ECE 515/792-068 "Digital Communications"

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Office hours: After class or by appointment. EOL and on-campus students are encouraged to contact the instructor by email to schedule a meeting.
TA information is announced in Moodle.

Prerequisites: A graduate probability and stochastic processes course (ECE 514 or equivalent) is required for ECE 792-068 and is helpful, but not required, for ECE 515. An undergraduate probability course is required for ECE 515 students. Though not required, a background in Linear Algebra (MA 305/405 or equivalent) and signal processing is helpful for both courses. Necessary probability/random processes and linear algebra concepts will be reviewed in the lectures and homework assignments. Matlab background is preferred.

Textbook: Proakis, G., *Digital Communications*, McGraw-Hill, Fourth Edition. ISBN: 0-07-232111-3 or Fifth Edition (co-authored by Salehi, M., ISBN 9780072957167).
Lectures notes and handouts will be posted on the course website.
The textbook is useful as a reference (in addition to the notes), and many homework assignments are related to the textbook material and problems.

Course Objectives: To develop fundamental design and analysis techniques necessary for understanding and working with modern digital communication systems.

Course Description: A graduate-level course in digital communications. Functions and interdependence of various components of digital communication systems will be discussed. Topics include modulation and demodulation, statistical channel modeling, optimal receiver design, performance analysis, and fundamentals of information theory. The focus of this course is on design and analysis of general communication systems. Specific communication systems will be discussed in class as time permits and addressed in group projects.

Grading:

Homework	10% (ECE 792) and 15% (ECE 515) (drop the lowest score)
Peer Grading	5% (drop the lowest score)
Midterm	30%
Final exam	35%
Group Project	15% (ECE 515) and 20% (ECE 792)

+/- grading policy will used.
Audit Requirements: Audit students will receive AU grade if they turn in and receive a passing score on at least half of the homework assignments, or pass one exam, or pass one part of the project.

Credit will not be given for both ECE 515 and ECE 792-068.

Homework: Homework assignments will be posted on the course website and submitted via Moodle Workshop. These assignments consist of problems that strengthen understanding and retention of course material. Students will grade their peers' homework using Moodle Workshop. Peer grading has been demonstrated to improve learning and retention of the material. Solutions and grading instructions will be posted. Students should carefully examine the grading guidelines and feedback and contact the TA or the instructor if they have questions on grading or prefer the homework regraded by the TA. Opting out of peer grading is discouraged but possible. This option will be discussed in the first lecture. You *must* email the instructor prior to the due date of the first homework if you would like to explore this option. Moreover, students should compare the posted solutions and the grading guidelines with their own work and determine the areas where additional practice or review is needed.

Group Project (2-3 members): For ECE 792 students, the project will have two required components: (1) simulation and performance analysis of several modulation methods; (2) literature review/presentation on a selected topic, e.g., multicarrier, multiuser or multiple antenna systems, millimeter wave channels, fiber optics communication, linear predictive coding, etc. ECE 515 students are required to submit the first project component. The second component is optional.

Depth of presentation in class will vary. The homework assignments and project will complement the material presented in class.

Exams will contain problems and multiple-choice questions. Exams will be closed-book. Three pages of handwritten notes and a conventional calculator will be permitted. The final exam will be comprehensive. Exam samples will *not* be provided. Exams will be based on homework problems, textbook material, and class notes.

Homework and exams will differ for ECE 515 and 792.

Computer Software: MATLAB and word processing software.

Artificial Intelligence (AI) has become an increasingly influential and powerful tool in various fields, including education. In this course, you are welcome to explore and incorporate AI-related concepts and technologies, provided they align with the learning objectives and academic integrity standards of this class. Below are the *acceptable uses of AI in this course*:

- *AI as a Learning Aid:* You are encouraged to leverage AI-based tools and platforms to enhance your learning experience. These tools can provide personalized study resources, interactive simulations, and adaptive learning experiences tailored to your individual progress and needs.
- *Ethical Considerations:* In any AI-related work, it is crucial to consider the ethical implications of AI technologies. Ensure that your use of AI aligns with ethical guidelines, respects privacy, avoids bias, and promotes fairness and transparency.
- *Collaboration with AI Systems:* You may collaborate with AI systems in projects or assignments, but remember that the primary goal is to enhance your understanding of course materials and concepts. Avoid over-reliance on AI to complete tasks without actively engaging with the subject matter. Moreover, the content and references provided by some AI tools are often unreliable or false. You are responsible for satisfying the assignment requirements, so check all AI content and citations very carefully!

