Boston University, ECE Department
ENG EC508 A1 Wireless Communication, Spring 2019

Course Information

Motivation and overview: Unlike tethered communication links (such as wires), the wireless channel varies rapidly with time and user mobility. This channel uncertainty was historically viewed as an obstacle to reliable communication. However, over the past few decades, sophisticated techniques have been developed to tame as well as exploit the uncertainty inherent to wireless channels. Thanks to these efforts, today there are over 5 billion cellular subscriptions and an ecosystem of untethered devices ranging from smartphones to tablets and laptops. This course is an introduction to the fundamental principles underlying modern wireless communications systems and standards, with an emphasis on the physical layer (i.e., the interface between waveforms and bits). The course will cover wireless channel modeling, optimal constellation and signaling design, channel coding, and network architectures to serve large numbers of users.

Course catalog description: Fundamentals of wireless communication from a physical layer perspective. Multipath signal propagation and fading channel models. Design of constellations to exploit time, frequency, and spatial diversity. Reliable communication and single-user capacity. Interference management, multiple-access protocols, and multi-user capacity. Cellular uplink and downlink. Multiple-antenna systems and architectures. Connections to modern wireless systems and standards.

Prerequisites: This course assumes knowledge of probability, linear algebra, and signals and systems at the undergraduate level. In addition, the homework will require proficiency in MATLAB. If you have have any doubts about your understanding of these concepts, please check with the instructor. In addition to these prerequisites, it is assumed that you have the interest, commitment, and maturity for understanding concepts in depth. Since this is a graduate-level class, you will be expected to spend time outside of class reading the textbook in order to gain a deeper understanding of both the key concepts and the underlying technical details.

Logistics:

Instructor:	Prof. Bobak Nazer Office: PHO 439, Email: `bobak@bu.edu`
Office hours:	Mondays 2:15pm-3:15pm and Thursdays 11:30am-12:30pm in PHO 439
Lectures:	Mondays and Wednesdays 12:20-2:05 pm in CAS 237
Website:	`http://learn.bu.edu/`
Discussion board:	`http://piazza.com/`
Textbook:	D. Tse and P. Viswanath, *Fundamentals of Wireless Communication.* **Available online:** `http://stanford.edu/~dntse/wireless_book.html`
Grading:	Homework: 25%, Midterm Exam: 25%, Final Exam: 25%, Final Project: 25%

Piazza: This semester we will be using Piazza as a discussion board. The system is highly catered to getting you help quickly and efficiently from myself and your fellow classmates. You have the option of asking (and answering) questions anonymously, meaning that your name will only be displayed as "Anonymous" to everyone else. Rather than emailing questions, I encourage you to post your questions on Piazza. If you have any technical issues or feedback for the developers, email team@piazza.com.

Additional references: The following books should be on reserve at the Science and Engineering Library:

- A. Goldsmith, *Wireless Communications*, Cambridge University Press, 2005.
- U. Madhow, *Fundamentals of Digital Communication*, Cambridge University Press, 2008.

Homework: Each student must submit an original set of solutions to the instructor at the *beginning of class* on the due date. Requests for late submissions and/or extensions will not be entertained (except under exceptional circumstances which must be discussed with the instructor).

The homework will have two components: "Problem Sets" that consist of pen-and-paper exercises and "Mini-Projects" that involve an in-depth MATLAB programming exercise.

MATLAB Mini-Projects: To receive full credit, you should turn in *all of the code* required to generated your solution as well as the solution itself (such as a plot). See `http://www.bu.edu/tech/services/cccs/desktop/distribution/mathsci/matlab/` for detailed instructions on installing MATLAB on your computer.

Collaboration policy: While you may discuss homework problems with other students for clarifying your understanding, you must *independently solve* and write your own solutions. Contact the instructor if you are not sure whether the extent of your collaboration with other students is acceptable. You will be cheating yourself if you simply copy your friend's solution without understanding it. When detected, the penalties can be severe.

General advice: The primary function of homework is to clarify concepts and develop proficiency, depth, and rigor through practice. Working on the homework problems is a crucial part of the learning process and will invariably have a major impact on your understanding of the material and, in turn, on your exam performances and final grade. If you miss a problem, study the solutions. Do not wait until the last minute before doing the homework.

Exams: Exams will be closed book and closed notes. Calculators, computing, and communication devices are neither needed nor permitted. However, you are allowed to bring one 8.5 $\times$ 11-inch sheet of *handwritten* notes (both sides) to the midterm exam and two sheets (all four sides) to the final exam. (If you want to bring your sheet from the midterm to the final, then you will have only one additional sheet.)

