Instructor: Jean-Daniel Medjo Me Biomo, jemed@sce.carleton.ca

Office Hours: Fridays 2-3 PM, ME 4239 (Mackenzie building).

TA Information: Zachary Baird, zachbaird@cmail.carleton.ca

Course Description and Objectives: The objective of this course is to introduce the student to advanced topics in modulation and coding. Topics covered include signal space representation, probability of error and bounds for AWGN channel, applications to PSK, QPSK, FSK, QAM, multi-carrier modulation and OFDM, spread-spectrum communication and CDMA, information theory, source coding theorem, channel capacity, linear block codes and convolutional codes.

Learning Outcomes:
By the end of the course, students will be able to:
- Dissect fundamental concepts behind digital communication systems, including: modulation, signal space representation, optimal reception, error probability analysis, and information theory
- Demonstrate their understanding of mathematical tools such as calculus, probability theory, and Fourier transforms

Graduate Attributes (GA’s):
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/. Activities related to the learning outcomes listed above are intended to develop students' competence in the following attribute:

Data from exam questions will be collected to assess students' progress towards achieving this attributes.

Prerequisites:
The prerequisites for SYSC 4600 are: SYSC 3501 (Communication Theory) and STAT 3502 (Probability and Statistics).

Coming into this course, students should:
- Understand concepts that underlie analog and digital communications. These concepts include: linear systems, Fourier theory, signal bandwidth and spectra, digital waveform coding, analog and digital modulation systems, synchronization, link budgets, communications media and circuits;
- Be able to characterize the effect of noise;
• Understand concepts of probabilities and random variables. These concepts include: conditional probability and independence, distributions (binomial, Poisson, hypergeometric, normal, gamma), confidence intervals;

• Be able to apply/use the central limit theorem, and perform distributions sampling and point estimation (maximum likelihood, method of moments);

• Be prepared to undertake this course that further explores and uses fundamental principles of digital communication systems.

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.


References:

• There are many other very good textbooks.

Grading Scheme: To pass the course, a student must obtain at least 50% in the final exam. Composition of final mark:

<table>
<thead>
<tr>
<th>Deliverable Type</th>
<th>Allocated Percentage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratories</td>
<td>20%</td>
<td>4 in total</td>
</tr>
<tr>
<td>Quiz Exam</td>
<td>October 7</td>
<td>Closed book</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>November 11</td>
<td>Closed book</td>
</tr>
<tr>
<td>Final Exam</td>
<td>December 9-21</td>
<td>Closed book</td>
</tr>
</tbody>
</table>

Please be advised that classes on Friday, December 6th will follow a Monday schedule. Therefore, there will be a class on Friday, December 6th.

• Final exam is for the evaluation purposes only and will not be returned to the students.
• A student who misses the quiz or midterm exam must submit formal documentation (such as a physician’s report) to prevent a penalty. If the documentation is accepted, there will be a deferred exam.

• Students are expected to attend all lectures and lab periods as required. The Faculty of Engineering and Design requires students to have a conflict-free timetable, so requests to accommodate missed exams, assignment due dates, etc., because of conflicts with other courses, jobs or vacation plans will not be considered.

Week-by-Week breakdown (may be modified)

Weeks 1-2  Overview of digital communications systems
Review of probability concepts and stochastic processes
Review of linear system concepts including frequency analysis

Weeks 3-6  Baseband transmission and matched filter
Signal space analysis and geometric representation of signals
Maximum likelihood detection
Probability of error

Week 7  Bandpass transmission

Weeks 8-9  Linear clock codes, syndrome decoding, Hamming distance
Error detecting and correcting capabilities of block codes
Examples of linear block codes

Weeks 10-11  Convolutional codes, distance properties, systematic and nonsystematic codes
Decoding of convolutional codes and Viterbi algorithm

Week 12  Introduction to information theory. Shannon’s channel capacity theorem
Shannon limits. Introduction to source coding

Laboratory and Tutorial sessions: There will be 7 tutorial sessions and 4 laboratory sessions. These sessions will be held on Wednesdays, 11:35 am – 2:25 pm, at 4233 ME (Mackenzie). The 4 laboratory sessions are mandatory (a report is due) and they are worth 5% of the final mark each. In these lab sessions, the students will use MATLAB to apply some of the concepts covered in class. The Tutorial sessions are not mandatory but they are highly recommended. Students will use these tutorial sessions to work on theoretical exercises. The TA will be around to assist the students in all these sessions (lab and tutorial). The schedule is as follows:
Labs and Tutorials Schedule:

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Room</th>
<th>Lab Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep 18</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td>Tutorial</td>
</tr>
<tr>
<td>Sep 25</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td>Tutorial</td>
</tr>
<tr>
<td>Oct 2</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td>Tutorial</td>
</tr>
<tr>
<td>Oct 9</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td><strong>Lab1:</strong> Simulation of a Simple Digital Communication System</td>
</tr>
<tr>
<td>Oct 16</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td>Tutorial</td>
</tr>
<tr>
<td>Oct 30</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td><strong>Lab2:</strong> Spectral Analysis of Digital Baseband Signals</td>
</tr>
<tr>
<td>Nov 6</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td>Tutorial</td>
</tr>
<tr>
<td>Nov 13</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td><strong>Lab3:</strong> Digital Bandpass Transmission</td>
</tr>
<tr>
<td>Nov 20</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td>Tutorial</td>
</tr>
<tr>
<td>Nov 27</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td><strong>Lab4:</strong> Probability of Error for 4-QAM and 16-QAM</td>
</tr>
<tr>
<td>Dec 4</td>
<td>11:35-14:25</td>
<td>ME 4233</td>
<td>Tutorial</td>
</tr>
</tbody>
</table>

**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](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/. 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, as well as allowing someone else to copy your own work) is a serious instructional offense that will not be tolerated. Please refer to the section on instructional offenses in the Undergraduate Calendar for additional information.

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.caPMC/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

Copyright on Course Materials: The materials created for this course (including the course outline and any 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).