Michigan State University
Department of Electrical and Computer Engineering

ECE 366: INTRODUCTION TO SIGNAL PROCESSING (Spring 2008)

Overview

Staff

Instructor

Dr. R. Mukkamala, Associate Professor of Electrical and Computer Engineering
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Email: rama@egr.msu.edu
Office hours: M, 2:30p-3:45p and W, 3:45p-5:00p and by appointment, 1219 EB
(**to discuss any topic related to the course**)

Grader

Name: Mr. Timothy Negron, Graduate Student of Electrical and Computer Engineering
Email: negronti@msu.edu
Office Hours: R, 4:00p-6:00p, 2220 EB
(to go over the problem sets and mini-projects; starting the week of 01/14)

Lectures

MWF, 8:00a-8:50a, 2400 EB

Course Web Page

https://angel.msu.edu

Log on to SS08-ECE-366-001 Intro to Signal Processing.

This web page will serve as the mechanism for information exchange in this course. That is, all lecture notes, problem sets, MATLAB mini-projects, solutions, and any other handouts will be made available through this web page. Class announcements will also be made through the web page. Thus, **the course web page should be frequently visited** throughout the semester.

Text

Signals Processing and Linear Systems, B. P. Lathi, Oxford University Press, 1998.

Prerequisite

(ECE 202 (Circuits and Systems II)) and (ECE 280 (Electrical Engineering Analysis))

Course Synopsis

This course is about signals and their interaction with systems. A signal is a measurable quantity that is usually a function of time. A system takes a signal (input), performs an operation on it, and produces another signal (output). Tools for the analysis of signals and a special class of systems (linear and time-invariant systems) will be introduced in both the time-domain and frequency-domain. The frequency-domain provides an insightful, alternative perspective of signals and systems and greatly simplifies their analysis. These analysis tools will be presented for both continuous-time and discrete-time signals and systems. In many instances, discrete-time signals and systems arise from the sampling of their continuous-time counterparts so as to facilitate the analysis with digital computers. Thus, through two mini-projects, initial experience will be provided in using the widely employed MATLAB software package to analyze signals and systems. Signals and systems are omnipresent, and the practical applications of the theory presented in this course are numerous. Some applications include the study of living systems and financial markets as well as the design of control and communication systems.

MATLAB Software Package

MATLAB is a significant part of this course. The mini-projects are based on MATLAB, and MATLAB questions will appear on the final exam. Students may find the MATLAB tutorials provided on the course web page to be useful. Note that the MATLAB software package is available on all Windows and UNIX-based computers in the college and likely elsewhere on campus. A student version of the software is also available for a reasonable price. However, it is not necessary to purchase the software.

Lecture Materials

Prior to the start of each week of the semester, the lecture topics (see detailed course outline below), textbook reading assignment (reference material), and lecture notes for the week will be posted on the course web page. The student may therefore skim the material to be covered prior to each lecture as well as bring the notes to class in order to facilitate the understanding of the lecture.

Problem Sets

Problem sets will be assigned on Fridays, which will re-enforce the concepts presented in the previous two to four lectures. **Each problem set will generally be due the next Friday in class.** A total of **13 problem sets will be assigned**; however, only **10 will be collected**. (That is, the problem sets will not be collected during each exam week.) The problem set schedule is specifically as follows:

Problem Set 1 OUT: 01/11/08, DUE: 01/18/08 Problem Set 1 Solutions OUT: 01/18/08
Problem Set 2 OUT: 01/18/08, DUE: 01/25/08 Problem Set 2 Solutions OUT: 01/25/08
Problem Set 3 OUT: 01/25/08, DUE: 02/01/08 Problem Set 3 Solutions OUT: 02/01/08
Problem Set 4 OUT: 02/01/08, DUE: 02/08/08 Problem Set 4 Solutions OUT: 02/08/08
Problem Set 5 OUT: 02/08/08, DUE: 02/15/08 Problem Set 5 Solutions OUT: 02/15/08
Problem Set 6 OUT: 02/15/08, DUE: NONE Problem Set 6 Solutions OUT: 02/15/08
Problem Set 7 OUT: 02/29/08, DUE: 03/14/08 Problem Set 7 Solutions OUT: 03/14/08
Problem Set 8 OUT: 03/14/08, DUE: 03/21/08 Problem Set 8 Solutions OUT: 03/21/08
Problem Set 9 OUT: 03/21/08, DUE: 03/28/08 Problem Set 9 Solutions OUT: 03/28/08
Problem Set 10 OUT: 03/28/08, DUE: 04/04/08 Problem Set 10 Solutions OUT: 04/04/08
Problem Set 11 OUT: 04/04/08, DUE: NONE Problem Set 11 Solutions OUT: 04/04/08
Problem Set 12 OUT: 04/18/08, DUE: 04/25/08 Problem Set 12 Solutions OUT: 04/25/08