While we encourage the integration of AI in your learning experience, there are certain *uses of AI that are not permitted in this course:*

- *Cheating and Academic Dishonesty:* Using AI to plagiarize or produce work without proper attribution is strictly prohibited. Per the Code of Student Conduct, all work submitted must be your original creation, with appropriate citations when referring to external sources.
- *Unauthorized Assistance:* Do not use AI to access unauthorized materials or solutions during examinations, quizzes, or other assessments. Any form of unauthorized assistance is a violation of academic integrity.

Late work submission and make-up policy: Late homework assignments or peer grading will not be accepted. Please note that peer grading for each assignment will be available only to those students who have turned in the assignment. The lowest homework score and the lowest peer-grading score will be dropped (including zero scores for missed work). Project deadline extension may be granted by the instructor in rare cases. Please email prior to the deadline. The instructor or TA should not be contacted directly if a student misses an exam and wishes to schedule a make-up exam and for other excuses caused by emergencies and medical problems. Please contact the Division of Academic and Student Affairs (DASA) https://dasa.ncsu.edu/students/absence-verification-process/ email: absence-verification@ncsu.edu

Students with Disabilities Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, Campus Box 7509, 919-515-7653. For more information on NC State's policy on

working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG02.20.01) https://policies.ncsu.edu/regulation/reg-02-20-01/

Academic Integrity By taking this course, you agree to follow all provisions of the code of academic integrity of NC State University, including the 'Pack Pledge:' "I have neither given nor received unauthorized aid on this test or assignment."

In an effort to affirm and respect the identities of transgender students in the classroom and beyond, please contact me if you wish to be referred to using a name and/or pronouns other than what is listed in the student directory.

Supplementary References and Useful Web Sites:
J. Barry, E. A. Lee, D. G. Messerschmitt, *Digital Communication*, Kluwer, 2004.
R. E. Ziemer, R. L. Peterson, *Introduction to Digital Communication*, Prentice Hall, 2001.
J. G. Proakis, M. Salehi, *Contemporary Communication Systems Using MATLAB and Simulink*, Thomson Brooks/Cole, Second Edition, 2004.
http://www.cyclismo.org/tutorial/matlab/

Syllabus

- Basic elements of digital communication systems; communication channels; mathematical models; brief history; performance measures. (Ch.1)
  Objectives: Students will learn to identify functions of different components of a digital communication system.
- Bandpass Signals and Systems, Signal Space Representations, Digitally Modulated Signals (Ch. 2 and 3 (5th ed); Ch. 4 (4th ed.)).
  Objectives: Students will convert a digital bandpass signal into an equivalent complex lowpass signal and represent a digital signal using several modulation methods.
- Characterization of Additive White Gaussian Noise Channels; Optimum Receivers; Correlation and Matched Filter Receivers; Performance of the Optimal Receiver. (Ch. 4 (5th ed); Ch, 5 (4th ed.))
  Objectives: Students will design correlation and matched filter receivers, compute the probability of error for several modulation methods, and compare modulation methods based on their error rates and spectral efficiencies.
- Introduction to Information Theory--- Entropy, Source Models, Source Coding, Average Mutual Information, Channel Models and Channel Capacity. (Ch. 6 (5th ed.); Ch. 3 and 7 (4th ed.))
  Objectives: Students will compute theoretical bounds on the rates of digital communication systems and employ codes for data compression.
- Specific communication system examples.
  Objectives: Students will apply the theoretical principles learned earlier in the course to investigate specific digital communication systems in their group projects (optional for ECE 515). Applications will also be discussed in the lectures.