EECS 206 -- Signals and Systems I

- Credits: 4; Prereq's: Math 116, Engn 101
- Lectures: MWF, Lab: 2 hr/wk
- Text: DSP First, McClellan, Schafer, Yoder
- Enrollment: Fall 260, Winter 215

- **Lectures**

Introduction	(1) (Ch. 1)	cont time	time dom
Elemen. signal concepts & op's	(3) (Notes)		
Basic signal processing tasks	(1) (Notes)		
Sinusoidal signals	(2) (Ch. 2)		
Complex exponential signals	(2) (Ch. 2)		
Spectra continuous-time signals, Fourier series	(4) (Ch. 3)		freq domain
Spectra discrete-time signals, discrete Fourier transform	(3) (Notes)	discr time	
Sampling	(3) (Ch. 4)		
FIR filters in time domain	(4) (Ch. 5)		
FIR filters in freq. domain	(4) (Ch. 6)		
Z-transforms and zeros	(5) (Ch. 7)		
IIR filters, poles and zeros	(5) (Chap 8)		
Wrap-up & selected topics	(3) (Notes)		

Lecture Syllabus with Details

- Introduction (1)
- Elemen. signal concepts (2) (Notes)

  Signals: definition, descriptions, discr. & cont. time
  Signal statistics: min, max, avg, MSV, RMSV,
  power, energy, histograms,
  signal value distribution
  Periodicity
- Elemen. signal operations (1) (Notes)

  Amplitude shift, amplitude scaling, time scaling, time shifting, time reversal, linear combinations
- Basic signal processing tasks (1) (Notes)

  Given $r(t) = s(t) + n(t)$

  Signal recovery:

  Recover $\hat{s}(t)$ from $r(t)$ via linear filtering
  Mean squared error

  Signal detection/classification:

  Make decision about $s(t)$ from $r(t)$
  Energy detector, correlating detector, decision rules, error rate

- Sinusoidal signals (2) (Ch. 2)

  $A\cos(\omega_o t+\phi)$
- Complex numbers and complex exponential signals (2) (Ch. 2)

  Key motivating problem: summing two sinusoids with same frequency

  Phasors
- Spectra of continuous-time signals, Fourier series (4) (Ch. 3)

  Spectra of a sum of sinusoids

  Spectra of periodic signals -- Fourier series
- Spectra of discrete-time signals, discrete Fourier transform (3) (Notes)

  Spectra of periodic signals -- DFT
- Sampling (3) (Ch. 4)

  Statement of sampling theorem without proof, aliasing, reconstruction

- FIR filters in time domain (4) (Ch. 5)

  Systems, linearity, time invariance, causality, FIR filters, difference equations, unit impulse, impulse response, convolution, cascaded systems, block diagrams, running average filter
- FIR filters in freq. domain (4) (Ch. 6)

  Frequency response, DFT of output, steady-state and transient response, cascaded systems, FIR filters, running average filter
- Z-transforms and zeros (5) (Ch. 7)

  Z-transforms of finite length signals,
  system function = z-transform of impulse response,
  input-output relationship, cascaded systems,
  shaping the frequency response with zeros
- IIR filters, poles and zeros (5) (Chap 8)

  IIR filters, impulse response, convolution, system function, stability, first and second order filters, block diagrams, shaping the frequency response with poles and zeros, partial fraction expansions
- Wrap-up and selected topics (3)

  More mathematical details

  Lookahead to continuous-time techniques: Fourier and Laplace transforms

  Electives in signals and systems

Lab Assignments

2 hour lab period each week.

Assignment completed after the lab.

Up to 36 students per session, working in pairs.

Facility: Room 2331. 18 PC's, LCD projector.
(It's a CAEN Lab when not used for 206, 306)

Lab Syllabus

0. Matlab tutorial, no assignment.
1. Signal Statistics and Detection I (new W02)
2. Signal Correlation and Detection II (new W02)
3. Sinusoids and Sinusoidal Correlation (new W02)

Review for exam

4. Signal Spectra - Fourier Series and DFT (new W02)
5. Images and Image Compression
6. FIR Filtering in Time Domain

Review for exam.