Problem Set 13 OUT: 04/25/08, DUE: NONE Problem Set 13 Solutions OUT: 04/25/08

Only a subset of the problems assigned will actually be graded. The problems to be graded will not be determined until after the students' submission of the problem set. These problems will specifically be evaluated according to a tertiary grading system (zero credit for no work with or without correct answer | half credit for wrong idea but demonstration of effort | full credit for right idea with or without correct answer). While students are encouraged to work together on the problem sets, the submissions must be original (no Xerox) and in the student's own handwriting. The solutions for each problem set will be made available immediately after the problem set is due. Thus, **no late problem sets will be accepted**. For the problem sets that are not collected, the solutions will be made available with those problem sets.

Mini-Projects

Two MATLAB mini-projects will be assigned. Each mini-project will be due one week later in class. The mini-project schedule is specifically as follows:

MATLAB Mini-Project 1 OUT: 02/22/08, DUE: 02/29/08
MATLAB Mini-Project 2 OUT: 04/11/08, DUE: 04/18/08

While students may again work together on the mini-projects, the submissions must be independent, consisting of each student's own MATLAB code. **No late mini-projects will be accepted**.

Examinations

There will be **two in-class midterm exams** and a **final in-class, cumulative exam**. These exams will be held on the following dates:

Midterm Exam 1	**February 22, 2008**
Midterm Exam 2	**April 11, 2008**
Final Exam	**May 1, 2008 (7:45a-9:45a)**

The lecture prior to each of these exams will be a review through practice problems. Each exam will include true/false questions in which no partial credit will be given and problems in which partial credit will be given if valid work is shown. These questions and problems will arise from the lectures and problem sets. (As indicated above, the textbook reading assignments may therefore be thought of as reference material.) In fact, **a subset of the problems for each exam will come exactly from the problem sets**. Thus, the problem sets may be viewed as additional practice problems for the exams. Each exam will not cover any new material presented during the week of the exam.

A **student will only be allowed to miss a midterm exam without penalty provided that there is a legitimate case of illness or personal emergency that is documented by a physician or other appropriate official**. In this case, the final, cumulative exam will carry the additional weight of the missed midterm exam. A student who finds it necessary to miss a midterm exam should contact the professor before the exam to explain the circumstances. A student who must miss the final exam should contact the professor as well as the Dean's Office according to MSU policy.

Additionally, Michigan State University is committed to providing equal opportunity for participation in all programs, services and activities. Accommodations for persons with disabilities, with valid (*i.e.*, not expired) documentation from RCPD, may be requested by

contacting the instructor at the start of the term and/or two weeks prior to the accommodation date (exam, etc). Requests received after this date will be honored whenever possible.

Grading

Each of the above assignments carries the following weight towards your final grade:

10 Problem Sets:	10% (*i.e.*, 1% for each Problem Set)
2 Mini-Projects:	10% (*i.e.*, 5% for each Mini-Project)
Midterm Exam 1:	20%
Midterm Exam 2:	20%
Final Exam:	40%
Total:	**100%**

Your final grade (*e.g.*, 3.5, 4.0) **will be assigned according to a curve**. That is, the raw score you receive on each of these five categories of assignments will be normalized with respect to the class performance (difference between student's score and the average of the class scores divided by the standard deviation of the class scores). Then, your five resulting normalized scores will be averaged according to the above weighting to form a total normalized score. Next, the total normalized scores earned by all the students in the class will be rank ordered. Finally, threshold scores (*e.g.*, score above which a 4.0 is earned) will be determined, thereby establishing your final grade. Note that **borderline scores can be "pushed up" by demonstration of effort**, which may be achieved through an outstanding problem set and mini-project record and/or class participation.

