ENEE 222
ELEMENTS OF DISCRETE SIGNAL ANALYSIS

Sections 0201 and 0202

Fall 2018

Syllabus (08/26/2018)

Lecturer:

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Office Hours: The office hour schedule will be posted on ELMS and updated on a weekly basis.

Class Schedule: Lecture: TuTh 11:00 – 12:15, AJC 2132

0201 Recitation: W 9:00–9:50, KEB 2107
0202 Recitation: W 10:00–10:50, KEB 2107

0201 Lab: F 9:00–9:50, KEB 2107
0202 Lab: F 10:00–10:50, KEB 2107

Course Website: Can be accessed on elms.umd.edu.

The course website will contain all course documents, including: syllabus, announcements, lectures, homework and MATLAB assignments, problem solutions, practice quizzes, practice exams, exam solutions and exam statistics. Very few of these documents will be handed out in hard copy, so it is important to check the web site regularly. All grades will also be posted on the course website.

- *Even though ELMS has a built-in messaging system, it is strongly recommended that you use **regular email** for communicating with the instructor and the TAs.*

- *Please **disregard any grade computations** (aggregation, averaging, etc.) that appear **on ELMS**. Course grading is explained below.*

Course Objectives: In this course, you will:

- Master basic tools from linear algebra that are particularly useful in modeling real-world signals and systems.
- Learn key concepts in the frequency analysis of signals, in both discrete and continuous time.
- Gain some understanding of what a digital filter is, how it is implemented, and how it can be used in signal processing.
- Become familiar with MATLAB, a powerful computational package, and some of its applications to signal and image processing.

Course Topics:

A. Numbers, Vectors and Signals

A.1 Review of complex numbers
A.2 Real-valued and complex-valued sinusoids in continuous time
A.3 Discrete-time sinusoids
A.4 Sampling of sinusoids; aliasing

B. Matrices and Systems

B.1 Linear transformations and linear systems
B.2 Matrix of a linear transformation; systems view of matrix multiplication
B.3 Miscellaneous matrix operations
B.4 Nonsingular matrices and their inverse
B.5 Solution of simultaneous linear equations via Gaussian elimination
B.6 Inner products, distances, projections
B.7 Orthogonality and signal approximation
B.8 Complex-valued signals and their approximation

C. Signals in the Frequency Domain

C.1 Orthogonality of Fourier sinusoidal vectors
C.2 The discrete Fourier transform (DFT) and its inverse; significance in the representation and approximation of signal vectors
C.3 Basic properties of the DFT
C.4 Matrix-based approach to the DFT and its inverse
C.5 Signal transformations and the DFT
C.6 Combinations and extensions of signals; the duality between convolution and multiplication
C.7 Detection of sinusoids using the DFT: theory
C.8 Periodic extensions of signal vectors; analogy to continuous-time periodic signals and sums of harmonically related sinusoids
C.9 Orthogonality of Fourier sinusoids in continuous time; Fourier series
C.10 Fourier series coefficients: properties, analogies to DFT

D. Linear Filters

D.1 Examples of finite impulse response (FIR) filters; linearity, time-invariance, frequency selection
D.2 Response of FIR filters to sinusoidal, periodic and exponential inputs; frequency response and system function
D.3 Classification of frequency selective-filters
D.4 Convolution in discrete time; practical implementation of FIR filters
D.5 Filters in cascade; convolution as multiplication in the *z*-domain

Textbooks:

- The main reference for the course is a complete set of lecture notes, which will be posted on the course website.
- An auxiliary textbook will also be posted:

  A. Papamarcou, "A New Sequence in Signals and Linear Systems, Part I: ENEE 241"

  (ENEE 241 was the precursor to ENEE 222.) This textbook does not, however, cover some course topics, such as Fourier series.