7. FIR Filtering in Frequency Domain
8. Vowel Lab I: IIR Source/Filter Models (rev'd W02)
9. Vowel Lab II: Vowel Features & Classification, (rev'd)

Review for Exam

Lab Assignments -- more details

Labs developed here.
Some patterned after "DSP First" labs.

0. Matlab tutorial, no assignment.
1. Signal Statistics and Detection I (new W02)

   Compute signal statistics, measure signal distortion. Implement signal detector based on energy and thresholding.

2. Signal Correlation and Detection II (new W02)

   Implement signal detector based on correlation and thresholding. Error rates. Noise statistics. Radar and CDMA type signals.

3. Sinusoids and Sinusoidal Correlation (new W02)

   Implement system that determines frequency and phase of sinusoid using correlation with complex exponential.

4. Signal Spectra - Fourier Series and DFT (new W02)

   To be determined.

5. Images and Image Compression

   Image display and properties. Downsampling. Additive noise. Quantization. Binary encoding. DFT based transform coding.

6. FIR Filtering in Time Domain

   Implement FIR filter. Image filtering with FIR filters.

7. FIR Filtering in Frequency Domain

   Implement touchtone telephone decoder -- bank of bandpass FIR filters, envelope detector, detect and decode.

8. Vowel Lab I: IIR Source/Filter Models (rev'd, W02)

   Design all pole IIR filters so pulse train into filter models spectra of certain vowels. Hand and automated pole placement.

9. Vowel Lab II: Vowel Features and Classification (rev'd, W02)

   Use spectrum, formants, AR coefficients as features. Train and implement a vowel classifier. Measure performance. ROC curves.

Overall Lab Goals

- Reinforce lecture material -- by hands-on practice with it, and by using it to implement useful systems.
- Engage students in signals and systems engineering.
- Acquaint students with signals and systems engineering problems/tasks and solution approaches beyond those of the lecture.
- Train students to be able to implement signals and systems solutions -- via Matlab.

Goals of Individual Labs

- Introduce some particular signals and systems problem/task.
- Introduce methods and theory that address this problem/task.
- Introduce additional Matlab skills.
- Design and implement some system(s) that performs the desired task.

  "Design" generally means choosing some parameter or parameters. "Implementation" means writing or making use of prewritten Matlab programs.
- Make quantitative performance measurements.

  E.g. mean-squared error, error rate.
- Design and/or performance analysis based on theory.

  E.g. Design filter frequency response by pole, zero placement. MSE of quantizer = $\Delta^2/12$.

Why Matlab?

Because Matlab is the "breadboarding" of signals and systems.

How Much Matlab?

It's a balancing act -- between having students write their own Matlab code and giving them canned routines.

Too much Matlab and they spend all their time programming and can't see the forest for the trees.

Too little and they won't feel like they can really "do things".

Matlab is also a tool for figuring things out.

Matlab can be used in future courses.

General Goals of EECS 206

Target Audience

Fall term sophomores majoring in EE and CE (or considering such)

who have had freshman calculus (Math 115, 116)

and introduction to programming including 2-3 weeks of Matlab (Engin 101).

Students whose career goals include an EE or CE career with a BS, MS or PhD.

High Level Goals

Course should be attractive, stimulating, challenging, but not overwhelming to the target audience.

At the end, students should

Have learned a significant amount of signals and systems concepts and theory.

Have an awareness of a number of problems/tasks that signals and systems engineering addresses.

Be capable of doing some signals and systems engineering.

Topical Goals

Introduce as much as possible of each of the following.

- Signals and systems concepts and theory.
- Signals and systems engineering problems/tasks and solution approaches.

This course begins (and perhaps ends) their study of and training in signals and systems. We want them to learn a sizeable chunk of conventional signals and systems material. We want them to learn something about what lies ahead in signals and systems engineering.

Big Issues

- Discrete- vs. continuous-time signals and systems.
- Time domain vs. frequency domain
- Theory vs. practice.
- Theory with engineering applications vs. engineering with theory as needed.

Topics Not Ordinarily Emphasized in Undergrad Curricula

- Signal value distribution, correlation, signal recovery, signal detection, decision making, performance measures.