

# EE648 (CC761M for NTU) Digital Signal Processing II

## Course Information and Syllabus for Spring 1999

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**Course Objective:** To introduce the student to a number of recent developments in digital signal processing that are having tremendous impact on the design of current and future generation digital audio systems, wireless communication systems, active noise cancellation systems, speech recognition systems, and speech/image transmission systems.

**Course Description:** A number of advanced topics in digital signal processing will be covered with heavy emphasis on applications to digital audio, wireless digital communications, active noise cancellation for automotive applications, and speech recognition. Topics covered include: adaptive signal processing, efficient digital schemes for sampling rate conversion, digital subbanding and perfect reconstruction filter banks, space-time processing of signals carried by propagating waves, and wavelets for time-frequency analysis.

**Texts:** The following text will be used starting around the fifth week of the semester and is the primary text for the whole course.

*Required Text:* P. P. Vaidyanathan, **Multirate Systems and Filter Banks**, First Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993, ISBN: 0-13-605718-7.

The *Student Edition of Matlab* will be needed unless you already have the professional version of Matlab on the computer system at your work.

*Required Software:* **Student Edition of Matlab**, Version 5, Prentice-Hall, 1997, ISBN: 0-13-272477-4. Be sure to specify whether you need the MAC or PC versions.

The following text will be referred to during the first few weeks of the semester. It is the required text for *EE538 Digital Signal Processing I*.

*Reference Text:* J. Proakis and D. Manolakis, **Digital Signal Processing**, Third Edition, Prentice-Hall, Englewood Cliffs, NJ, 1996, ISBN: 0-13-373762-4.

**Prerequisites:** A first course in digital signal processing. Prerequisite background topics: sampling theory, discrete-time Fourier analysis, digital filter design, and basics of A/D and D/A conversion.

**Computer Requirements:** Access to local computer with Student Edition of Matlab or equivalent mathematics processing software. Dial-in access to Purdue's Engineering Computer Network will be provided on a per need basis.

**Homeworks/Projects:** There will be 5 bi-weekly small-scale mini-projects involving the use of Matlab that will be collected and graded. *Successful completion of these 5 computer-based homework assignments will constitute over half of your overall grade for the course.* Some of these problems involving Matlab include spectral analysis of speech signals and sums of damped sinusoids, adaptive noise cancellation and adaptive line enhancement, space-time processing for wireless communications, equalization of digital communication signals, and sampling rate alteration for digital audio. These assignments will NOT be time-consuming; they will NOT require a lot of code development. Further, I will post Matlab help files at the course web site that will assist you in doing these assignments.

**Examinations:** There will be only one in-class 75 minute examination on the date listed below.

**Exam Date:** *Session 16.* (Live: Thursday, March 4.) 75 minutes.

**Final Project:** There will be a small-scale final mini-project in place of a final exam that can be either work-related or chosen from a set of possible course-related topics.

**Grade Breakdown:**

<i>Category</i>	<i>Number</i>	<i>Points Per</i>	<i>Sub-Total</i>
Homeworks	5	12	60
Examination	1	20	20
Final Project	1	20	20
Total			100

**Web Site:** A web site has been set up for the course to post matlab scripts for course demonstrations done in class, grade information, and other course related information. The web site is: <http://shay.ecn.purdue.edu/ee648/> I will also scan in my handwritten notes after each class and post them at the course web site in the form of an Adobe Acrobat pdf file. The acrobat reader is free software that can be downloaded over the internet from the web site <http://www.adobe.com/> Experience has revealed the pdf file for a given lecture to be somewhere between 100K and 200K in size. Solutions to homework problems will be scanned in and posted as well.

**E-mail:** I encourage everyone in the class to send me an initial e-mail at [mikedz@ecn.purdue.edu](mailto:mikedz@ecn.purdue.edu) as soon as possible so I can create an e-mail alias to broadcast course related announcements throughout the semester. Please include your phone and FAX numbers at work in the e-mail as this information will not be provided to me by the Purdue Continuing Engineering Education office. You are welcome to e-mail me or the TA course related questions throughout

the semester and we will reply to you as soon as we can. Again, always include your phone and FAX numbers with questions sent by e-mail as it may be easier for me to reply by phone or by FAX depending on the nature of the question.

