EE483: Introduction to Digital Signal Processing

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1. Schedule for Fall 2014

Lectures:	11.00am - 12.20pm Tuesday/Thursday
Discussion:	12.00pm - 12.50pm Fridays
First Class	Tuesday, August 26th
Midterm:	11.00am - 12.20pm (in class) Tuesday October 14th.
Last Class	Thursday, December 4th
Final:	8.00am - 10.00am Tuesday Dec 16th.

2. Textbooks

Required:
Digital Signal Processing: A Computer-Based Approach, 4th (US) edition, Sanjit K Mitra, McGraw Hill, 2010. An excellent modern and comprehensive text on DSP.

Schaum's Outlines: Digital Signal Processing, 2nd edition. M. Hayes, McGraw Hill 2011. This complements Mitra with lots of worked examples and summaries of each topic as well as a large number of additional problems.

Suggested:
Discrete Time Signal Processing, 3rd edition, A. Oppenheim and R. Schafer, Prentice-Hall, New Jersey, 2009. -- this is the classic textbook for DSP, and a model for most of the other introductory books on the subject. Highly recommended.

Digital filter design, T. W. Parks and C. S. Burras, J. Wiley & Sons, 1987. - this book is closer in spirit to the way that I will teach filter design. It's a useful book.

A course in Digital Signal Processing, Boaz Porat, J. Wiley, 1996. This is an excellent DSP book - I used to use it as a course text, but many students didn't share my enthusiasm, can be terse in places.

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. I think 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.

Digital Signal Processing, R. Roberts and Cliff Mullis, Addison Wesley, 1987 - this is a very good book on DSP - I used it as a course text a couple of times. It's now out of print.

Introduction to Signal Processing, S. Orfandis, Prentice Hall, 1995 - a good book to read, lots of interesting examples.

Others: there are a huge number of books on DSP as well as numerous web-based resources. Do make sure to explore on-line as well as read about the topic using the resources I suggest.

3. Course Objectives

The objective of this course is to provide a basic introduction to the theory of digital signal processing (DSP). I assume a basic familiarity with complex variables, 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 use this as the basis to briefly explore techniques for spectral analysis. 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: how do 1-bit A/D converters work?, why is the DCT used in JPEG image compression?, 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.

4. Course Evaluation

Homework: 8-10 homeworks over the semester (20% of final grade)
Midterm: 11.00am - 12.20pm Tuesday October 14th (35% of final grade)
Final Examination: 8.00am - 10.00am Tuesday Dec 16th. (45% of final grade)
Extra Credit: for participation, upto 3%.

All exams are cumulative and closed book - please check the scheduled exam times *now* to see if there are any schedule conflicts.

Homeworks must all be turned in by 5.00pm on the due date; this applies to both on-campus and DEN students. On campus students should place homeworks in the EE483 dropbox in EEB. DEN students should submit homeworks electronically through DEN. Late homeworks will not be graded. The final homework grade will be based on your average score after I discard the lowest score - **make sure that you do not miss more than one homework.** Several of the homeworks will involve the use of Matlab - it is your responsibility to make sure that you have access to this software and that you learn how to use it.

5. On-Line Materials and Discussion Board

All course materials will be distributed via DEN's Blackboard 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://gapp.usc.edu/contact for contact info. All students enrolled in the class have access to all DEN materials, including the streamed lectures.

I will post homeworks and solutions on the course website. It is your responsibility to check the website regularly to for new assignments, notes and due dates. You will also have access to the lectures via streamed video. Please note - (live) attendance at the class is REQUIRED for on-campus students. The archived classes should be used only to review the material or if you miss a class because of illness or work-related travel.

I use Piazza for discussion of homeworks and other class material. I find it far more effective than email as it gives you the opportunity to read other's questions, see the response from me and/or the TA, and to join in the discussion. You need to sign up for the Piazza page for EE483 - follow this link: piazza.com/usc/fall2014/ee483 . Participation extra credit is based on your activity on this site (which provides me a list of the number of questions, responses and views from each student).

