

ECE 414 - Wireless Communication
ECE 614 - Communications over Fading Dispersive Channels
Spring 2026

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Office hours: TBA

Calendar Description Overview of mobile communications, characterization and modelling of wireless fading dispersive channels, optimum receiver structure, transmission performance in fading channels, diversity and performance improvement, co-channel interference, spread spectrum and multiple access, mobility and resource management of cellular systems, and some special topics.

Schedule

Lectures	2:30pm - 3:50pm TTh, E7 4433 06/29, 07/20, 4:00pm-05:20pm M, E7 4437. Those are make-up lecture time slots for the middle term exam week if there is a need. Otherwise, there is no lecture in those two time slots.
Tutorials	TBD*

* TA is not a full TA, so the tutorials will not be held every week. There will be one tutorial session, which will provide an introduction to basic programming for wireless communication simulations. The schedule for those sessions will be announced later on LEARN.

Textbook and References

Textbook:

- A. Goldsmith, *Wireless Communications*, Cambridge University Press, 2005 (reprinted 2007,2009). Access e-book in the library of UW at: <https://www-cambridge-org.proxy.lib.uwaterloo.ca/core/books/wireless-communications/800BA8A8211FBECB133A7BB77CD2E2BD>

Suggested references. The following reference books will be helpful for your reading if you wish to read more.

- D. Tse and P. Viswanath, *Fundamentals of Wireless Communications*, Cambridge Univ. Press, 2005.
- A. F. Molisch, *Wireless Communications*, Wiley, 2010, 2019.

Grading.

Component /Activity	Due Date	Location/Submission Method	Weight (%)
Project Report /Presentation Slides	July 29 (11:59pm ET)	Learn Drop box	40%
Final exam			60%

Audit option. Project only.

Homework Assignments. Homework assignments and solutions will be posted on LEARN. Homework assignments are not graded, but are helpful for the final exam.

Projects. The project includes two types of the projects. You may choose to do one of them.

Project 1 This project includes a review and a presentation on a selected publication. First, select a published paper from a list posted on LEARN, or choose one related to the topics of this course by yourself (needing the approval of the instructor). Write a review of the paper, summarizing its main contributions, and also evaluating its quality including both its strengths and weaknesses. Discussions on different solutions with your own ideas are highly encouraged.

Project 2 The purpose of the project is to give you some basic experience with OFDM signal processing in a receiver system. You will be given a unique received baseband OFDM signal that has gone through an unknown channel. The received signal contains a preamble and an OFDM symbol with 128 sub-carriers, where each sub-carrier contains a 16-QAM symbol. The goal of the project is to recover the ASCII message in the received signal by employing realistic receiver processes. You will also be given a skeleton python file with recommended functions and steps in a receiver system, though any programming language can be used to recover the message (e.g., MATLAB). You must submit a report detailing the steps and processes to recover the message. Specific details will be provided on LEARN.

Differentiation for the classes. The requirements for ECE 414 and ECE 614 differ for both projects. For Project 1, each class will be assigned different research papers. For Project 2, ECE 414 students are only required to recover the transmitted signal in ASCII format. In contrast, ECE 614 students must simulate various receiver structures under both AWGN and fading channels to recover the transmitted signal in ASCII format.

The deadline to submit the report for Project 1, and the report and code for Project 2 on LEARN is on July 29 (11:59pm ET). You will also give about a 10-15 minutes presentation, and questions may be asked. Evaluation will be based on the quality of your presentation and the demonstration of your understanding of the paper for the first project and how well you dealt with

SNR in the simulation of the second project. The exact time of presentations will be determined later depending on the total number of the presentations. For the project whichever you choose, you can either work on your own, or work with a partner, i.e., form a team of two.

Learning Outcomes. By the end of this course, students should be able to

- Understand the basic characteristics of wireless channels.
- Appreciate the fundamental role of diversity in wireless communications.
- Have a deep understanding of different transmission and reception techniques.
- Have a basic understanding of cellular systems.
- Analyze and compare the performance of different coding schemes.

Tentative Class Plan. There is no lectures on May 11 and, June 8, which are extra lecture time slots.

Main Contents

1. Introduction to some basic concepts of wireless communications (1 lecture)
2. Characterization of the wireless channel (3 lectures)
 - (1) Fading characteristics (slow and fast)
 - (2) Multipath delay spread and coherence bandwidth
 - (3) Doppler spread and coherence time
 - (4) Frequency-selective fading and frequency-nonselective fading
 - (5) Propagation loss models
3. Digital modulation and detection (4 lectures)
 - (1) Digital modulation techniques
 - (2) Power spectral densities of shift-keyed signals
 - (3) Probability of error in additive white Gaussian noise (AWGN)
 - (4) Frequency diversity and OFDM
4. Receiver techniques for fading dispersive channels (4 lectures)
 - (1) Receiver diversity
 - (2) Transmit diversity
 - (3) Diversity analysis
 - (4) MIMO Diversity

- (5) Equalization
- 5. Spread spectrum and multiple-access techniques (5 lectures)
 - (1) Direct sequence spread spectrum
 - (2) Frequency-division multiple access (FDMA)
 - (3) Time-division multiple access (TDMA)
 - (4) Code-division multiple access (CDMA)
 - (5) Spectral efficiency
 - (6) Random access
- 6. Fundamentals of cellular communications (3 lectures)
 - (1) Frequency reuse
 - (2) Dynamic resource allocation
 - (3) Interference reduction
- 7. Special topics (2 lectures, if the time permitted)
 - (1) Ad hoc wireless network
 - (2) Coding for wireless channels
 - (3) Space-time modulation and coding
 - (4) Reconfigurable intelligent surfaces (RIS)

Academic Integrity, Discipline, Grievances, and Appeals

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check www.uwaterloo.ca/academicintegrity/ for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please be certain to contact the departments administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity [check www.uwaterloo.ca/academicintegrity/] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about rules for group work/collaboration should seek guidance from the course instructor, academic advisor, or

the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities: The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term [check <http://www.studentservices.uwaterloo.ca/disabilities/>].

Turnitin.com: Text matching software (Turnitin) may be used to screen assignments in this course. Turnitin is used to verify that all materials and sources in project reports are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time project details are provided, about arrangements and alternatives for the use of Turnitin in this course.