
University of New Mexico, Albuquerque
Department of Electrical and Computer Engineering
ECE-539: Digital Signal Processing
Spring Semester 2012, 3 Credit Hours

COURSE INFORMATION

Course Instructor	Prof. Balu Santhanam
Office Location	Room 326A, ECE Bldg.
Contact Info	Email: bsanthan@ecece.unm.edu Tel: (505) 277-1611 , Fax: (505) 277-1439
Prerequisite	ECE-314, ECE-340, linear algebra, knowledge of MATLAB
Location	ECE-132
Lectures	TR: 3:30 - 4:45 PM
Textbook	A. V. Oppenheim, R. W. Schafer and J. R. Buck, "Discrete-Time Signal Processing," Third Edition, Prentice Hall Inc., Upper Saddle River, New Jersey, 1999. & S. K. Mitra, "Digital Signal Processing: A Computer Based Approach," Third Edition, McGraw Hill Publications, New York, 2006 (optional).
Office Hours	TBA

GRADING SYSTEM

1. Problem Sets/Computer Projects : 20%
2. Midterm Exam: 40%
3. Final Exam : TBA: 40%

REFERENCES

- J. H. McClellan, R. W. Schafer, et al., "Computer Based Exercises for Signal Processing Using MATLAB 5.0," Prentice Hall Inc., Upper Saddle River, New Jersey, 1998 (very highly recommended).
- J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications," Third Edition, Prentice Hall Inc., Upper Saddle River, New Jersey, 1996.
- Gilbert Strang and Truong Nguyen, "Wavelets and Filterbanks," Wellesley-Cambridge Press, Massachusetts, 1996.

- P. P. Vaidyanathan, “Multirate Systems and Filterbanks,” Prentice Hall Inc., Englewood Cliffs, New Jersey, 1993.
- M. H. Hayes, “Statistical Digital Signal Processing and Modeling,” John Wiley & Sons Inc., New York, 1996.
- K. S. Shanmugan and A. M. Breipohl, “Random Signals: Detection, Estimation and Data Analysis,” John Wiley and Sons, New York, 1988.
- A. V. Oppenheim, A. S. Wilsky and S. H. Nawab, “Signals and Systems,” Second Edition, Prentice Hall Inc., Upper Saddle River, New Jersey, 1997.

COURSE OUTLINE

This course is a first-level graduate course in discrete-time signal processing. Computer exercises in MATLAB will be used to supplement the lectures. Concepts covered in the class include:

- **Review of Discrete-time LTI Systems:**
Difference Equations and impulse response, DTFT, computation and properties. frequency response and system function, Zee transform, ROC, inverse Zee transform¹, residue theorem.
- **Nyquist Sampling Theorem:**
Hilbert space representation, orthonormal basis, KLT expansion, Hilbert spaces and sampling theorem, decimation and interpolation, multirate systems and filterbanks, polyphase decomposition and structures, arbitrary sampling rate conversion.
- **Quantization of Discrete-time Signals:**
Two’s complement digital representation, uniform quantization : round-off and saturation, Lloyd–Max quantization, gain-noise model, differential quantization, DPCM, noise shaping by oversampling, sigma-delta modulation.
- **Minimum Phase Systems and Factorization:**
Minimum phase and All-pass systems, relationship between magnitude and phase of the DTFT, properties of minimum phase systems, minimum phase all-pass factorization, linear prediction and lattice structures, all-pole signal modeling, Linear phase systems.
- **Discrete Fourier Transform (DFT):**
Definition and a very brief overview of properties, decimation in time and frequency, Cooley-Tukey FFT algorithms, computational Complexity analysis, spectral analysis via the DFT, linear Convolution via the DFT, nonuniform DFT. Quantization effects and the DFT, symmetric convolution and the discrete cosine and sine transforms.
- **LTI systems, Signal Flow-graphs and Quantization:**
Direct form I and II, cascade forms, parallel and transposed forms, structures for FIR systems, structures for all-pass filters, lattice structures and linear prediction, quantization noise analysis, finite word-length effects in digital filters.

