CARLETON UNIVERSITY

Department of Systems and Computer Engineering

SYSC 5608 || ELG 6168 Wireless Communications Systems Engineering Winter 2022

COURSE OUTLINE (Jan 05, 2022)

Instructor: Halim Yanikomeroglu
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Website: Carleton University Brightspace portal.

Lectures: Mondays & Wednesdays, 08:35 – 9:55 am ET
Lectures will be delivered LIVE through Zoom.
Recurring Zoom link: https://carleton-ca.zoom.us/j/93146292053
The Zoom lectures will also be recorded and posted subsequently at Brightspace.

Office Hours:After the lectures and by appointment.

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.

Assumed Knowledge: Upon entry into the course, the students are expected to have an undergraduate level signals & systems, and digital communications background. Having taken SYSC 5504 Digital Communications will help.

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

Textbook: There is no single textbook that covers all the topics in this course. The students should rely mainly on the lecture slides and notes (will be available at Brightspace). There is no need to purchase a textbook.

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.
- W. Stallings, 5G Wireless: A Comprehensive Introduction, Pearson, 2021.
- B. Sklar and F. Harris, Digital Communications: Fundamentals and Applications, Pearson, 2021.

***Light* References**: Recent issues of IEEE magazines (IEEE Communications Magazine, IEEE Wireless Communications, IEEE Vehicular Technology Magazine, IEEE Communications Standards Magazine, IEEE Network, IEEE Spectrum, …), IEEE Communications Surveys and Tutorials, sci & eng websites, news portals, blogs, YouTube videos (ex: Halim Yanikomeroglu), …

Grading: Term exam: **20%** (Monday, Feb 28, 08:30–10:00 ET)
Project: **40%** (oral presentation & written report)
Final Exam: **40%** (date to be determined)

Term Exam: Open-book during lecture time (90 mins) on Feb 28; more information will be posted at a later time.

Final Exam: Open-book (3 hours); more information will be posted at a later time.
- The final examination is for evaluation purposes only and will not be returned to students.
- In order to pass the course, the final exam mark should be at least 50/100.

Exercises: Exercise questions will be posted regularly (but there will be no collected assignments).

Course Project: The project will be on a forward-looking topic in wireless communications and networks. For instance, last year's (Winter 2021) project topic was "Broadband Connectivity in Rural and Remote Canada: Present (2021) and Future (2030s)". The project topic and outline will be posted by early February. The project includes a written report and a presentation (~15 mins). Each student will do the project individually.

Wireless News: Subscribe to at least one wireless news portal:
- https://www.fiercewireless.com
- https://www.wired.com/tag/wireless
- https://www.mobileworldlive.com
- https://www.rcrwireless.com
- https://www.eweek.com/mobile
- https://www.5gtechnologyworld.com
- https://mobilesyrup.com (Canadian)

Lecture Dates:

Mondays	Wednesdays
Jan 10: L01	Jan 12: L02
Jan 17: L03	Jan 19: L04
Jan 24: L05	Jan 26: L06
Jan 31: L07	Feb 02: L08
Feb 07: L09	Feb 09: L10
Feb 14: L11	Feb 16: L12
Feb 21: Winter break	Feb 23: Winter break
Feb 28: L13 (term exam)	Mar 02: L14
Mar 07: L15	Mar 09: L16
Mar 14: L17	Mar 16: L18
Mar 21: L19	Mar 23: L20
Mar 28: L21	Mar 30: L22
Apr 04: L23	Apr 06: L24
Apr 11: L25	

General Regulations:

- **Attendance:** Students are expected to attend all lectures.

- **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 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 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*). **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

- **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).

- **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

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

- **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, VHetNets, small cells, distributed antennas, CRAN, CoMP
  4G LTE & 5G networks
  3GPP

- **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 (satellite and aerial networks)
  6G networks
  Sensor networks
  Cognitive radio
  Multihop/mesh/relay networks
  Cooperative communications
  WLAN (802.11)

Lecture Breakdown (24 lectures)**:**

1. Introduction to digital and wireless communications (**3**)

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 (RAN); cooperative communications; distributed antennas (**1**)

6. Cellular communications; 1G-5G+ technologies (**3**)

7. Scheduling (**2**)

8. Fading (**2**)

9. Error analysis in fading channels; spectrum, spectral efficiency (**1**)

10. Diversity and its impact on performance (**2**)

11. Miscellaneous applications (**2**)

12. Project presentations (**2**)