CARLETON UNIVERSITY
Department of Systems and Computer Engineering

SYSC 5608 Wireless Communications Systems Engineering Winter 2020

SYSC 5608 ≡ ELG 6168

Course Objectives:

- To learn the fundamental analytical dynamics of wireless communications (theory)
- To become familiar with the current and emerging wireless technologies (applications)

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Lectures: Tuesdays and Thursdays, 8:35 – 9:55 am, SA 417 (Southam Hall)

Office Hours: After the lectures and by appointment

Course Website: http://www.sce.carleton.ca/courses/sysc-5608/w20

Course Description: This course covers mainly the systems aspects of wireless communications. The emphasis is on the multiple access and related issues; the course also covers certain aspects of radio propagation, physical layer, medium access control (MAC) layer and networking layer. The course relies on fundamentals of communication theory and stochastic processes.

Prerequisites: Carleton University, Graduate Calendar: "**SYSC 5503** (Stochastic Processes) and **SYSC 5504** (Digital Communications), or their equivalents. May be taken concurrently."

Marking Scheme:

- Term Exam 1: 20% – Tue, Feb 04
- Term Exam 2: 25% – Tue, Mar 10
- Final Exam: 55% – (date and time will be set by the Examinations Services)

Note 1: The final examination is for evaluation purposes only. It will not be returned to the student. In order to pass the course, the final exam mark should be at least 50/100.
Note 2: Exercise questions will be posted regularly (but there will be no collected assignments).

Textbook: There is no single textbook that covers all the topics in this course. The students should rely mainly on the lecture notes. More than half of the lecture notes will be available online.

Reference Books:

- T.S. Rappaport, *Wireless Communications: Principles and Practice*, 2nd ed., Prentice-Hall PTR, New Jersey, 2002, ISBN 0-13-042232-0. [Main reference]
- D. Tse and P. Viswanath, *Fundamentals of Wireless Communications*, Cambridge, 2005. www.cambridge.org/9780521845274.

- A. Goldsmith, *Wireless Communications*, Cambridge, 2006. www.cambridge.org/9780521837163
- S. Haykin and M. Moher, *Modern Wireless Communications*, Pearson Prentice Hall, 2005.
- A.F. Molisch, *Wireless Communications*, Wiley, 2005.

Important Dates (tentative):

Tue	**Thu**
Jan 07: L01	Jan 09: L02
Jan 14: L03	Jan 16: L04
Jan 21: L05	Jan 23: L06
Jan 28: L07	Jan 30: L08
Feb 04: **L09 TE1**	Feb 06: L10
Feb 11: L11	Feb 13: L12
Feb 18: Fall break	Feb 20: Fall break
Feb 25: L13	Feb 27: L14
Mar 03: L15	Mar 05: L16
Mar 10: **L17 TE2**	Mar 12: L18
Mar 17: L19	Mar 19: L20
Mar 24: L21	Mar 26: L22
Mar 31: L23	Apr 02: L24

General Regulations:

Attendance: Students are expected to attend all lectures and lab periods. The University requires students to have a conflict-free timetable.

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

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**: Contact the instructor for any request for academic accommodation during the first two weeks of classes, or as soon as possible after the need for accommodation is known to exist. For more details, refer to

https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf.

- **Religious obligation**: Contact the instructor for any request for academic accommodation during the first two weeks of classes, or as soon as possible after the need for accommodation is known to exist. For more details, refer to 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.

- **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/.

- **Absences**: Medical certificates for absences from tests must be presented within one week after the test or assignment due date or tour date. Otherwise, the student will get zero from that component of the course.

Topics Covered: Actual coverage (as we progress) will be listed on the course web site.

- **Physical Layer Fundamentals of Wireless Communications**

- **Propagation and Link Budget**
  dB notation
  Antennas
  Pathloss
  Shadowing, coverage
  Channel measurements and simulation
  Link budget

- **Cellular Communications and Networks**
  Cellular communications principles
  Multiple access methods: FDMA, TDMA, CDMA, OFDM, random access
  Interference characterization
  Capacity, outage
  HetNets, small cells, distributed antennas, CRAN
  4G LTE & 5G networks

- **Wireless Channel Characterization**
  Multipath fading characterization
  Coherence time, Doppler spread
  Coherence bandwidth, power delay profile

- **Digital Modulation and Interference**
  Spectral efficiency
  Digital modulation methods, AMC (adaptive modulation and coding)
  Error performance in interference and fading

- **Diversity and Adaptive Equalization**
  Principles, types and performance of diversity combining
  Adaptive equalization techniques for combating multipath

- **Wireless Systems Issues**
  Scheduling, routing
  Admission control
  Multiuser diversity
  Interference management
  Radio resource management

- **Miscellaneous Applications**
  Non-terrestrial networks
  6G networks
  Sensor networks
  Cognitive radio
  Multihop/mesh/relay networks
  Cooperative communications
  WLAN (802.11)

Lecture Breakdown (22 lectures)**:**

1. Introduction to digital and wireless communications (**2 lectures**)
2. Antennas, electromagnetic propagation, pathloss, shadowing, link budget (**3**)
3. Multiple access, FDMA, TDMA, CDMA, OFDMA, contention-based (**2**)
4. Interference, interference management (**1**)
5. Radio access network architectures; cooperative communications; distributed antennas (**1**)
6. Cellular communications; 1G-5G technologies (**3**)
7. Scheduling (**2**)
8. Fading (**3**)
9. Error analysis in fading channels; spectrum, spectral efficiency (**1**)
10. Diversity and its impact on performance (**2**)
11. Miscellaneous applications (**2**)