Please carefully read this and all other course related instructions, particularly those pertaining to the Academic Honesty Policy!

Course Mechanics:
Pre-requisites: ECE242: Communication Systems, ECE 440/271: Random Processes (may be taken as a co-requisite), and MATLAB™ familiarity (or instructor permission)
Credit Hours: 4
Lectures: Tue, Thu 4:50-6:05 p.m, CSB 523

Course Description:
Communication systems are at the heart of today’s information driven economy and support our modern-day lifestyles and even our very existence. From the familiar telephone that was invented over a century ago, to modern day cell phones, wireless networks, and Internet, as well as radio, television, cable and satellite systems, we now rely on electrical communication systems in almost all aspects of our lives.

The course focuses on the technologies underlying these systems, which constitute the field of digital communications. Topics include digital transmission and reception, signal space representations, spectral analysis of digitally modulated waveforms, design considerations for bandlimited channels, introductory concepts of information theory, and error correction coding.

The course is intended for graduate/senior undergraduate level students. While the course is intended to serve as an introduction to digital communications, the pre-requisites/co-requisites listed are absolutely necessary.

Course Objectives:
The primary goal of the course is to provide the student an understanding of the principles, techniques, trade-offs, and fundamental limits in modern digital communication systems. Upon successful completion of the course, students should be able to develop signal space representations for digital modulation methods and recognize representations published in the literature; compare the strengths, weaknesses, and requirements of different modulation techniques; model constraints imposed by a bandlimited channels and formulate methods for dealing with these constraints, describe the concept of channel capacity and the promise of coding; describe the basic operating principles of block and convolutional codes and implement encoding and decoding algorithms. In addition, the student should develop competency in modeling and analysis communication system elements and an appreciation for the inter-relations within the different elements in modern communication systems.

Course Outline:
The course is an introduction to modern digital communications at a graduate/senior undergraduate level. The coverage emphasizes a conceptual understanding of principles, techniques, and fundamental limits and trade-offs in digital communication systems. The focus will be on modulation and coding for the AWGN channel setting, with discussion of the latter focused on the power-limited region.

1. **Introduction:** Motivation for digital communication systems, Analog vs. digital communication systems, system overview, channel characteristics.

2. **Characterization of Communication Signals and Systems:** Representation of bandpass signals and systems, representation of bandpass noise, vector space concepts for signal representation.

4. **Channel Capacity:** Fundamental limits for communication systems, capacity for the bandlimited AWGN channel, asymptotic behavior.

5. **Channel Coding:** Introduction to error correction codes principles of encoding and decoding. Linear block codes and their properties, Hamming and cyclic codes, overview of cyclic codes, Reed-Solomon and BCH codes. Elementary concepts of convolutional codes, Viterbi decoding. MAP decoding and iterative decoding methods. LDPC codes. Concatenated codes and Turbo-codes.

6. **Selected Topics:** (time and background permitting or through class projects) Spectral characteristics of digital modulation methods, representations of bandpass stationary stochastic processes, regenerative repeaters and link budget analysis, coded modulation and multi-level modulation for bandlimited channels, synchronization, equalization and sequential detection for tackling ISI, wireless communications and multiple-access, joint source/channel coding, cooperative communications.

**Text:**

Notes will be provided electronically and a text is not required.

**References**


*The text and the first three reference books will be made available on reserve at the library for the duration of this semester.*

**Grading:**

- Homework: 20%
- Midterm: 30%
- Final: 30%
- Term Project: 20%

For the project, 70% of your grade will be based on the report and 30% on the presentation in class. Also see additional information on projects later in this document.

**Tentative Exam Schedule:**

- Mid-term Exam: TBD
- Final Exam: Thursday, December 21, 12:30pm CSB 523 (subject to change)

**Instructor:**

Prof. Gaurav Sharma  
Office hours: 9:00-10:00am, Thu.  
Office: Hopeman 417  
Email: gsharma@ece.rochester.edu  
Homepage: [http://www.ece.rochester.edu/~gsharma](http://www.ece.rochester.edu/~gsharma)

*If you are unable to make these times because of valid reasons, you may request additional office hours by appointment.*
Course Web Sites:

Homework assignments, handouts and general announcements relating to the class will be posted on the Blackboard course web-site accessible from:

- [http://learn.rochester.edu/](http://learn.rochester.edu/)
  You will need your UR NETID to access the Blackboard course content.

