3**
- Understand the process of sampling of signals and analog to digital/digital to analog conversions
- Design digital modulation techniques and corresponding optimum receivers **KB1**, **D1, PA3, ET2**
- Analyze the performance of a communication system through its bit error rate and capacity **PA1, PA2, PA3, ET2, D3**
- Investigate and Understand organization, principles of operation and performance metrics of existing communications systems in the real world applications (case study) **ITW1, ITW2, I3, PA3, D1**
- Investigate characteristics of different sources of information and be able to map these characteristics to parameters of communications system to transmit this source, **I1, I2, I3**

**Evaluation**

| | | **Maximum Penalties (*)** | |
|---|---|---|---|
| **Course Component** | **Weight** | **English** | **Presentation** |
| Assignment | 12% | 10% | 10% |
| Investigation study | 10% | 10% | 10% |
| Self-study review | 5% | N/A | N/A |
| Midterm | 15% | 10% | 10% |
| Final Examination (3 hours) | 50% | 10% | 10% |
| Participation quizzes | 8% | N/A | N/A |

To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination as well as on the laboratory. A final examination or laboratory mark < 50% will result in a final course grade of 48% or less.

**Assignments:** A total of THREE assignments would be given during the course. These assignments must be submitted on the due dates indicated on them (upload PDF files with the scans to OWL). Failure to submit on due dates will attract a penalty at the rate of 20% per day.

**Midterm:** A total worth of 15 % of the final mark will be given to midterm (closed book).

**Final Examination:** The final examination will be partially open book (3 hours) and carries weight of 50%. The final examination will be taken place during the regular examination period.

**Investigation study**: Will be conducted in groups of 4 students. Subject for each group will be assigned from a list of prepared topics.

**Self-study review**: An additional assignment which is based on the material designated as a self-study review.

**Assignment Submission:** All course related assignments will be submitted on OWL.

**Late Submission Policy:** Assignments/Laboratory Reports: all submissions are due by 5:00PM on the due dates. Failure to submit on due dates will attract a penalty at the rate of 20% per day.

**Course Website:** OWL https://owl.uwo.ca A course website will be maintained. Assignments, submission deadlines, announcements for the course etc. will be posted on the website for electronic viewing and download in Portable Document Format (PDF) format.

**Use of English:** In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

**Online Activities (only if required by COVID-19 epidemic):** Lectures of this course are delivered online with Zoom, which requires the online participation of students. During the online lectures, students are required to participate the online Zoom sessions with computers equipped with microphone and camera. Students will be asked to turn on microphone and camera during the online interactive activities.

**Recording Online Activities (only if required by COVID-19 epidemic):** All of the remote learning sessions for this course will be recorded. The data captured during these recordings may include your image, voice recordings, chat logs and personal identifiers (name displayed on the screen). The recordings will be used for educational purposes related to this course, including evaluations. The recordings may be disclosed to other individuals participating in the course for their private or group study purposes. Please contact the instructor if you have any concerns related to session recordings. Participants in this course are not permitted to record the sessions, except where recording is an approved accommodation, or the participant has the prior written permission of the instructor.

**Attendance:** Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

**Absence Due to Illness or Other Circumstances:** Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached "Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled"). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, see the relevant section of the Academic Handbook: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf

For more information concerning accommodations for religious holidays, see the relevant section

of the Academic Handbook: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

**Missed Midterm Examinations:** If a student misses a midterm examination, the exam will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests and provide documentation to their department within 24 hours of the missed test. The department will decide whether to allow the reweighting of the test, where reweighting means the marks normally allotted for the midterm will be added to the final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the test.

If a student is going to miss the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam.

**Cheating and Plagiarism:** Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (http://www.turnitin.com).

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

**Policy on Repeating All Components of a Course:** Students who are required to repeat an Engineering course must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment, or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted by the student for grading in subsequent years.

**Internet and Electronic Mail:** Students are responsible for regularly checking their Western e-mail and the course web site (https://owl.uwo.ca/portal/) and making themselves aware of any information that is posted about the course.

**Accessibility:** Please contact the course instructor if you require material in an alternate format or

if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

**Support Services:** Office of the Registrar, http://www.registrar.uwo.ca/
Student Development Centre, http://www.sdc.uwo.ca/
Engineering Undergraduate Services, http://www.eng.uwo.ca/undergraduate/
USC Student Support Services, http://westernusc.ca/services/

Students who are in emotional/mental distress should refer to Mental Health @ Western, http://www.health.uwo.ca/mental_health/, for a complete list of options about how to obtain help.