ME 57900
FOURIER METHODS IN DIGITAL SIGNAL PROCESSING

**Course Outcomes**

1. To familiarize the students with the theory behind the functions found on most frequency analysis systems or software tools so that they can understand the effects of parameter settings on the analysis results.
2. To introduce the basics of digital filtering and digital filter design so that students understand the effects of manipulating discrete spectra, and are able to design simple digital filters.
3. To introduce the basics of stationary signal analysis, and show how it is used to derive input-output relationships for linear time-invariant systems excited by random processes.
4. To familiarize the students with methods of estimating correlation functions, spectral densities, frequency response functions and coherence, and the errors that arise from the estimation process.

**Deterministic Continuous Signals and Systems (4 wks)**

1. Fourier Series and transforms
2. Windowing of signals and resolution issues.
3. Convolution of signals
5. Calculations of Fourier series coefficients and Fourier transforms.

**Revision Date: 6/27/12**

**Random Signal Analysis (3 wks)**

1. Revision of basic statistics: PDFs, expectation.
3. Correlation functions.
4. Spectral density functions.
5. Random excitation of systems: input-output relationships.
6. Coherence

**Deterministic Discrete Signals and Systems (3 wks)**

1. Sampling and aliasing.
2. ADC and DAC operation.
3. $z$-transforms.
4. Transfer functions of discrete systems (ARMA models) and finite difference equations.
5. Frequency response of discrete systems.

**Estimation of Spectra and Frequency Response Functions (2 wks)**

1. Estimation theory basics: bias and variance.
2. Estimation of correlation and spectral density functions.
3. Estimation of frequency response and coherence functions.

**Digital Filtering (3 wks)**

1. Filter performance evaluation.
2. Finite impulse response (FIR) filter design
3. Infinite impulse response (IIR) filter design.
4. Discrete–time integrators, differentiators and Hilbert transformers.
### 1. COURSE NUMBER AND NAME: ME 57900 Fourier Methods in Digital Signal Processing

### 2. CREDITS AND CONTACT HOURS: 3 credits
   - a. Lecture – 3 days per week at 50 minutes for 16 weeks

### 3. COURSE COORDINATOR OR INSTRUCTOR:
   - P. Davies

### 4. TEXTBOOK: None

### 5. SPECIFIC COURSE INFORMATION:
   - a. Catalog Description: Fundamentals of signal processing associated with commonly used Fourier analysis systems/software packages are presented. Emphasis is on the development of an understanding of the experimental methodologies & data acquisition requirements for robust spectral estimation, correlation analysis, & non-parametric system identification. Deterministic, as well as random, data analyses are presented. Students develop their own code to simulate signals & to implement signal processing algorithms. Typically offered in the fall.
   - b. Prerequisites: ME 47500 – Automatic Control Systems
   - c. Status: Elective

### 6. SPECIFIC GOALS FOR THE COURSE
   - a. Course Outcomes:
     1. To familiarize the students with the theory behind functions found on most frequency analysis systems or software toolboxes so that they can understand the effects of parameter settings on the analysis results.
     2. To introduce the basics of digital filtering and digital filter design so that students understand the effects of manipulating discrete spectra and are able to design simple digital filters.
     3. To introduce the basics of stationary signal analysis and show how it is used to derive input-output relationships for linear time-invariant systems excited by random processes.
     4. To familiarize the students with methods of estimating correlation functions, spectral densities, frequency response functions and coherence and the errors that arise from the estimation process.
   - b. Related ME Program Outcomes:
     - A2. Analytical Skills; B3. Prof/Ethical Responsibility; B4. Contemporary Issues;
     - A3. Experimental Skills; B5. Life-Long Learning;
     - A4. Modern Engr Tools; C1. Leadership,
     - A5. Design Skills; C2. Global Engineering Skills;
     - A6. Impact of Engr Solns; C3. Innovation;
     - B1. Communication Skills; C4. Entrepreneurship

### 7. LIST OF TOPICS: See following page.

**PREPARED BY:** P. Davies  
**REVISION DATE:** June 29, 2012