ELEN 4810 – Digital Signal Processing

The goal of this course is to equip students with basic tools for processing signals on a computer. We will introduce the basic mathematical ideas necessary to design and analyze discrete time systems, and interface them with the continuous world. Homeworks and a course project on a topic of students’ choosing will provide additional implementation experience.

Main Topics

Digital filtering in time and frequency domain, including properties of discrete-time signals and systems, sampling theory, transform analysis, system structures, IIR and FIR filter design techniques, the Discrete Fourier Transform, Fast Fourier Transforms.

Administrative

Time and place: Monday and Wednesday 10:10-11:25 AM, Fayerweather 310 (please note new room!).

Instructor: John Wright
Office hours: Friday 3:30-5 PM, Mudd 408
Instructor email: johnwright@ee.columbia.edu. For course related email, please start the subject line with “ELEN 4810:”. Thanks in advance for your help.

Teaching Assistant: Yenson Lau
TA Office hours: Tuesdays and Fridays, 10-11 AM, Location TBA
TA email: yl3027@columbia.edu

Course webpage: http://www.columbia.edu/~jw2966/ELEN4810_Fa15.html

Prerequisites

ELEN E3801 or a similar class in signals and systems at the undergraduate level. If you do not meet this prerequisite, but would still like to take the course, please discuss your background with the instructor.

Text

Oppenheim and Schafer, Discrete-Time Signal Processing, Third Edition.¹

¹I’m often asked whether students can use other editions of the Oppenheim and Schafer book. The second edition also provides a very nice and comprehensive coverage of the course material. I may assign homework problems out of the text. Please note that the problems are not necessarily the same from edition to edition. Any homework problems assigned from the text refer to the third edition.
Wright, *ELEN4810 Lecture Notes, Fall 2015*. Supplementary notes will be provided on the course website. They cover all of the material in lecture and a bit more. These are a work in progress; there is a (very small!) amount of extra credit available to anyone who finds a typo.¹

## Computing

We will use the Matlab environment for problem sets. You may also opt to use Matlab in your course project. You can obtain a copy of Matlab to run on your laptop for free through SEAS: look at [https://portal.seas.columbia.edu/matlab/](https://portal.seas.columbia.edu/matlab/) for details. For the course project, you can use whatever computing languages and environment you prefer; most students end up using Matlab.

## Grades

The course will be graded on the following basis:

- Homework 10%
- Midterm Exam 30%
- Final Exam 30%
- Course Project 30%

**Homework**: One assignment per week; a mix of analytical and computational questions. Homework will be assigned on Wednesday and due the following Wednesday at the start of class. Later in the semester, we will relax this schedule to allow two weeks per assignment; this is to allow enough time for you to do a good job on your course project.

  Late homework will not be accepted. As a buffer against illness, emergency, meteor strike, etc., we will drop your lowest homework score. You are free to discuss homework assignments with other students, but must prepare your solutions independently.

**Course Project**: You should process some sort of real signal. Beyond this baseline requirement, you are free to design the project according to your goals and interests – be creative! For examples of past student projects, you can look at the course website from previous semesters. We will also discuss some possible project ideas in lecture.

  The course project will be completed in teams of 3-4 students. You can self organize via the forum on CourseWorks – e.g., propose project topics and form teams. Teams of 1-2 are also acceptable, with explicit approval from the instructor. I want to talk to you first to make sure you have a clear idea of what you are doing. Once you have formed a team, please submit a very brief (1 paragraph) proposal listing the members of your team, with UNI’s, and describing (i) the problem you will work on, (ii) the tools you will use, (iii) desired outcomes, and (iv) listing a few references. This should be at most half a page, and will be graded on completion only – the point is simply to make sure you’ve thought about what you will do. Please submit this to the instructor by October 20. For the students who cannot find teams by the October 20 deadline, we will randomly assign

¹To be clear, to get the extra credit, you need to be the first to report the particular typo to me.
you to teams, and ask each of these teams to produce a project topic and proposal by October 31.

**Exams:** The midterm and final are closed book. Calculators, cell phones, and other computing devices are not allowed, nor are they necessary. You are allowed one sheet (two-sided) of handwritten notes to the midterm, and two sheets to the final. The midterm is tentatively scheduled to take place in class on **Monday, October 26**. This date is subject to change. The final will take place during the University-wide exam slot for this time period. SSOL currently projects that our final will be **Monday, December 21**, from 9 AM to 12 PM. This date is also subject to change. The final will be cumulative, but will contain more material from the second half of the semester.

**Syllabus:** A rough syllabus is as follows. Please refer to the course website for more detailed information.

1. DSP Overview, motivating applications
2. Review of complex numbers, basic sequences
3. Time domain: linear shift invariant systems, convolution, impulse response
4. Fourier domain processing: DTFT, DFT, STFT, applications
5. Sampling and analog-to-digital conversion
6. Midterm Exam
7. Z-transform, poles, zeros
8. Z-transform based system analysis
9. Magnitude and phase response, linear phase, basic filters
10. FIR / IIR filters, generalized linear phase
11. FIR filter design
12. IIR filter design
13. Special topics, examples and applications