¹This review will be very brief. Problem Set 0.0 has been posted to the web-page for purposes of overview. It is assumed that the student can determine if they have the prerequisite knowledge.

- **Time–Frequency Analysis:**

Time–frequency representations, fractional Fourier transform (FRFT), Short–time Fourier transform (STFT), Wigner distribution, Wavelet transforms and filterbanks.

Additional Information

Course Webpage

The webpage for the course is located at [www.eece.unm.edu/ faculty/bsanthan](http://www.eece.unm.edu/faculty/bsanthan) under ECE-539. Information regarding homework, homework solutions, MATLAB assignments, MATLAB resources, problem sessions etc, will be posted here so please check there often.

Library and Computer Resources

There will be a folder for ECE-539 at the *centennial science and engineering library* (CSEL) reserve desk. I will also be putting some of the reference material on reserve so that they can be checked out for a limited period of 2 hours. In regards to the computing resources, you should obtain a ECE computer account if you do not already have one. There is an online application form that you need to fill in and submit once you are in the ECE network this will give you access to the ECE Unix and Windows machines that have MATLAB 7.x loaded on them. These will come in handy during the MATLAB assignments.

Exams and Tests

The midterm exam and the final exam for the course will be take-home type exams. You will be given 24 hours to complete the exam. These exams are open book open notes mode exams. For example, the final exam is on May 11, Thursday and therefore the take-home exam will be posted on May 10, Wed around 5:00 PM and will be due back the next day. Please note that **I do not entertain students taking the exam out of order, i.e., neither before or after the exam date** unless it is really extraneous circumstances (health reasons).

Policies and Assumptions

Homework and Office Hours

Homework assignments are meant to strengthen your conceptual understanding in the course. They are not intended to be a masochistic ritual. I also recommend that you use my office hours properly and judiciously. If you have not had related material before, this material takes a while to sink in. This is not a “easy” course by any definition and if you have not had exposure to these concepts before then I suggest you do extra problems from the references to strengthen your concepts.

Attendance Policy

It is assumed that the students are aware of and understand the university attendance policy. In any case if you do not attend class, honestly I don’t care, because you are assumed to be adults and it is your money going down the drain.

Make-up Exam Policy

I do not give make-up exams. If you need to take the exam ahead of time then it is **your responsibility** to arrange a alternative date/time with me and this will be only under extraneous circumstances.

Exam Regrade Policy

Questions regarding grading in the midterms and the final exam need to be addressed within 1 day of the return of the graded exams. Note further that partial credit assignment remains at the discretion of the instructor and is not subject of debate.

Cheating and Academic Honesty

It is also assumed that you are familiar with the university academic honesty policy. Needless to say that academic dishonesty will be dealt with seriously. Specifically one take-home exams students are not allowed to consult with each other and their work is expected to be their own effort.

Prerequisites

I am assuming that you are familiar with the computing software, MATLAB. If you need some review or introduction I can direct you to reference material. I will also go through the review material from ECE-314 and ECE-340 in a very brief fashion. So if you feel that your knowledge of this material is inadequate then you should probably register for the undergraduate courses instead. Problem Set # 0 has been posted on the course webpage and is intended to be a guide to what is expected in terms of ECE-314, ECE-340 concepts. I also have some notes from the ECE-314 course if you need a quick review of the material. The course ECE-439, i.e., the undergraduate DSP course is recommended for students who have not seen system theory before and feel a need to review DSP concepts. Needless to say that it is the **responsibility of the student** to make sure that they have the prerequisite knowledge needed for the course and not the instructors

Academic Fairness

There will also be a file containing all my homework and tests from previous years placed at the CSEL reserve desk which students can copy. This is an effort to equalize the "playing field" and provide equal access to all students to old material.