EEL 4514 - Communication Systems and Components

SYLLABUS

1. **Catalog Description:** (3 credits) Theory of communication and applications to radio, television, telephone, satellite, cellular telephone, spread spectrum and computer communication systems.

2. **Pre-requisite:** EEL 3112 and EEL 3135

Pre-requisite knowledge for success in this course:

- Ability to work and learn **independently**. Course material may be assigned that is not covered in class but will be evaluated on the homework and the exams. Pop quizzes may be given that test the *fundamentals* of material covered in class, even **before** homework is given on that material.

- Ability to apply fundamental techniques to solve new problems. Homework problems will be chosen to both strengthen the understanding of the fundamentals and to teach the application of the fundamental techniques to new problems. Exams will be designed to test the depth of understanding of the fundamentals and the ability to apply these techniques to new problems.

- Understanding of systems theory, including convolution, Fourier transforms, and impulse functions.

- **Strong** mathematical background, especially differentiation, integration, and working with trigonometric functions.

- Knowledge of elementary circuit theory.

3. **Course Objectives:** Upon completion of this course, the student should be able to

- Characterize signals in terms of energy/power, frequency domain characteristics/bandwidth, and relation to other signals

- Work with common equations for propagation and be able to answer questions about different propagation modes

- Translate between signals or impulse responses and their Fourier transforms

- Represent analog signals by digital signals that are sufficient to capture all the information and behavior of the analog signals

- Identify pros and cons of common analog and digital communication techniques

- Perform system-level design of receivers for common modulations

- Identify key techniques used in many communication systems and discuss the advantages and disadvantages of these techniques

- Compare digital modulations based on bandwidth- and energy-efficiency

- Build basic software-defined radio receivers using GNU Radio Companion
4. **Contribution of course to meeting the professional component:** Teaches engineering design through system-level design and evaluation of communication systems.

5. **Relationship of course to program outcomes:** Teaches application of mathematics and engineering to solve engineering problems (Criteria A, E); applies knowledge to contemporary issues (Criterion J); teaches use of techniques, skills, and modern engineering tools necessary for engineering practice (Criterion K).

6. **Instructor:** Dr. John M. Shea
   - (a) Office: 439 NEB
   - (b) Phone: 352.575.0740 (Text messaging is okay)
   - (c) Email: jshea@ece.ufl.edu
   - (d) Web site (personal): http://wireless.ece.ufl.edu/jshea
   - (e) Twitter (personal account): @jmshea
   - (f) Office hours: Monday 1:30 PM – 2:45 PM, Wednesday 3:30 PM – 4:30 PM, or by appointment

7. **Teaching Assistant:** None

8. **Meeting Times:** Tuesdays, Periods 8 & 9: 3:00–3:50PM, 4:05–4:55 PM
   Thursdays Period 9: 4:05–4:55 PM

9. **Class/laboratory schedule:** 3 classes/week, 50 minutes each

10. **Meeting Location:** LAR 310

11. **Class Response System:**
    Learning Catalytics will be used for in class quizzes. Students need to sign up for a Learning Catalytics account, which costs $12 for a 6-month subscription. Students need to bring a smart phone, tablet, or laptop computer to class to answer questions in Learning Catalytics.

12. **Material and Supply Fees:** Students are required to have a Learning Catalytics account.


14. **Additional References:**

15. **E-Learning**: All students must use the class web site, which is on E-Learning Sakai: [https://elearning2.courses.ufl.edu/portal](https://elearning2.courses.ufl.edu/portal).

**Some problems will require Python with NumPy or MATLAB.** I recommend IPython with NumPy over MATLAB for most applications now. The Anaconda distribution is free and has almost any package you need for scientific computing. It is available at [https://store.continuum.io/cshop/anaconda/](https://store.continuum.io/cshop/anaconda/).

MATLAB is available on the ECEL cluster. As departmental computer resources are limited, students may want to purchase the student version of MATLAB or install GNU Octave, which is a free MATLAB replacement.¹

Students will be required to use GNU Radio Companion to build software defined radios, using a digital software radio platform, which will be provided. Students need to use their own laptop and may need to run Linux off of a flash drive.

