EECS 644 Introduction to Digital Signal Processing

Catalog Data: EECS 644 (3) Discrete time signal and systems theory, sampling theory, z-transforms, digital filter design, discrete Fourier transform, fast Fourier transforms, and hardware considerations.

Prerequisites: EECS 361 Signal & System Analysis or similar background in Fourier signal analysis (series and transform); linear system analysis (continuous and discrete); z-transforms, analog and digital filter analysis; analysis and design of continuous and discrete time system using MATLAB.

Instructional Mode: In-person class, 3150 LEA, TR 8:00 - 9:15

Class Web Page: http://www.ittc.ku.edu/~sdblunt/644/EECS644.htm

Instructor: Dr. Shannon D. Blunt
3034 Eaton Hall
357 Nichols Hall (864-7326)
e-mail: *sdblunt@ku.edu*

Course Notes: Will be posted on the course web page prior to the class in which they will be covered.

Office Hours: TR 9:15 - 10:30 or **by appointment**.

Text: *Digital Signal Processing: Principles, Algorithms, and Applications (4th edition)* by Proakis and Manolakis

Grading Scale: The following plus/minus grading will be used for this course. The lower limit on these ranges may be reduced as a function of the distribution of the final scores.

90.0–92.9: A−	93.0–100: A	
80.0–82.9: B−	83.0–86.9: B	87.0–89.9: B+
70.0–72.9: C−	73.0–76.9: C	77.0–79.9: C+
60.0–62.9: D−	63.0–66.9: D	67.0–69.9: D+
	0–59.9: F	

The following percentages will be used to weigh the components of the course.

Exam #1 - 25%
Exam #2 - 25%
Final Exam - 35%
Homework - 15%

Homework: Homework is intended to illustrate and reinforce concepts covered in class. Homework assignments are posted on the class website. There will be roughly 6-7 homework assignments. Collaboration with classmates is permitted; copying is not. Homework is due by the beginning of the class period in which it is due. Solutions will be posted to the class website after homework is graded.

Computer Usage: Some homework problems will require the use of Matlab.

Exams: There will be 2 mid-term exams during the semester and a final (all in-class). Makeup exams will not normally be given.

Make-ups: Make-up exams are given rarely, and only if:

1. I am informed IN ADVANCE, and
2. I deem the reason to be sufficiently meritorious (job interviews and pleasure trips are not). If the reason is illness, I REQUIRE documentation of the illness from a health-care professional.

Course Objectives: The primary objective of this course is to introduce methods for processing discrete-time signals. This includes waveforms that originate as continuous-time signals. Other objectives are:

- to understand the processes of analog-to-digital and digital-to-analog conversion;
- to analyze and evaluate the performance of discrete-time linear systems;
- to acquire familiarity with digital filters in terms of analysis, design and implementation;
- to understand discrete Fourier analysis (DTFT, DFT, DFS, FFT) as it applies to discrete-time signals;
- to present several applications of digital signal processing algorithms.

This course is intended to provide you with the necessary analytical tools for work in digital signal processing. This is not a computer course, nor is it a digital design course. This course is aimed at a higher level - we will try to address the problem of what we can do to process a signal if we have a computer to help us. Therefore, our primary emphasis will be on algorithms for processing waveforms. A strong background in linear systems theory (i.e. Fourier and Laplace transforms,

convolution and system impulse response, transfer functions, and poles/zero behavior) will prove essential.

Useful Reading: I suggest everyone look through some of the past issues of the Signal Processing Magazine which can be found on the IEEE Xplore database (available through the KU library system). This will give you a better idea of the numerous research areas in signal processing and possibly help you get started on your own research/career in the field.

Class decorum: The School of Engineering is a professional school, and the decorum in this class will reflect that. You are expected to arrive on time, leave on time, and act professionally in class. This includes being intellectually and physically involved in the class.

Attendance Policy: Attendance at all class meetings is expected. Anything presented in class is considered required material. Academic success in this class requires: regular class attendance, doing the homework, and class participation. There is a strong correlation between attendance and the course grade.

Academic Misconduct: Instances of cheating will be referral to the Dean. Cheating includes, but is not limited to: copying another exam, copying of hardcopy or online solutions or previously worked homework or exam solutions, having another person do your work, use of "tutoring" websites like chegg.com.

