University of New Mexico, Albuquerque
Department of Electrical and Computer Engineering
ECE-539: Digital Signal Processing
Spring Semester 2020, 3 Credit Hours

COURSE INFORMATION:

Course Instructor	Prof. Balu Santhanam
Office Location	Room 326A, ECE Bldg.
Contact Info	Email: `bsanthan@unm.edu`
	Tel: (505) 269-0703
Prerequisite	ECE-314, ECE-340, knowledge of MATLAB
Location	ECE-237
Lectures	TR: 11:00 AM - 12:15 PM
Textbook	Discrete–Time Signal Processing A. V. Oppenheim, R. W. Schafer and J. R. Buck 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).
Coordinator	Eric Hamke, `ehamke@unm.edu`
Office Hours	TBA

GRADING SCHEME:

Problem Sets/Computer Projects : 35%
Midterm Exam, date TBA : 35%
Final Project : May 12, Tuesday, 2:30 PM, 30%

References

1. 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).

2. J. G. Proakis and D. G. Manoloakis, "Digital Signal Processing: Principles, Algorithms, and Applications," Third Edition, Prentice Hall Inc., Upper Saddle River, New Jersey, 1996.

3. Gilbert Strang and Truong Nguyen, "Wavelets and Filterbanks," Wellesley-Cambridge Press, Massachusetts, 1996.

4. P. P. Vaidyanathan, "Multirate Systems and Filterbanks," Prentice Hall Inc., Englewood Cliffs, New Jersey, 1993.

5. M. H. Hayes, "Statistical Digital Signal Processing and Modeling," John Wiley & Sons Inc., New York, 1996.

6. K. S. Shanmugan and A. M. Breipohl, "Random Signals: Detection, Estimation and Data Analysis," John Wiley & Sons, New York, 1988.

7. 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**[1]:
  Difference Equations and impulse response, DTFT, computation and properties. frequency response and system function, Zee transform, ROC, inverse Zee transform, 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.
- **Linear prediction and Lattice Structures**:
  Linear predictive modeling, orthogonality principle, Levinson Durbin step-up and step-down recursions, Schur-Cohn Stability, all-zero and all-pole lattice structures. Lattice structures and PR filterbanks.
- **Discrete Fourier Transform (DFT)**:
  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 extension 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, quantization noise analysis, finite word-length effects in digital filters.
- **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 ece-research.unm.edu/bsanthan/courses 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 x.x loaded on them. These will come in handy during the MATLAB assignments.

[1]This 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.

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. This is so that students can concentrate on understanding the material rather than getting tested over an hour during class-time as to how many silly mistakes they can make. These exams are due back 24 hours from the date/time that is posted for the exams on the web-page (no exceptions).

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.