Foundations of Digital Signal Processing

EEL4750 / EEE 5502
Class Periods: M, W, F | 1:55 PM – 2:45 PM
Class Location: NEB 100
Academic Term: Fall 2025
Website: http://smartdata.ece.ufl.edu/eee5502/

Instructor

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Supervised Teacher(s) and Teaching Assistant

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Course Description

This course covers topics related to the foundations of digital signal processing. After completing this course, students should understand the essential properties of discrete-time signals and systems; understand the sampling and reconstruction of signals; be able to perform transform analysis of digital signals and systems and apply filter design techniques; as well as understand the fundamental principles of multi-rate signal processing.

Course Pre-Requisites / Co-Requisites

Prerequisite: EEL 3135 (Introduction to Signals and Systems) or equivalent

Course Objectives

At the conclusion of this course, you should be able to:

- Apply discrete-time systems to discrete-time signals
- Explain aliasing caused by under-sampling data
- Apply convolution and correlation to modify and locate signals
- Create a Fast Fourier transform algorithm
- Analyze data with the short-time Fourier transform / spectrogram
- Design FIR & IIR filters for modifying time-domain signals
- Analyze data with a multi-channel filter bank

Recommended Materials

- Digital Signal Processing, 4th edition
  - Authors: John G. Proakis and Dimitris K. Manolakis
  - Publisher: Prentice Hall, 2006
  - ISBN: 0131873741
- **OR** Digital Signal Processing: Principles, Algorithms and Applications, 5th edition
  - Authors: John G. Proakis and Dimitris K. Manolakis
  - Publisher: Prentice Hall, 2022
  - ISBN-13: 9780137348244
- EEL4750 / EEE 5502 Course notes
  - Author: Joel B. Harley

Recommended Software

- MATLAB

Course Schedule

Part 1, Objective 1: Normalize Signals and Systems Knowledge

Since this is an introductory graduate course, you may start the class with different signals and systems knowledge relative to other students. As a result, this half of the course aims to normalize knowledge across the class. Hence, parts of this half of the course may be a review of signals and systems material for you.

Part 1, Objective 2: Increase Depth of Signals and Systems Knowledge

While some topics may not be new for students, the course aims to give you a more in-depth, mature understanding of the theory and implementation of digital signal processing. This may require you to see old topics from new perspectives and with new mathematics.

Part 1: Signals, Systems, and Transforms (21 Classes) — *All markers indicate due dates*

DATE			LECTURE	READING	ASSIGNMENTS	QUIZZES
Chapter 2: Discrete-Time Signals and Systems						
MON	Aug	18	*(No class)*	--		
WED	Aug	20	*(No class)*	--		
FRI	Aug	22	Motivation, Policies, DSP	Ch. 1		Quiz 0
Custom Material: Linear Algebra, Signals, and Systems						
MON	Aug	25	Continuous and Discrete-Time Signals	Ch. 2.1		
WED	Aug	27	Continuous and Discrete-Time Systems	Ch. 2.2		
FRI	Aug	29	Signals, Inner Products, and Bases	--		
Chapter 2: Discrete-Time Signals						
MON	Sep	01	***(Holiday)***	--		
WED	Sep	03	Impulse Responses and Convolutions	Ch. 2.3	HW 1 + Code 1	Quiz 1
FRI	Sep	05	Difference Equations and System Implementations	Ch. 2.4-2.6		
Chapter 3: The Z-Transform						
MON	Sep	08	The Z-Transform	Ch. 3.1-3.3		
WED	Sep	10	The Inverse Z-Transform	Ch. 3.4	HW 2 + Code 2	Quiz 2
FRI	Sep	12	Poles and Zeros / Causality / Stability	Ch. 3.5		
Chapter 4: Frequency Analysis of Signals						
MON	Sep	15	Continuous-Time Fourier Transforms	Ch. 4.1		
WED	Sep	17	Discrete-Time Fourier Transforms	Ch. 4.2	HW 3 + Code 3	Quiz 3
FRI	Sep	19	Fourier Transform Properties	Ch. 4.3-4.4		
Chapter 5: Frequency Domain Analysis of LTI Systems						
MON	Sep	22	The Frequency Response	Ch. 5.1-5.2		
WED	Sep	24	Frequency Selective Filters	Ch. 5.4	HW 4 + Code 4	Quiz 4
FRI	Sep	26	Filter Properties	--		
Chapter 6-7: Sampling and Reconstruction of Signals						
MON	Sep	29	Sampling (Continuous Time to Discrete Time)	Ch. 6.1-6.2		
WED	Oct	01	Reconstruction (Discrete Time to Continuous Time)	Ch. 6.3-6.4	HW 5 + Code 5	Quiz 5
FRI	Oct	03	The Discrete Fourier Transform	Ch. 7.1-7.2		
Chapter 2-6: Exam 1						
MON	Oct	06	Short-Term Fourier Transform	--		
WED	Oct	08	Review	--	HW 6 + Code 6	Quiz 6
FRI	Oct	10	Exam 1	--		