Incomplete grades will be given only in unusual cases of illness or other personal emergency, which causes the student to miss a significant amount of the course. This grade cannot be given for any other reason.

Article 2.3.3 of the Academic Freedom Report states: "The student shares with the faculty the responsibility for maintaining the integrity of scholarship, grades, and professional standards." In addition, this instructor adheres to the University regulations, policies, and ordinances on academic honesty and integrity, as specified in General Student Regulation 1.0, Protection of Scholarship and Grades; the all-University Policy on Integrity of Scholarship and Grades; and Ordinance 17.00, Examinations, all of which are available on the MSU web site (www.msu.edu). Students who violate these rules may receive a penalty grade, including, but not limited to, a failing grade on the assignment or in the course. The following conduct is specifically cited: (1) Supplying or using work or answers that are not one's own; (2) Providing or accepting assistance with completing examinations; (3) Interfering through any means with another's academic work; and (4) Faking data or results.

Detailed Course Outline

0. Introduction to the course

I. Basic continuous-time (CT) signal and system concepts
   A. Definition of a signal
   B. Signal properties (*e.g.*, periodic vs. aperiodic and energy vs. power)
   C. Special signals
      1. Sinusoids and Euler's relation
      2. Even and odd signals and even and odd parts of an arbitrary signal
      3. Singularity signals (*e.g.*, step and impulse functions)
   D. Definition of a CT system
   E. CT system properties (*e.g.*, linearity, time-invariance, and stability)

II. Time-domain analysis of CT linear and time-invariant (LTI) systems
   A. Convolution integral and the impulse response
   B. Convolution properties
   C. Graphical approach for computing the convolution integral
   D. Using convolution to solve the zero-state response of linear constant coefficient differential equations
   E. System properties in terms of the impulse response
   F. Eigensignals and sinusoidal inputs

III. Fourier (frequency-domain) analysis of CT signals and LTI systems
   A. Motivation and conceptual basis
   B. Fourier series (FS) for representing periodic signals
      1. Orthogonal series expansion
      2. Exponential (or complex) FS
         a. Definitions
         b. Symmetry properties
         c. Line spectra
      3. Compact trigonometric FS and trigonometric FS
         a. Definitions (and relationship amongst the three FS forms)
         b. Symmetry properties
         c. Line spectra
      4. Power relations
      5. LTI system response to periodic inputs
   C. Fourier transform (FT)
      1. Definition and relationship to FS
      2. Convergence of the FT
      3. Relationship between the FT and Laplace transform
      4. Spectra and Parseval's relation
      5. FT of power signals
      6. Properties of the FT (with example of amplitude modulation (AM) radio)
      7. Frequency response (eigensignals and sinusoidal inputs revisited)
      8. Transmission, distortion, and ideal filters

IV. Basic discrete-time (DT) signal and system concepts
   A. Definition of a DT signal

B. Sampling theory (with example of sampling a CT sinusoid)
C. DT signal properties (*e.g.*, periodic vs. aperiodic and energy vs. power)
D. Special DT signals
    1. Sinusoids
    2. Exponentials
    3. "Singularity" signals
E. Operations on DT signals
F. Definition of a DT system
G. DT system properties (*e.g.*, linearity, time-invariance, and stability)

V. Time-domain analysis of DT LTI systems
A. Convolution sum and the impulse response
B. Convolution properties
C. Computing the convolution sum
D. System properties in terms of the impulse response
E. Eigensignals

VI. Frequency-domain analysis of DT signals and LTI systems
A. Unilateral z-transform (ZT)
    1. Definition and existence
    2. Relationship between the ZT and the Laplace transform
    3. Evaluation of the ZT
    4. ZT properties
    5. Inverse ZT
        a. Partial fraction expansion
        b. Power series
    6. System function
        a. Definitions
        b. Frequency response (sinusoidal inputs)
B. DTFS for representing periodic signals
    1. Definition
    2. Line spectra
C. DTFT
    1. Definition
    2. Convergence of the DTFT
    3. Relationship between the DTFT and the ZT
    4. Relationship between the DTFT and the CTFT
    5. Spectra
    6. DTFT properties
    7. Frequency response of a DT LTI system revisited