6. Office Hours, Discussion

You can find me in EEB400C, Tel: (213) 740 4659. My office hours are 12.30-2.00pm Tuesdays and Thursdays. This is your opportunity to ask me about material covered in the class and technical aspects of homework assignments. Use it. If you have a time conflict with other classes during my office hours, let me know and I will make other arrangements to meet with you.

Your TAs for the course is Ronald Salloum <rsalloum@usc.edu> . He will lead the discussions and hold office hours (times to be announced shortly).

7. Suggestions and Policies

My primary interest here is that you learn as much as possible about digital signal processing, that you find the material interesting and that you finish the course wanting to know more about this subject. There are a few things that you can do to facilitate this: (i) ask me questions, (ii) make use of my office hours, (iii) read something other than the required text book, (iv) if you are struggling with the material, come and ask me about it as soon as you realize this and not the day before the midterm or final, (vi) learn to use MATLAB, (vii) turn in all of the homework assignments, (viii) remember that exams and grades are a means to an end and not the end in itself. And turn up for the lectures.

It goes without saying that cheating on exams is unacceptable and will result in a minimum of the grade of F. Write your homework solutions on your own although I would encourage you to discuss the problems with your classmates. Likewise with the Matlab assignments: by all means discuss them, but you must write the code yourself. In cases where solutions are taken from a manual, from my prepared solutions, or are clearly the same as another students (either the text of your solution, or the Matlab code), you will receive at minimum an F for the course and be referred to the office of student conduct. **Please note**: in recent years I have had to report students to the Office of Student Conduct for cheating on homework - I hope not to have to to do this again.

Finally, please be on time - late arrivals are very disturbing to other students in the class and also to me. I review the previous class at the start of each lecture and also make announcements at this time.

8. Outline

Part 1: Signal and Systems in the Time Domain
Class 1: Introduction and overview
Class 2: continuous time signals and systems vs. discrete time signals and systems.
Class 3: LTI systems, causality and BIBO stability, impulse response
Class 4: Linear difference equations (LDEs) for LSI systems

Part 2: Signal and Systems in the Fourier Domain
Class 5: The Discrete Time Fourier Transform (DTFT) and its properties; practical aspects of convergence.
Class 6: LTI systems: LDEs, the impulse response and the frequency response.
Class 7: The importance of phase in signals and systems.
Class 8: The discrete Fourier transform (DFT): definition and properties.
Class 9: The FFT.
Class 10: Other unitary transforms and their applications: DCT and Haar wavelet transforms. 2D transforms.
Class 11: Sampling of analog signals: aliasing, sampling theorem, signal reconstruction.
Class 12: More sampling: 2D sampling, Fourier sampling, and applications.
Class 13:The four Fourier transforms. Relationships between the FT, DFT and DTFT: leakage, resolution and effects of zeropadding and windowing
Class 14: Practical (nonparametric) spectral analysis
Class 15: MIDTERM EXAM (Tuesday, Oct 14th)
Class 16: If time permits: sample rate modification and polyphase filters, the sigma-delta converter, compressed sensing.

Part 3: Z-transforms, LTI System Analysis and Digital Filters
Class 17: The Z-transform, its invervse and its properties
Class 18: LTI systems and the system function. FIR and IIR systems. Poles and zeros.
Class 19: Characterization of LTI systems summary - impulse response, LDEs, frequency response and system functions.
Class 20: Filter types and applications I: Linear phase, minimum phase, all-pass systems
Class 21: Filter types and applications II: differentiators, Hilbert transformers
Class 22: Design of Linear phase FIR filters - least squares and window design methods
Class 23: Design of Linear phase FIR filters - Chebyschev approximation
Class 24: IIR filter design from analog prototypes: bilinear transforms
Class 25: IIR filter design by numerical optimization. Relations to parametric spectral estimation and signal modeling.
Class 26: Structures for digital filters. Quantization effects in digital systems.
Class 27: Multirate filter banks and wavelets
Class 28: Introduction to adaptive filtering
Class 29: Review