**Office Hours:** The TA and I will hold dedicated phone-in office hours (no walk-ins allowed) for office-campus students, as well as dedicated walk-in office hours (no phone calls answered) for on-campus students. The list of office hours for both the TA and I will be mailed to you some time during the first week of classes, and will be posted at the course web site as well. Off-campus students should note that if I am on the telephone talking to another student, your call will be transferred to my secretary's office after several rings. Thus, if the phone rings over to my secretary that does not mean I am not in my office. You may leave a message with her for me to return your call or you may hang up after the third ring and call me back in a few minutes.

**Make-Up Policy:** The dates for the one and only in-class exam is Session 16. For logistical reasons and in the interest of fairness to all students enrolled in the course, we must adhere to a strict policy regarding make-up examinations. *On-Campus* students will only be allowed to make up an exam for health reasons. It is assumed that a missed exam is the result of serious extenuating circumstances. A doctor's note will be required and I should be notified before the examination is to take place if at all possible. If it is not possible to notify me a-priori, then you need to contact me as soon as possible after the exam has been given. A conflict due to a job interview trip is not an acceptable excuse for missing an exam since the exam date is being announced now.

The above condition applies to *Off-Campus* students as well, except for the following proviso relative to work related business trips. An *Off-Campus* student may be considered a candidate for a make-up exam if the following condition is met: please have your supervisor write me at least one week in advance of the date of the examination requesting that you be allowed to take the exam at a later date. The letter should be written on your company's letterhead and should provide an explanation of why you must miss the examination. The name and telephone number of your supervisor should be included as well. I will make a decision based on the information contained in this letter. You should verify with me that you have been excused from the exam and arrange the earliest date you can take a make-up.

**Grade Disputes:** If you dispute your grade on any exam or homework assignment, you have *one week* from the date that the graded paper was returned to you to request a regrade. Please attach a brief note of explanation to your paper when you return it. For off-campus students, the regrade request must be post-marked within 7 days of the date you receive the graded paper. Please send all regrade requests to me.

**Lecture:** I would like to encourage active participation from the class as much as possible. You are certainly welcome to ask questions during the lecture, or e-mail questions after the lecture. I will occasionally ask questions during class to stimulate your thinking at various points during the lecture. *Off-Campus* students will naturally have to use the call-in facilities provided at their off-campus locations. For *On-Campus* students, it is very important that you speak clearly into the microphone; so that everyone, including those off-campus, can hear your question or response.

One advantage of the TV medium is that you have the option of viewing the lecture at a later time. *On-Campus* students may view the lecture at the Engineering Library in Potter at any time within one week of the date of the lecture. *Off-Campus* students should consult their site coordinator regarding the availability of tapes of the lecture.

*Topic:* *Lectures Handout: Chap. 12 of 1st Ed. of Proakis and Manolakis*

- I. Adaptive Signal Processing** 6
- A. Applications: Equalization, Interference Suppression, Noise Cancellation
  - B. Adaptive Direct-Form FIR Filters
    - 1. Minimum Mean Square Error Criterion
  - C. The Widrow LMS Algorithm and Convergence Properties
  - D. The Recursive Least Squares Algorithm and Convergence Properties

- II. Space-Time Processing** 6 *Handouts*
- A. Analysis of Space-Time Signals
  - B. Beamforming
    - 1. Weighted Delay-and-Sum Beamformer
    - 2. Array Pattern
  - C. Narrowband Array Processing
  - D. Applications
    - 2. Antenna Arrays for Cellular Communications
      - 1. Microphone Arrays for Noise Cancellation

*Topic:* *Lectures Vaidyanathan*

- III. Fundamentals of Multirate DSP** 5
- A. Interpolation and Decimation 4.1
  - B. Polyphase Representations 4.3
  - C. Multistage Implementations 4.4
  - D. Applications of Multirate DSP 4.5

- IV. Perfect Reconstruction Filter Banks** 6
- A. Power Symmetric Filter Banks 5.2, 5.3
  - B. Alias-Free Multichannel Filter Banks 5.4, 5.5
  - C. Tree-Structured Filter Banks 5.8
  - D. Applications of PR Filter Banks 5.9

- V. Wavelets** 6
- A. The Short-Time Fourier Transform 11.2
  - B. The Wavelet Transform 11.3
  - C. Discrete-Time Orthonormal Wavelets 11.4
  - D. Continuous Time Wavelet Basis 11.5