1. Schedule and Introduction

This class meets 6:30 PM - 9:10 PM every Wednesday evening in OHE 100D beginning May 21, 2014 and ending on August 6, 2014. There currently is no TA or grader assigned. **IMPORTANT dates are:** Midterm exam (June 25) and the Final exam (August 6). These are hard dates so make sure you have no conflicts with these dates.

The objective of this course is to provide a basic introduction to the theory of digital signal processing (DSP). I assume a familiarity with the Fourier and Laplace transforms and concepts such as linearity and shift invariance that are used in the description and analysis of linear analog systems. Much of what we do extends these ideas to the field of discrete time systems. Major parts of the course will concentrate on signal analysis using Fourier transforms, linear system analysis, Filter design and a few more advanced topics. We will study the discrete Fourier transform and its properties. We will also study the sampling theorem and the relationship between continuous and discrete time transforms. We will see how discrete time, linear shift invariant systems can be characterized using linear difference equations and the impulse response and show how tools such as the z-transform and discrete Fourier transform can be used in the design and analysis of such systems. We will then study the design and implementation of digital filters. I will also include some topical material: what is bandpass sampling?, what are polyphase filters and filterbanks?, what are adaptive filters? While this course deals largely with the theory of DSP, we will use a powerful software package, MATLAB, to look at applications of this theory, particularly Fourier analysis and digital filter design.

The sections given below are an outline of the topics I hope to cover in this course. Section 4 is mainly a review of material you should have covered in a Linear Systems course. If you are not too familiar with this material or need to refresh your memory, I suggest you use the "Signals and Systems" book by Oppenheim and Wilsky referenced below or perhaps the “Signals and Systems Made Ridiculously Simple” book by Karu also referenced below (actually I have not read this book but its title sounds interesting!).

**Policy on class attendance for on-campus students:** There is no requirement to attend the class in the studio (though I appreciate in-studio attendance as it can get lonely !!!!). But if you do, please do not talk amongst yourselves during the lecture (though questions to me about the lecture are welcome during class).

2. Grading and Computers

Midterm: 30%

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Please note that I will actually pre-tape the May 21 lecture as I will be out of town on May 21. The pre-tape will be May 9 at 11 AM in OHE100B.
Final: 30%
Homeworks: 10%
Two Matlab computer projects: 30% (15% each)

Throughout the semester I will assign 5-6 homework sets plus two Matlab computer projects. The homework sets will help prepare you for the midterm and final exams. The Matlab projects will help you learn the material by conducting practical computer experiments on real world problems. If you do well on the homeworks and the projects, then you will be able to perform well in the class. Do the homeworks on your own (although I encourage you to discuss the problems with your friends). Likewise with the Matlab assignments: please discuss them, but write them yourself. The midterm will include all material covered up to the midterm and the final will cover the remainder of the course. Both exams will be closed book.

**Policy on late assignment submittals:** I will allow late submittals **provided you let me know in advance via e-mail.** However, once the solutions are posted (typically about a week after the assignments are due), no submittals will be accepted or graded. **One other important note regarding assignment submittals for on-campus students:** Do not interrupt the class to submit an assignment (I will not accept or grade assignments submitted during the class). You must submit your assignment either before or after class or during the break.

3. **Office Hours**

My office hours are 5:00-6:15 Wednesdays in PHE 414. TV students may call me during this time (213 740 7654), or arrange an appointment for Wednesday evenings. I strongly encourage you to make use of this time to discuss problems with the course material or any related aspects of digital signal processing which interest you. If you can't reach me otherwise, my e-mail address is: **Edgar.H.Satorius@jpl.nasa.gov.**

Questions related to the homework, projects, Matlab, etc. should initially be addressed to the grader. The mentor’s office hours are TBD. Please make use of our TA/grader – remember: he’s located on-campus and I'm not!
COURSE OUTLINE:

4. Introduction to discrete linear systems (Class 1)
   [Mitra, §§2.1-2.7]

5. Discrete-Time Fourier Transform and Linear Time Invariant Systems (Class 1-2)
   [Mitra, §§3.1-3.9]

6. The Z transform (Class 2-3)
   [Mitra, §§6.1-6.7]
   [1] Z-transforms by summation of left, right, and two-sided sequences.

7. Properties of digital filters (Class 3)
   [8] Group delay, linear phase, all-pass, minimum phase

8. Fourier transforms, sampling – Part I (Class 4-5)
   [Mitra, §§4.1-4.6, 13.1]

8. Fourier transforms, sampling – Part II (Class 7)
   [Mitra, §§4.7-4.11, 13.2-13.6]
   [1] A/D conversion and quantization
   [2] D/A conversion
   [3] Polyphase decomposition
   [4] Polyphase DFT filterbanks
   [5] Bandpass sampling

10. The discrete Fourier transform (Class 8-9)
    [Mitra, §§5.1-5.9, 15.1, 15.2]
    [2] Properties of the DFT.
    [3] Linear and periodic convolution using the DFT.
    [4] Zero padding, spectral leakage, resolution and windowing in the DFT.

11. The fast Fourier transform (Class 9)
    [Mitra, §§11.1, 11.3]
    [1] Decimation in time FFT.
    [2] Decimation in frequency FFT.

12. Digital filter design

12.1. Finite impulse response (FIR) filters (Class 10)
    [Mitra, §§10.1, 10.2, 10.5]

12.2. Infinite impulse response (IIR) filters (Class 10-11)

13. Structures and properties of FIR and IIR filters and review (Class 11)
    [Mitra, §§8.1-8.9]
[3] Coefficient quantization effects in digital filters

14. Final: 6:30-8:30 PM, August 6, 2014
15. References

15.1. Required Texts/Notes


[3] Supplementary class notes, available over the USC Distance Education Network.

All course materials will be distributed via the DEN website (http://den.usc.edu/). Access to the materials at the DEN website requires login with an individual i.d. and password. If you have problems accessing DEN please contact the folks at DEN directly - see http://den.usc.edu/contact/index.htm for contact info and telephone numbers. All students enrolled in the class should have access to all DEN materials, including the streamed lectures.

15.2. Recommended Reading and Some Comments:

There are a huge number of books on DSP, many of which are strongly influenced by Oppenheim and Schafer (see below) and in most cases are inferior. But do take a look in the bookstore or library and see what else is available:

[1] Schaum's Outline of Digital Signal Processing, M. Hays, McGraw-Hill, 1999: This complements Mitra with lots of worked examples and summaries of each topic as well as a large number of additional problems.


[6] A Course in Digital Signal Processing, B. Porat, J. Wiley and Sons, 1996: This is an excellent DSP book – It has been used by Prof. Leahy as a course text, but according to Prof. Leahy: “many students didn’t share my enthusiasm…”


[10] The Fast Fourier Transform and its Applications, E. O. Brigham, Prentice-Hall, 1988: This is a popular book with a lot of graphic illustrations of discrete convolutions and
Fourier transforms. It is very useful for developing a better understanding of the DFT but it is probably a little too basic to be of long term value.

[11] Digital Signal Processing, R. Roberts and Cliff Mullis, Addison Wesley, 1987: This is a very good book on DSP – it covers a lot of ground but tends to be a little terse.


15.3. Background Material


