

ECE 414 - Wireless Communication
ECE 614 - Communications over Fading Dispersive Channels
Spring 2025

Instructor: Professor G. Gong
Office: E7 5436, x45650, ggong@uwaterloo.ca
<https://uwaterloo.ca/scholar/ggong>
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, capacity analysis in cellular environments.

Schedule. Lectures: 2:30pm - 3:50 TTh.

Textbook.

D. Tse and P. Viswanath, Fundamentals of Wireless Communications, Cambridge Univ. Press, 2005. Free online: https://web.stanford.edu/~dntse/wireless_book.html. Or you may wish to access e-book in the library of UW at: <https://www.cambridge.org/core/books/fundamentals-of-wireless-communication/04C749B2C2247374B36E573078356350>

Grading. Projects (40%) + Final exam (60%)

Audit option. Projects 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. A python skeleton file will be provided which provide you a very basic simulation of an OFDM system, where all timing and synchronization is perfect. The only piece that is missing is the decoding of the OFDM data symbol. Your task is to write this sub-routine which will return a list of 4-QPSK symbols that represent the decoded data for each OFDM symbol and a presentation. (You may also use Matlab for simulation.) The OFDM parameters are based on actual 802.11a specifications.

The deadline to submit the report on LEARN is on July 30 (11:59pm ET), the last day of classes. For both projects, you are requested to submit a report about your project. You will also give a 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. 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.

Main Contents

1. Characterization of the wireless channel
 - (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
2. Point-to-point communication
 - (1) Detection, non-coherence and coherence

- (2) Receiver techniques for fading dispersive channels (Rx/Tx diversity)
- (3) Frequency diversity and OFDM
- (4) Channel uncertainty
- 3. Cellular systems: multiple access and interference management
 - (1) Narrow band systems
 - (2) Wideband systems CDMA
 - (3) Wideband systems OFDM
 - (4) Spectral efficiency
 - (5) Random access
- 4. Capacity of wireless channels
 - (1) AWGN
 - (2) SIMO, MISO, and power allocation
 - (3) Fading, CSI and ML-based CSI estimation
- 5. Multiuser capacity and opportunistic communication
 - (1) Successive interference cancellation
 - (2) Up/down link AWGN
 - (3) Techniques for fading channel
 - (4) Multiuser diversity

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 assignments 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 assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.