16. **Course Topics (as time allows):**

• Intro to Communications
  – History and survey of communications
  – Fundamentals of communication systems
  – Analog vs. digital information and communication
  – Communication Channels

• Signals and Spectra: Chapters 2 and 3
  – Time averages
  – Energy and power signals
  – Decibel measurements
  – Fourier transforms
  – Bandwidth
  – Digital representation of bandlimited signals
  – Complex baseband representation of bandpass signals
  – Linear time-invariant filtering
  – Equivalent low-pass filter

• Baseband analog communication
  – APPLICATION: POTS (plain-old telephone service)

• Bandpass analog communication: Chapters 4 and 5
  – Amplitude Modulation (AM)
  – Frequency Modulation (FM)

¹Some problems may require MATLAB toolbox commands that are not available in Octave, and not all code is directly compatible
– Phase Modulation (PM)
– APPLICATION: Radio & Television Broadcasting
– APPLICATION: AMPS analog mobile phone system

• Sampling and Pulse Modulation: Chapter 6
  – Pulse Amplitude Modulation (PAM)
  – Pulse Code Modulation (PCM)
  – APPLICATION: T1 telephone line

• Baseband Digital Modulation: Sections 7.1, 7.2, App. C, 7.6, 7.7, 7.9
  – Line codes
  – Gram-Schmidt orthogonalization
  – Receiver design
  – Error probabilities
  – APPLICATION: USB
  – APPLICATION: Ethernet
  – Intersymbol Interference
  – Time-division multiplexing (TDM)
  – APPLICATION: T1 telephone line revisited

• Bandpass Digital Modulation: Sections 7.8, 12.1–12.6, 13.7
  – Common I-Q modulations
  – Minimum-shift keying and GMSK
  – APPLICATION: GSM cellular system
  – OFDM
  – APPLICATION: 802.11a/g wireless LAN
  – Spread spectrum
  – APPLICATION: 802.11b wireless LAN
  – APPLICATION: IS-95 cellular system

17. **Attendance and Expectations:**

   Attendance will not be taken. However, the classroom response system will be used to ask questions in almost every class, and the responses are a significant part of students’ grades. In addition, students are expected to know all material covered in class, even if it is not in the book.

18. **Grading:** Grading will be based on one midterm exam (25%), one final exam (25%), software-defined radio exercises (25%), classroom responses and quizzes (15%), and homework (10%). *Homework sets will be graded based on submission or spot checking. Expect problems to be graded on a 0/1 basis. Late homework will not be accepted.*

   When students request that a submission (test or homework) be regraded, I reserve the right to regrade the entire submission rather than just a single problem.
19. **Grading Scale:** Grades (and the corresponding grade points) will be assigned according to the Registrar’s official policies. Grades will be curved. However, a grade of $> 90\%$ is guaranteed an A, $> 80\%$ is guaranteed a B, etc.

Undergraduate students, in order to graduate, must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: a C- average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this graduation requirement. Graduate students, in order to graduate, must have an overall GPA of 3.0 or better (B or better). Note: a B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement. For more information on grades and grading policies, please visit: [https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx](https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx)

20. **Make-up Exam Policy:** If an exam must be missed, the student must see the instructor and make arrangements **in advance** unless an emergency makes this impossible. Approval for make-up exams is much more likely if the student is willing to take the exam early. Any other exam absence will result in the student receiving a zero for that grade. Students who miss pop quizzes or online quizzes will receive zeros for that grade.

21. **Honesty Policy:** All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action.

This statement is a reminder to uphold your obligation as a student at the University of Florida and to be honest in all work submitted and exams taken in this class and all others.

*Additional requirements and information:*

Honor statements on tests must be signed in order to receive any credit for that test.

I understand that many of you will have access to at least some of the homework solutions. Time constraints prohibit me from developing completely new sets of homework problems each semester. Therefore, I can only tell you that homework problems exist for your benefit. It is dishonest to turn in work that is not your own. In creating your homework solution, you should not use the homework solution that I created in a previous year or someone else’s homework solution. If I suspect that too many people are turning in work that is not their own, then I will completely remove homework from the course grade.

Collaboration on homework is permitted **and encouraged** unless explicitly prohibited, provided that:

(a) Collaboration is restricted to students currently in this course.

(b) Collaboration must be a shared effort.

(c) Each student must write up his/her homework independently.

(d) On problems involving programming or GNU Radio Companion, each student should write their own program or build their own radio design. Students may discuss the
implementations, but students should not work as a group in writing the programs or building their radio designs.

I have a zero-tolerance policy for cheating in this class.

If you talk to anyone other than me during an exam, I will give you a zero. If you plagiarize (copy someone else’s words) or otherwise copy someone else’s work, I will give you a failing grade for the class. Furthermore, I will be forced to bring academic dishonesty charges against anyone who violates the Honor Code.

22. Accommodation for Students with Disabilities: Students requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

23. UF Counseling Services: Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:

- UF Counseling & Wellness Center, 3190 Radio Rd, 392-1575, psychological and psychiatric services.
- Career Resource Center, Reitz Union, 392-1601, career and job search services.

24. Software Use: All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.