Part 2, Objective 1: Design and Implement Filter Systems
In the second half of the course, we will design filter systems to satisfy specific requirements. Our focus will emphasize on stable, causal, linear phase filter systems that remove and retain specific frequencies. We will also briefly investigate how to design filter with other phase or magnitude requirements.

Part 2, Objective 2: Multi-Resolution Signal Processing
The final part of the course will delve into multi-resolution signal processing (i.e., filters operating at multiple sampling rates). These systems allow us to simultaneously process data at both coarse and fine timescale. This allows far more flexible capabilities than what available to typical filtering techniques.

Part 2: Filter Design and Implementation (21 Classes) — *All markers indicate due dates*

DATE			LECTURE	READING	ASSIGNMENTS	
Chapter 7-8: The Discrete Fourier Transform & The Fast Fourier Transform						
MON	Oct	13	Filtering with DFT	Ch. 7.3-7.4		
WED	Oct	15	The Fast Fourier Transform Algorithm	Ch. 8.1-8.2		
FRI	Oct	17	*(Homecoming)*			
Chapter 9: Implementation of Discrete-Time Systems						
MON	Oct	20	FIR Filter Structures	Ch. 9.1-9.2		
WED	Oct	22	IIR Filter Structures	Ch. 9.3	HW 7 + Code 7	Quiz 7
FRI	Oct	24	Challenges / Desirable Filter Properties	Ch. 10.1		
Chapter 10: Design of Digital Filters						
MON	Oct	27	Designing FIR Filters	Ch. 10.2		
WED	Oct	29	Designing IIR Filters	Ch. 10.3	HW 8 + Code 8	Quiz 8
FRI	Oct	31	Filter Transformations	Ch. 10.4		
Chapter 10-11: Multirate Digital Signal Processing						
MON	Nov	03	Downsampling / Decimation	Ch. 11.2		
WED	Nov	05	Upsampling / Interpolation	Ch. 11.3	HW 9 + Code 9	Quiz 9
FRI	Nov	07	Sample Rate Conversions	Ch. 11.4-11.8		
Chapter 11: Multirate Digital Signal Processing						
MON	Nov	10	Two-Channel Filter Banks	Ch. 11.10-11.11		
WED	Nov	12	M-Channel Filter Banks	Ch. 11.12	HW 10 + Code 10	Quiz 10
FRI	Nov	14	Localization and Uncertainty	--		
Chapter 11: Wavelet Signal Processing						
MON	Nov	17	Wavelets	--		
WED	Nov	19	Discrete Wavelet Transform	--	HW 11 + Code 11	Quiz 11
FRI	Nov	21	Signal Enhancement	--		
Chapter N/A: Thanksgiving Break!!						
MON	Nov	24	*(Thanksgiving)*	--		
WED	Nov	26	*(Thanksgiving)*	--		
FRI	Nov	28	*(Thanksgiving)*	--		
Chapter 7-11: Exam 2						
MON	Dec	02	Review	--	HW 12 + Code 12	Quiz 12
WED	Dec	03	Exam 2	--		
FRI	Dec	05	*(No Class)*	--		
MON	Dec	13	Final	--		

Attendance and Participation Policies

While attendance is not graded, lectures will include regular homework help and in-class discussions and demonstrations on the subject material. While participation is not graded, it is an integral part of each class that can help you learn the material.

Evaluation Methods and Criteria

The following section discusses the policies for each of the graded assessments in this course. You should look here first for answers to any general, course-related inquiries.