The course sheet and general information on the class is also available at the ECE course website:
- [http://www.ece.rochester.edu/courses/ECE244](http://www.ece.rochester.edu/courses/ECE244)

Academic Honesty Policy:

The University of Rochester academic honesty policy applies to all assignments and exams for this class. The full-text of the academic honesty policy can be found at:
- [http://www.rochester.edu/College/CCAS/AdviserHandbook/AcadHonesty.html](http://www.rochester.edu/College/CCAS/AdviserHandbook/AcadHonesty.html)

In addition to the general guidelines mentioned in the above policy, for this course I require that: In examinations, you must work individually with no communication with others and use only materials/tools that have been explicitly allowed. For homework, you may discuss problems with your colleagues but final solutions need to be worked out, written and submitted individually. **Any external material used should be clearly cited.** In your own writings (example project reports, homework solutions, proposals etc), **no more than one or two sentences may be used verbatim from any source. READ THESE INSTRUCTIONS CAREFULLY!** If any aspect of the academic honesty policy and guidelines for this course are unclear, please ask me for clarifications. Lack of awareness or understanding of this policy will not be an acceptable excuse or defense against disciplinary action.

Scheduling Issues:

1. Homeworks are due on the day indicated and should be handed in at the **start of class**. No homeworks will be accepted more that 5 minutes into the lecture session. If you need to travel, you may choose to typeset or scan in your homework and email it before the time it is due.

2. The **schedule for the course final exam** is set by the registrar and announced with the course timetables. Please note the exam times and make your vacation, travel, and other extra-curricular plans for the end of the semester taking this schedule into account. No changes are possible in this schedule under normal circumstances.

3. The tentative schedule for the mid-term exam is also listed on the course sheet. Again, no changes will be made to this under normal circumstances.

4. If you cannot attend a class lecture, please contact a classmate to borrow notes and find out what was covered in the lecture. Depending on questions and discussion, the topics we cover can and will vary.
Class Project

Students taking the course for graduate credit are required to complete a project on a topic related to digital communications. The primary intent of the project is to expand the learning beyond the material presented in class in a focused area. Students are strongly encouraged to select projects based on their own research/learning interests. Projects must have a simulation/analysis element and purely literature surveys are not acceptable. Team projects are preferred over individual projects and you may work in groups of up to 4 students. Each group is expected to share their work with the class in a brief seminar and turn in a report. Grading will be based on the project report, presentation, implementation demonstration, and in-class participation during presentations.

Project Topic:
The project is your opportunity to explore an area of Digital Communications for deeper exploration. It is your job to identify an area that interests you and enough of your peers (in order to form a project team). For this purpose, you may find it helpful to read articles published in IEEE Communications Magazine and IEEE Signal Processing Magazine. These provide tutorial/review articles covering the significant developments in the field. You may also wish to consult recent issues of IEEE Transactions in the Communications and Signal Processing areas for ideas. By the project proposal deadline you should have your topic identified and one/two key journal paper references on which you will base your work. These should be included along with your proposal. NOTE: Conference papers will not be acceptable as primary references for your project.

Project Report:
The project report should be under 10 single-spaced pages (additional pages may be allowed for images/figures/citations). It should be readable and understandable at the general level of the class. Explain and outline the central ideas of the technique you are investigating and explicitly indicate what is your own work. Clearly state your conclusions and provide comparisons with other related published literature if appropriate. Cite references for all material that is not original to you (ideas/algorithms/software/papers/reports) that you use in the project. Be sure to express yourself in your own words. Verbatim reproduction of more than two/three sentences from any source is not acceptable. Please read the Academic Honesty policy section of this document carefully. Any plagiarism will be reported and be subject to disciplinary action by the University. Do not include any programs in your report (small code segments may be included for illustration of ideas). Software should be submitted separately by email to assist in the evaluation of your work (submit a single zip file or UNIX tarred+compressed file containing all programs and sub-directories – do not include any executables, but do include instructions on how to run the software and appropriate data if required). The report should be typeset using a word-processing or desktop publishing package. In addition to a printed copy of the report, you should turn in an electronic copy of your project report. Electronic report submissions must be in PDF (portable document format).