Final Project: Students will have the opportunity to explore a topic related to wireless communication in depth through a final project. Some possibilities for the project include a theoretical analysis, MATLAB simulation, literature survey, or some combination thereof. Grading will be based on a project report and an in-class presentation, both due at the end of the semester. A separate document provides details on the project format and requirements. A list of suggested topics will be made available shortly.

Schedule: The table below provides an overview of the topics covered in each lecture, the required readings, the dates that homework will be assigned and due, and the exam days. Please note that this schedule will most likely be *updated throughout the semester* to ensure that topics are covered in sufficient depth and to adapt to any unforeseen circumstances. The abbreviation PS refers to Problem Set, MP to Mini-Project, and [T&V] to the textbook by Tse and Viswanath.

Date	**Topic**	**Reading**	**Assigned**	**Due**
Jan. 23	Intro & Digital Communication	Review Notes	PS 1	
Jan. 28	Gaussians and Detection	[T&V] App. A	PS 2	
Jan. 30	Channel Modeling	[T&V] Ch. 2	MP 1	PS 1
Feb. 4	Channel Modeling	[T&V] Ch. 2		
Feb. 6	Channel Modeling	[T&V] Ch. 2		PS 2
Feb. 11	NO CLASS (Conference Travel)			
Feb. 13	NO CLASS (Conference Travel)			
Feb. 19	Detection under Fading	[T&V] Ch. 3.1	MP 2	MP 1
Feb. 20	Time Diversity	[T&V] Ch. 3.2		
Feb. 25	Time and Antenna Diversity	[T&V] Ch. 3.2, 3.3	PS 3	
Feb. 27	Antenna Diversity	[T&V] Ch. 3.3		MP 2
Mar. 4	Frequency Diversity	[T&V] Ch. 3.4	PS 4	
Mar. 6	Viterbi Algorithm	[T&V] Ch. 3.4		PS 3
Mar. 18	Cellular Systems	[T&V] Ch. 4		PS 4
Mar. 20	**Midterm Exam**	[T&V] Ch. 4		
Mar. 25	Cellular Systems	[T&V] Ch. 4		
Mar. 27	Cellular Systems	[T&V] Ch. 4		
Apr. 1	WiFi Systems	[T&V] Ch. 4		
Apr. 3	Channel Capacity	[T&V] Ch. 5	MP 3	Proposal
Apr. 8	Channel Capacity	[T&V] Ch. 5		
Apr. 10	Multi-User Capacity	[T&V] Ch. 6		
Apr. 17	Multi-User Capacity	[T&V] Ch. 6	PS 5	MP 3
Apr. 22	Multi-User Capacity	[T&V] Ch. 6		
Apr. 24	MIMO Channels	[T&V] Ch. 7.1, 8		
Apr. 29	MIMO Architectures	[T&V] Ch. 8		PS 5
May 1	**Project Presentations**			Report
May ?	**Final Exam**			

General Policies:

Academic misconduct: The student handbook defines academic misconduct as follows:

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Academic misconduct is conduct by which a student misrepresents his or her
academicaccomplishments, or impedes other students' opportunities of being
judged fairly for their academic work. Knowingly allowing others to represent
your work as their own is as serious an offense as submitting another's work
as your own.
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This basic definition applies to ENG EC508 A1. If you are ever in doubt as to the legitimacy of an action, please talk to me immediately. The penalty for academic misconduct at BU is severe. For further information on the BU Academic Code of Conduct, visit the following website: `https://www.bu.edu/academics/policies/academic-conduct-code/`

Make-up exams: There will be no make-up exams. If there is a legitimate reason for missing an exam, such as illness as supported by a doctor's note, then the scores of other exams will be used appropriately to compensate for the missed exam. If there is no legitimate reason provided for missing an exam, a grade of *zero* will be assigned for the missed exam.

Incomplete grades: Incomplete grades will not be given to students who wish to improve their grade by taking the course in a subsequent semester. An incomplete grade may be given for medical reasons if a doctor's note is provided. The purpose of an incomplete grade is to allow a student *who has essentially completed the course* and who has a legitimate interruption in the course, to complete the remaining material in another semester. Students will not be given an opportunity to improve their grades by doing extra work.

Drop dates: Students are responsible for being aware of the drop dates for the current semester. Drop forms will not be back-dated.