USC Viterbi School of Engineering

EE301L: Linear Systems (Spring 2015)

Course Units: 4

Instructor: Keith M. Chugg
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Office Hours: Monday 10:00-12:00, Wednesday, 1:00-3:00

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Grader: Karthiek Reddy Bokka
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Lecture: Monday, Wednesday 8:30-9:50 in SLH102

Labs: Wednesday 4:00-5:50 in OHE 230 (Sundar)
Wednesday 6:00-7:50 in OHE 230 (Morteza)
Attend the lab you for which you registered.

Webpages: Piazza Class Page for everything except grades
and USC Blackboard Class Page for grades

– All HWs, handouts, solutions will be posted in PDF format
– *Student has the responsibility to stay current with webpage material*

Prereq: EE202L

Other Requirements: Basic computer skills (e.g., plotting and Matlab).

Grading: 16% Homework
10% Lab Reports
22% Midterm Exam 1 (1 hour, 20 minutes)
22% Midterm Exam 2 (1 hour, 20 minutes)
30% Final Exam (2 hours)

Note on e-mail vs. Piazza: If you have a question about the material or logistics of the class and wish to ask it electronically, please post it on the piazza page (not e-mail). You may post it unanimously if you wish. Often times, if one student has a question/comment, other also have a similar question/comment. Use e-mail with the professor, TA, graders only for issues that are specific to your individually (*e.g.,* a scheduling issue or grade issue).

Catalogue Description: Representation and analysis of linear time-invariant systems primarily for the continuous time case. Convolution, Fourier series and transform, Laplace transform, controls and communications applications.

Course Description: Systems engineers often view physical systems as "black boxes" that process signals. In this view the systems engineer is not concerned with the detailed operations of components inside the box, but rather focuses on how the box responds to an input signal as gauged by the corresponding output signal. This allows many disparate physical systems to viewed in a single context. For example, there are electrical circuits, chemical reactions, audio systems, biological processes, information flow, and mechanical systems that are all equivalent under the systems view. Linear time invariant (LTI) systems are those whose input-output mappings do not change with time and for which linear combinations of input signals produce the same linear combinations of the corresponding output signals. LTI systems are good models for many real-world systems and lend themselves powerful analysis and design methods. For these reasons, LTI systems are particularly important in real-world engineering. The primary tool for analysis and design are based on transform theory – *i.e.,* Fourier, Laplace, and discrete time variants. These methods enable image processing, audio processing, digital media representation, modulation of signals, and control. This course will cover continuous time systems, discrete time systems, the corresponding transforms, and applications in controls, communications, and signal processing.

Learning Objectives: Upon successful completion of this course a student will

- Have an understanding of functions as representations of signals
- Be able to transform signals by amplitude and time scaling
- Identify the properties of systems from input output relations
- Understand conceptually convolution and apply the method in CT and DT
- Be able to interpret signals in time and frequency
- Be familiar with common signals used in systems engineering
- Understand why exponential-based transforms are used for LTI system analysis
- Be proficient in the various continuous and discrete time transforms
- Understand the traits of canonical first and second order systems
- Be able to realize CT and DT LTI systems using standard electrical/logical components
- Become proficient with MATLAB as a tool for analyzing LTI systems
- Be prepared for 400-level classes in communications, signal processing, and controls.

Exam Dates:

- **Midterm Exam 1:** Monday, February 23, 8:30-9:50
- **Midterm Exam 2:** Monday, April 6, 8:30-9:50
- **Final Exam:** Monday, May 11, 11:00-1:00 as set by the university

Homeworks and Labs: Homeworks will be assigned every two weeks. Lab meets every week, but each lab assignment will be allotted two lab meetings. Lab reports and HW assignments will be collected on alternating weeks. Labs will focus on applications of the material from lecture and homework, with an emphasis on improving MATLAB skills. Several labs around the midterms will include guest lectures illustrating the role of linear systems in research and applications in the areas of signal processing, controls and communications.

Class Policies:

- **Final grades** will be assigned by a combination of student score distribution (curve) and the discretion of the instructor. Final grades are nonnegotiable.
- **Homework Policy**
  - **Late HW** will not be accepted. A late assignment results in a zero grade. Please have your homework turned in by the beginning of lecture on the date that it is due.
  - Show your work in your homework solution; the correct answer alone is worth only partial credit.
  - Homework collaboration is encouraged. This is discussing problems and solution strategies with your classmates, the TA, and/or the instructor and is to be distinguished from copying solutions of others which is prohibited.
- **Exam Policy**
  - **Make-up Exams:** No make-up exams will be given. If you cannot make the above dates due to a class schedule conflict, you must notify me by the last day to add/drop. If I cannot accommodate your schedule, you must drop the class. In the case of a medical emergency, a signed letter from your doctor is required. This letter must include the telephone number of your doctor.
  - Exams will be closed book (possibly with a crib sheet allowed).
  - The weight of each exam in the course grade is proportional to the duration of the exam.
  - All exams are cumulative, but with an emphasis on material presented since the last exam.
- **Attendance:** Lecture and laboratory session attendance is encouraged and students are responsible for all material presented in both. The laboratory session will focus on example problems and MATLAB examples.

Statement for Students with Disabilities: Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity: USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect ones own academic work from misuse by others as well as to avoid using anothers work as ones own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at http://www.usc.edu/student-affairs/SJACS/.

Emergency Preparedness/Course Continuity in a Crisis In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.

Textbooks:

- **Required Textbook (ordered):**

  1. A. V. Oppenheim and A. S. Wilsky, *Signals and Systems, 2nd Ed.*, Prentice Hall, 1997.

- **References:**

  1. J.R. Buck, M.M. Daniel, A.C. Singer, *Explorations in Signals and Systems Using MATLAB, 2nd Ed.*, Prentice Hall, 2002.
  2. A.D. Poularikas and S. Seely, *Signals and Systems, 2nd Ed.*, Krieger Publishing Company, 1994.
  3. James H. McClellan, Ronald W. Schafer and Mark A. Yoder, *Signal Processing First*, Pearson Prentice-Hall, Upper Saddle River, NJ 07458, USA, 2003. (ISBN: 0-13-09099-8)
  4. Hahn and Valentine, *Essential Matlab for Engineers and Scientists*, Elsevier 2002
  5. Matlab Tutorials

- **Note:** There are a number of books that are similar to Oppenheim and Wilsky. Poularikas and Seely is one example.

Class Material

1. Introduction and Motivation: Signals & Systems (1.1-1.3)
2. Signals & Systems Preliminaries (1.4-1.6)

3. Linear Time-Invariant Systems (2.1-2.3)
4. Linear Time-Invariant Systems (2.4-2.5)

Midterm Exam 1

5. Fourier Series Representation of Periodic and Time-Limited Signals (Chapter 3)
6. Continuous Time Fourier Transform (Chapter 4)
7. Sampling and Reconstruction (Chapter 7)
8. Discrete Time Fourier Transform (Chapter 5)

Midterm Exam 2

9. Application of Fourier Analysis to LTI Systems (Chapter 6)
10. Applications in Communications and Signal Processing (Chapter 8)
11. The Laplace Transform with Application to Control (Chapter 9, 11.1-3)
12. The Z-Transform (Chapter 10)
13. Advanced topics and applications (covered by handouts, time permitting)