EdTech Services: The use of EdTech services (e.g. Chegg.com) for posting or downloading material for the preparation and/or submission of exams, homework, etc., constitutes academic misconduct, which is not tolerated in the School of Engineering at the University of Kansas. It violates Article 3r, Section 6 of its Rules & Regulations, and may lead to grades of F in the compromised course, a note on your transcript, dismissal from the School, or expulsion from the University of Kansas. When a person signs up to use EdTech services, the "terms of service" that are agreed to do <u>not</u> protect the person when an academic unit (e.g. KU School of Engineering) conducts investigations related to academic misconduct (e.g. plagiarism and/or cheating). These services retain contact and information (e.g. IP address, email, time of use) of subscribers and users, which is released upon request. If you are feeling unsure about an assignment, it is important to use the allowable resources available to you, such as instructor office hours or the book.

Video and audio recording of the EECS 644 class lectures is strictly prohibited.

Course Evaluation: A course evaluation will be available to students at the end of the semester. Students are strongly encouraged to participate.

Special Needs: Any student with a disability requiring special accommodation should contact the Student Access Center at https://access.ku.edu/ in order to make arrangements. Members of KU sanctioned organizations (band, athletic teams, etc.) that have special needs should also contact the instructor as the need arises.

Course Schedule (subject to change)

No class October 15, 2024 (Fall break)
No class November 28, 2024 (Thanksgiving break)

Topic

1. Course/topic introduction ~ 0.5 weeks
2. Discrete-time signals & systems review ~ 1.5 weeks
    a. Linear time-invariant (LTI) systems
    b. Linear constant-coefficient difference equations (LCCDE)
    c. Frequency-domain representations
3. z-transform ~ 1.5 weeks
    a. Derivation
    b. Properties
    c. Inverse z-transform
4. Correlation ~ 0.5 weeks
    a. Auto-correlation and cross-correlation
    b. Properties
5. Sampling of continuous-time signals ~ 2 weeks
    a. Periodic sampling
    b. Frequency domain representation of sampling
    c. Reconstruction of bandlimited signals
    d. Changing the sampling rate
    e. Digital processing of analog signals

--------- End for Test 1 ---------

6. Transform analysis of LTI systems ~ 1.5 weeks
    a. Frequency response of LTI systems
    b. System functions for LCCDE

    c. Frequency response for rational system functions
    d. Relationship between magnitude and phase
    e. All-pass systems
    f. Minimum/maximum/mixed-phase systems
7. Structures for discrete-time systems ~ 1 week
    a. Signal flow representations
    b. Basic structures for finite impulse response (FIR) and infinite impulse response (IIR) systems
    c. Finite precision numerical effects
8. IIR filter design techniques ~ 1 week
    a. Design of discrete-time IIR filters from continuous-time IIR filters
    b. Design by approximation of derivatives
    c. Design by impulse invariance
    d. Design by bilinear transform
9. FIR filter design techniques & beamforming ~ 1 week
    a. Design by windowing
    b. Standard beamforming & windowing

--------- End for Test 2 ---------

10. Discrete Fourier transform (DFT) ~ 1.5 weeks
    a. Discrete Fourier series
    b. Sampling the Fourier transform
    c. Properties of the DFT
    d. Linear convolution using the DFT
11. Computation of the DFT ~ 1 week
    a. Goertzel algorithm
    b. Decimation of the DFT in time & frequency
12. Fourier analysis of signals using the DFT ~ 1 week
    a. DFT analysis of short, long, and continuous signals
    b. Practical considerations

Comprehensive Final Exam: Wed. Dec. 18, 2024, 7:30 a.m. - 10:00 a.m.

Late work: Assignments should be submitted on the indicated due date. I acknowledge that life happens, and sometimes a deadline cannot be met because of illness, caregiving responsibilities, work demands, mental health struggles, and emergencies. In these cases, I request that you contact me via email as soon as

possible to arrange an alternative due date. If I do not receive any communication from you before the assignment is due, you will receive a 0 for late assignments.

Changes: Changes announced in class and on the class web page will supersede these written instructions.