Stanford University
EE 102B: Signal Processing and Linear Systems II
Spring 2014-15, Professor Joseph M. Kahn

Syllabus

Description: Continuation of EE 102A. Concepts and tools for continuous- and discrete-time signal and system analysis with applications in communications, signal processing and control. Analog and digital modulation and demodulation. Sampling, reconstruction, decimation and interpolation. Finite impulse response filter design. Discrete Fourier transforms, applications in convolution and spectral analysis. Laplace transforms, applications in circuits and feedback control. Z transforms, applications in infinite impulse response filter design.

Prerequisite: EE 102A or knowledge of: continuous- and discrete-time signals, linear time-invariant systems, convolution, Fourier series and Fourier transforms, as well as sampling and reconstruction.

Instructor: Professor Joseph M. Kahn, Spilker Engineering and Applied Sciences 216, (650) 724-9584, jmk@ee.stanford.edu. Office hours: M 3-4 and W 1-2 in Spilker 216.

Teaching Assistants:

Kevin Chavez, kjchavez@stanford.edu. Office hours: time and place TBD.

Maisy Wieman, mwieman@stanford.edu. Office hours: time and place TBD.

Class Meetings: MWF 11:00-12:15 in 380-380Y.

Review Sessions: time and place TBD.

Poll for Office Hour and Review Sessions: http://doodle.com/tsy92m7p947mikgh. Please respond as soon as possible so we can set the times and places.

Website: https://coursework.stanford.edu/portal/site/Sp15-EE-102B-01. Lecture notes, other handouts, homework assignments and solutions, announcements and grades are posted.

Textbooks:

Required: *Course Reader for EE 102B*. This is available for $31 from the Stanford Bookstore. Alternatively, you can download PDF files from the website and print them. Please bring the course reader to lecture, as we will refer to it and you may wish to annotate it. You are responsible for all the material in the course reader, except when noted.

Recommended: *Signals and Systems, Second Edition*, A. V. Oppenheim, A. S. Willsky and S. H. Nawab, Prentice-Hall, 1996 (designated OWN). Two copies are available on four-hour reserve in the Engineering Library. You are expected to have hard copies of the transform tables appearing in this book (Tables 3.1, 3.2, 4.1, 4.2, 5.1, 5.2, 9.1, 9.2, 10.1, 10.2). Most of the subjects we study are covered in OWN.

Supplementary: *Discrete-Time Signal Processing, Third Edition*, A. V. Oppenheim and R. W. Schafer, Prentice-Hall, 2010 (designated OS).Two copies are available on four-hour reserve in the Engineering Library. Certain subjects we study (FIR filters, discrete Fourier transforms, IIR filters) are covered in OS but not OWN. This may not provide sufficient reason for you to buy a copy, but if you plan further study of signal processing, you should consider buying it.

Recommended: *MATLAB and Simulink Student Version*, MathWorks. MATLAB is available on many Stanford computers for free. Nevertheless, you may find it convenient to purchase a student version of MATLAB so you can work exercises on your own computer.

Grading Guidelines: 35% homework, 25% midterm, 40% final.

Homework: Assignments may include both analytical and MATLAB components. It is fine if you collaborate with fellow students, but each of you should turn in your own paper. Homework will usually be assigned on Friday and due the following Friday. It should be turned in by 5 p.m. to the EE 102B drawer on the second floor of Packard. Graded homework will be available at the same location. Unless arranged in advance with the instructor or a TA, late homework will lose points for each day it is late. No points will be given after the solutions are made available, typically on Monday or Wednesday following the due date.

Homeworks 5 (before the midterm) and 9 (before the final) will include practice exam problems. They will be assigned on Wednesdays and will not be collected. Solutions will be made available at the midterm and final review sessions. These two assignments will not include MATLAB components.

Exams: Exams will be open-book and open-note. Electronic devices will not be permitted.

Midterm: Friday, May 8, 11-12:15 in 380-380Y.

Final: Friday, June 5, 8:30-11:30 a.m., place TBD. The final exam will be given at an alternate time only under exceptional circumstances and by prior arrangement with the instructor.

Outline and Readings: Lecture dates are tentative, as the course has been revised since the last offering. You are not responsible for topics that are *italicized* (including the whole chapter on Communication Systems). It is possible that additional topics (e.g., Feedback Control Systems) will be italicized if we run short of time.

Topics	**Recommended and Supplementary Readings**	**Lecture Dates**
Fourier representations. Review of continuous- and discrete-time Fourier series and Fourier transforms and their properties. Parseval's identity.	OWN chs. 3, 4, 5, espec. Tables 3.1, 3.2, 4.1, 4.2, 5.1, 5.2, 5.3	3/30
Communication systems. *Communication media. Multiplexing and reuse. Analog and digital communications. Double-sideband amplitude modulation, quadrature amplitude modulation, single-sideband amplitude modulation. Synchronous demodulation. Hilbert transforms. Angle modulation.*	OWN 8.0-8.4	–
Sampling and reconstruction. Ideal sampling. Nyquist requirement. Ideal reconstruction using sinc pulses or zero-order hold. Digital decimation and interpolation. *Bandpass sampling.*	OWN 7.0-7.6. OS 4.0-4.6.	3/30, 4/1, 4/3

Finite impulse response discrete-time filters. Finite vs. infinite impulse response filters. Ideal lowpass, highpass, bandpass filters. Design of finite impulse response filters by Fourier series expansion of desired frequency response. Window functions.	OS 7.5.	4/6, 4/8, 4/10
Discrete Fourier transforms and applications. Discrete Fourier transform (DFT) as one period of discrete Fourier series. Properties of DFT, especially circular convolution. Efficient linear convolution using DFT. Overlap convolution. Spectral analysis using DFT. *Fast Fourier transform algorithms.*	OS 8.1-8.7, 10.1-10.2, 9.2.	4/13, 4/15, 4/17
Laplace transforms and applications. Eigenfunctions of linear time-invariant (LTI) systems. Bilateral Laplace transform (LT) and its inverse. Region of convergence. Rational LTs. Poles and zeros. Relationship of LT to Fourier transform. Properties of LT. Inversion of LT by partial fraction expansion. Transfer function, relationship to impulse response and to system differential equation. Bode plots. Inverse systems. Stability of LTI systems. Unilateral LT, solution of differential equations.	OWN 9.0-9.10, A.1-A.2, 6.5.	4/20, 4/22, 4/24, 4/27, 4/29, 5/1
Feedback control systems. Applications and consequences of feedback. Feedback control. Transient and steady-state response. Stability analysis.	OWN 11.0-11.2.	5/4, 5/6
Z transforms and applications. Eigenfunctions of LTI systems. Bilateral Z transform (ZT) and its inverse. Region of convergence. Rational ZTs. Poles and zeros. Relationship of ZT to discrete-time Fourier transform. Properties of ZT. Inversion of ZT by partial fraction expansion. Inversion of ZT by long division or power series expansion. Transfer function, relationship to impulse response and to system difference equation. Inverse systems. Stability of LTI systems. Unilateral ZT, solution of difference equations.	OWN 10.0-10.10, A.3, 6.6.	5/11, 5/13, 5/15, 5/18, 5/20, 5/22
Infinite impulse response discrete-time filters. Impulse invariance. Bilinear transformation.	OS 7.2.	5/27, 5/29, 6/1