Homework (12 in total)

When: Assigned roughly once a week (see course schedule).
What: Two parts: (1) Analytical and theory problems that can be solved by hand and (2) coding problems solve thru MATLAB.
Why: Homework guides you through the course material and presents you with questions that require time to think about and complete. Homework assignments are not meant to be completed in a single day.
Grading: Each of the two homework parts is graded separately. Homework is graded on a scale from 0 to 10. How points are assigned will vary with the assignment.
Late policy: Late assignments can be submitted one day late and can receive a maximum grade of 8/10. Assignments will not be accepted after one day. This policy allows us to post solutions before an exam.
Submission: Homework will be submitted on canvas before class on the due date. Please ensure that your submission is readable.

In-Class Exams / Final Exams (2 in total)

When: There are two non-cumulative exams covering each part of the course and one cumulative final exam.
What: Questions will be similar to homework concept problems
Why: Exams are an opportunity to show what you know about the course
Calculators/Open Book: Exams will be open book but time-constrained, so do not rely on them
Grading: Exams are graded on a 100-percentage scale.
Final/Makeup exams: Each part of the final exam acts as a re-take or make-up exam. If you perform poorly on an in-class exam, you will have the opportunity to take one or more final exam parts to replace your grade(s). You will receive the highest grade from each midterm/final part pair.

Group Quizzes (Best 10 / 12 in total)

When: Assigned roughly once a week (see course schedule). Completed during class.
What: Relatively straightforward multiple choice and true/false problems solved together with other students.
Why: These quizzes are intended to be low-stakes assessments. They keep you up to date with the class and ensure that I know everyone is following along.
Grading: Quizzes will be graded on a scale from 0 to 10. How points are assigned will vary with the assignment.
Late policy: No late quizzes can be turned in.
Submission: Quizzes will be completed on canvas during class.

Evaluation of Grades

Assignment	**Percentage**
Homework (Theory) (best 11 out of 12)	15%
Homework (Coding) (best 11 out of 12)	25%
Group Quizzes (best 10 out of 12)	10%
Midterm Exam 1	25%
Midterm Exam 2	25%
Final Exam	See section on exams
Total	**100%**

Grading Policy

Percent	Grade	Grade Points
93.3 - 100.0	A	4.00
90.0 - 93.3	A-	3.67
86.6 – 90.0	B+	3.33
83.3 – 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.6 - 80.0	C+	2.33

Percent	Grade	Grade Points
73.3 – 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.6 - 70.0	D+	1.33
63.3 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
00.0 – 60.0	E	0.00

More information on UF grading policy may be found at:
http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Course & University Policies

Collaboration

Healthy collaboration: To solve homework assignments, healthy discussion and collaboration amongst classmates is encouraged. Healthy collaboration includes:

- Discussing and explaining general course material and assignments for better understanding
- Providing assistance for general programming and debugging issues

If another student contributes substantially to your understanding of a problem, you should *cite* this student to let myself and the teaching assistants be aware of your similar interpretations of a problem. You will not be judged negatively for citing another student.

Cheating and plagiarism: While collaboration is encouraged, you are *expected to submit your own work*. Submitting work completed by another student is considered plagiarism and will be dealt with according to university policy. In general, if you do not fully understand your solution, the work is not your own. Examples of plagiarism or cheating include:

- Copying (or allowing someone to copy), even partially, an assignment solution or program from the course
- Submitting material, particularly code, using material taken from another source without proper a citation
- Obtaining solutions to assignments or exams through inappropriate means

Note that I may elect to use a plagiarism detection service in this course, in which case you will be required to submit your work to such a service as part of your assignment.

Consequences: If you are suspected of dishonest academic activity, university policy to is immediately report the activity to the Student Conduct & Conflict Resolution office to have paper trails and ensure students receive fair representation. Once reported, the Student Conduct & Conflict Resolution office will review the report act on it.

Academic Policies & Resources

To support consistent and accessible communication of university-wide student resources, instructors must include this link to academic policies and campus resources: https://go.ufl.edu/syllabuspolicies. Instructor-specific guidelines for courses must accommodate these policies.

Commitment to a Positive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University's core values.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

• Your academic advisor or Graduate Coordinator
• HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
• Pam Dickrell, Associate Dean of Student Affairs, 352-392-2177, pld@ufl.edu