Optional Materials:

- A college-level textbook in linear algebra (such as the one used in MATH 240 or MATH 461) may be useful as supplementary reference.
- A companion introductory textbook for MATLAB, e.g.,

  R. Pratap, Getting Started with MATLAB (7 and later)

  Gilat, An Introduction with Applications (4^{th} edition and later)

Homework Assignments: Generally, there will be one homework assignment per week, due on Tuesday. Each assignment will contain one, two or three problems to be solved (and submitted)

Solutions to the homework problems (*in plain ASCII text*) *will also be posted at the same time. Outright copying from the solutions will be of little help in understanding the material and preparing for the exams, which carry far greater weight.*

Some homework problems will require the use of MATLAB. Unless otherwise stated, you should *submit a printout of all MATLAB commands* (i.e., code) used, as well as your *results*.

ENEE 222 Lab: The lab has a dual purpose: (a) providing essential training in MATLAB and (b) illustrating some of the more important applications of the concepts taught in class. In each session you will be going through a script that includes MATLAB code, which you will run on the lab workstation. Almost every lab will have an assignment due six days later. *Attendance at labs is mandatory; a clear pattern of absences may adversely affect your grade.*

Lab Grade: Each MATLAB assignment (including quizzes if given) will carry 10, 15 or 20 points depending on its difficulty. Lab assignments may be similar to ones from previous semesters. *Consulting solution keys to those assignments is acceptable, but outright copying is not. If your code contains elements* (*such as parameter values*) *that pertain to a past semester's assignment but not the current one, it will receive zero credit.*

Examinations: Two midterm exams (75 minutes, 4 problems each) and a final exam (2 hours, 5 problems) will be given. Each exam will cover a different portion of the syllabus—thus the final exam will *not* be comprehensive. Barring delays due to weather and other emergencies, the exam dates will be:

- **Exam 1:** Thursday, October 4
- **Exam 2:** Thursday, November 8
- **Final Exam:** Wednesday, December 12, 8:00 – 10:00 am

Makeup exams will be given in cases of excused absence, which include *documented* illness, religious observance, participation in university activities at the request of university authorities, or compelling circumstances beyond the student's control. *Travel for recreation or for planned social occasions is not excused.* Please inform the lecturer at once if you anticipate missing an exam, or have just missed one. *Please be as accommodating as possible in scheduling makeup exams, as they are an inconvenience for all those involved.*

Calculators: Calculators will *not* be allowed in any exam. *Mobile phones and other personal devices (including audio with headphones) must be switched off during examinations.*

Grade Inquiries: Regrade requests for exams must be submitted in writing (by attaching to your paper a note explaining the dispute) to the lecturer, *not the TAs*. A scan of your final exam will be also provided upon request.

Semester Grade: The raw numerical grade will be obtained by summing together

- the exam grades (15 points per problem, i.e., maximum of 195 points);
- the lab grades (renormalized to a maximum of 45 points);
- the homework grades (renormalized to a maximum of 30 points).

Letter grade thresholds are at the instructor's discretion and *are not subject to discussion or review*. The following performance levels will *guarantee* the corresponding letter grade:

- A– : 230 total points, with 160 or more from exams
- B– : 205 total points, with 135 or more from exams
- C– : 180 total points, with 115 or more from exams

Academic Integrity : The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit

http://www.shc.umd.edu

Campus Policies : For comprehensive information about undergraduate course-related policies, please visit

http://www.ugst.umd.edu/courserelatedpolicies.html

CLASSROOM ETIQUETTE

We expect you to do your best in maintaining a classroom climate which is conducive to learning and is respectful to everyone. To that effect, please:

- arrive at the classroom or lab promptly
- submit your homework before or immediately after (not during) the lecture
- refrain from having private conversations during class
- obey the ban on food and drinks in the classroom (only bottled water is allowed)
- silence your mobile phone
- use your electronic devices only to record or access material directly related to the course
- resist the urge to wish good health to someone who sneezes, if doing so would distract others (who may be speaking, taking an exam, etc., at that time)