Several excellent guides are available on the web for how to write a good paper/report. See for example:

http://infolab.stanford.edu/~widom/paper-writing.html

Project Presentation:
The objective of the presentations is to learn about each other’s projects. They also provide an opportunity to rehearse your presentation skills. Presentations should be typeset using suitable software (e.g. Microsoft Powerpoint, Latex Beamer Package, etc) and will utilize overhead projection. You are required to attend all project presentations any absence will incur a penalty equal to 20% of your project grade.

Useful Tips: Spend time and energy up-front planning a clear and logical organization for your presentation connecting to and building upon concepts that your audience is likely to be familiar with. Anticipate and have data/results to answer obvious questions that are likely to arise. During the presentation, speak loudly and clearly in full sentences and make eye contact with your audience. Use a pointer to point to images/graphs/diagrams projected on the screen. Ensure that all graph axes are correctly labeled and use a consistent set of terms throughout your presentation. Limit the material to 6–8 bullets of key “talking-points” on each slide. On your slides, do not use full sentences, only use key phrases that remind you what to talk about and convey the central idea to the audience. Use pictures/graphs instead of words wherever possible. Ensure that you stick to the allotted time (allow 2 – 4 minutes per slide). Doing a few practice runs will help improve your final presentation. Remember that audience attention peaks at the beginning and the end of your talk - so be sure to present an outline of your talk at the beginning and to summarize/highlight the conclusions at the end.

You will find several good guides online that provide information on how to prepare and deliver a good presentation. See for example:


Implementation Demonstration:
You will be required to submit working code to demonstrate your project implementation. Your code should function in the existing University computing environment. For example, you can submit MATLAB™ code that functions on the machines in the university computational environment or code in C/C++ that can be compiled and executed on a typical UR Linux workstation that is available for student use. You should submit complete code that allows easy validation of any results...
you include in your report and presentation. For example, you can provide a single MATLAB\textsuperscript{TM} script along with associated additional functions and scripts that generates one of the key graphs in your report/presentation. Your demo should not require complicated instructions or execution of multiple steps in order to be able to relate it to the results you present. Keep this in mind as you write and document your code (all documentation should be in English so I can follow it) and be sure to have script that will reproduce your key results. Depending on class size and time availability, I may request you to demonstrate to me that your code is functional in an individual meeting.

Project Grading:

Approximately seventy percent of the project grade will be based on the report and the remaining 30 percent on the presentation and in-class participation during the project presentations. Grading will take into account:

- **Quality, depth, and innovativeness of work.** This will be assessed based on your ability to clearly explain your implementation, the theory behind the work, and to highlight both strengths and weaknesses of the work you are considering and any ideas on how improvements may be made.

- **Clarity and completeness of your project report.** The report will be graded for clarity of communication, completeness of the work and documentation, and originality of expression. Innovative/novel implementations and original ways of thinking and understanding the technique will be rewarded. Use diagrams to communicate the main ideas and clearly labeled and captioned figures to illustrate your results, include a succinct critique of the results. Cite relevant material that you utilized in the course of the project and format citations using conventions common in ECE journals in a consistent format and provide complete information.

- **In class presentation clarity and ability to answer questions.** Your class presentation should summarize the motivation and background for your project, indicate specifically what you have done in the project, what external resources (code/libraries etc) you have used. Please ensure you include suitable citations on your slides. The presentation will be graded based on how clearly I understand from your presentation what you performed and the central conclusions from the project. Note that I will be reading the project reports only after the presentations, so do not assume I am familiar with the work/report.

- **Implementation Demonstration.** The demonstration will be used to validate that you have indeed implemented the ideas yourself and will have a bearing on the grade for both the report and the presentation. In particular, if you cannot readily demonstrate that your implementation provides the results you present, you will lose points.