Course Outline

Instructor: Professor Amir H. Banihashemi, Office: 7034MC, Tel: 520-2600, Ext. 8026, Email: ahashemi@sce.carleton.ca.

TA Information and Office hours: To be determined.

Lectures: Monday and Wednesday, 2:30 pm – 4:00 p.m., ME 4236.

Office Hours: Monday and Wednesday, 10:00 – 11:00 a.m.

Calendar Description: Wireless radio channel characterization, diversity, equalization; cellular architecture, multiple access principles, spread spectrum systems, radio resource management; examples from modern wireless systems, networks, and standards, including cellular networks, WLANs, ad hoc networks, and satellite systems. http://calendar.carleton.ca/undergrad/courses/SYSC/

Prerequisites: SYSC3501 or SYSC 3503. 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.

Assumed Knowledge: Upon entry into this course, students are expected to have knowledge of probability theory, calculus, complex numbers, signals and systems, digital communications and MATLAB.

Course Objectives: The course is aimed to demonstrate to the students the wide range of wireless communication applications. Within the context of such applications, the course discusses the wireless communication channel, its characteristics and capacity for both fixed and mobile scenarios, as well as techniques to transmit information over this channel reliably and efficiently.

Learning Outcomes:
1. The students should have a good understanding of the characteristics of a wireless communication channel and its modeling for both fixed and mobile scenarios.
2. They should be able to calculate the capacity of different wireless communication channels with Gaussian noise.
3. They should know the techniques used for transmission of information over different wireless communication channels and their analysis/design.

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/.

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<thead>
<tr>
<th>Graduate Attribute</th>
<th>Learning Outcome (s)</th>
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<tr>
<td>3. Investigation: 3.2. Design of Experiment</td>
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<tr>
<td>3. Investigation: 3.5. Interpretation of data (synthesis) and discussion</td>
<td>1-3</td>
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<tr>
<td>5. Use of engineering tools: 5.2. Document processing and graphics packages</td>
<td>1-3</td>
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References:


**Grading Scheme:** Composition of final mark: Final exam: 60%

- Midterm Exam: 25%
- Labs: 15%

**Breakdown of course requirements**

**Midterm Exam:** The midterm exam will be on Wednesday, February 26, during the lecture time.

**Assignments:** There will be eight assignments. Assignments and their solutions will be posted on the course webpage.
Tutorial and Lab Sessions: Tuesday 2:30 – 5:30 p.m., ME4233, even weeks, starts January 14th. There will be three software labs based on MATLAB, each worth 5% of the total mark. The dates for the labs will be announced later.

Final Exam: 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.

Tentative Week-by-Week breakdown:

**W1:** Overview of wireless communications, radio wave propagation, transmit and receive signal models, free-space path-loss, ray tracing, empirical path-loss models, simplified path-loss model.

**W2:** Shadow fading, combined path-loss and shadowing, outage probability under path-loss and shadowing, cell coverage area, time-varying channel impulse response, narrowband fading models.

**W3:** Narrowband fading models (autocorrelation, cross-correlation, power spectral density, envelope and power distributions, level crossing rate and average fade duration).

**W4:** Wideband fading models (power delay profile, coherence bandwidth, Doppler power spectrum and channel coherence time), capacity of wireless channels.

**W5:** Capacity in AWGN, capacity of flat fading channels (channel side information at receiver, channel side information at transmitter and receiver, capacity comparisons), capacity of frequency-selective channels.

**W6:** Review of digital modulations (signal space analysis, passband modulations, amplitude and phase modulations, frequency modulation, pulse shaping), performance of digital modulations over fading channels (probability of error over AWGN channel, outage probability and average probability of error for fading channels).

**W7:** Effect of Doppler spread on differential modulations, inter-symbol interference for frequency-selective fading, modulations for major wireless standards, diversity systems, methods of obtaining diversity branches.

**W8:** Receiver diversity (diversity combining techniques, performance of diversity in fading channels), transmitter diversity, adaptive modulation and coding.

**W9:** Adaptive techniques (variable-rate, variable-power, variable-rate variable-power), variable-rate variable power MQAM, channel estimation error and delay.

**W10:** MIMO systems, parallel decomposition of MIMO channels MIMO channel capacity, MIMO diversity gain: beamforming.

**W11:** Diversity-multiplexing tradeoff, ISI counter measures, multicarrier modulation (MCM), MCM with overlapping subchannels, mitigation of subcarrier fading.

**W12:** Discrete implementation of MCM, FFT implementation of MCM-OFDM, OFDM challenges (peak-to-average power ratio, intercarrier interference).

**W13:** Spread spectrum, direct sequence spread spectrum, ISI and interference rejection properties of spread spectrum, basics of frequency hopping spread spectrum, maximum length sequences, rake receivers.
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/](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/](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
Carleton University
Department of Systems and Computer Engineering
SYSC 4607 Wireless Communications Winter 2020

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- **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).* **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) 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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