Foundations of Digital Signal Processing
EEL 4750 / EEE 5502
Class Periods: M, W, F | Period 9 (4:05 PM - 4:55 PM)
Class Location: NEB 100
Academic Term: Fall 2021
Website: http://smartdata.ece.ufl.edu/eee5502/

Instructor
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Office Hours: T, R 4:05 PM – 4:55 PM

Supervised Teacher(s) and Teaching Assistants
- TBA

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
- EEL 4750/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 a 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 (18 Classes)   *All markers indicate due dates*

DATE			LECTURE	READING	ASSIGNMENTS
Chapter 2: Discrete-Time Signals and Systems					
MON	Aug	23	Motivation, Policies, DSP	Ch. 1	
WED	Aug	25	Continuous and Discrete-Time Signals	Ch. 2.1	
FRI	Aug	27	Continuous and Discrete-Time Systems	Ch. 2.2	
Chapter 2: Discrete-Time Signals					
MON	Aug	30	Impulse Responses and Convolutions	Ch. 2.3	HW #1
WED	Sep	01	Difference Equations and System Implementations	Ch. 2.4-2.6	
FRI	Sep	03	The Z-Transform	Ch. 3.1-3.3	
Chapter 3: The Z-Transform					
MON	Sep	06	*(Holiday)*		
WED	Sep	08	The Inverse Z-Transform	Ch. 3.4	HW #2
FRI	Sep	10	Poles and Zeros / Causality / Stability	Ch. 3.5	
Chapter 4: Frequency Analysis of Signals					
MON	Sep	13	Continuous-Time Fourier Transforms	Ch. 4.1	HW #3
WED	Sep	15	Discrete-Time Fourier Transforms	Ch. 4.2	
FRI	Sep	17	Fourier Transform Properties	Ch. 4.3-4.4	
Chapter 5: Frequency Domain Analysis of LTI Systems					
MON	Sep	20	The Frequency Response	Ch. 5.1-5.2	HW #4
WED	Sep	22	Frequency Selective Filters	Ch. 5.4	
FRI	Sep	24	Short-Time Fourier Transforms	--	
Chapter 6: Sampling and Reconstruction of Signals					
MON	Sep	27	Sampling (Continuous Time to Discrete Time)	Ch. 6.1-6.2	HW #5
WED	Sep	29	Reconstruction (Discrete Time to Continuous Time)	Ch. 6.3-6.4	
FRI	Oct	01	Fourier, Periodicity, and Sampling	--	
Chapter 2-6: Exam 1					
MON	Oct	04	Review	--	HW #6
WED	Oct	06	Exam 1	--	
FRI	Oct	08	*(Homecoming)*	--	

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 (19 Classes)   *All markers indicate due dates*

DATE			LECTURE	READING	ASSIGNMENTS
Chapter 7-8: The Discrete Fourier Transform & The Fast Fourier Transform					
MON	Oct	11	Frequency-Domain Sampling / Time-Domain Periodicity	Ch. 7.1-7.2	Take Home #1
WED	Oct	13	The Fast Fourier Transform Algorithm	Ch. 8.1-8.2	
FRI	Oct	15	Filtering with DFT / FFT	Ch. 7.3-7.4, 8.3	
Chapter 9: Implementation of Discrete-Time Systems					
MON	Oct	18	FIR Filter Structures	Ch. 9.1-9.2	HW #7
WED	Oct	20	IIR Filter Structures	Ch. 9.3	
FRI	Oct	22	Implementation Considerations	Ch. 9.4-9.6	
Chapter 10: Design of Digital Filters					
MON	Oct	25	Challenges / Desirable Filter Properties	Ch. 10.1	HW #8
WED	Oct	27	Designing FIR Filters	Ch. 10.2	
FRI	Oct	29	Designing IIR Filters	Ch. 10.3	
Chapter 10-11: Design of Digital Filters					
MON	Nov	01	Filter Transformations	Ch. 10.4	HW #9
WED	Nov	03	Downsampling / Decimation	Ch. 11.2	
FRI	Nov	05	Upsampling / Interpolation	Ch. 11.3	
Chapter 11: Multirate Digital Signal Processing					
MON	Nov	08	Sample Rate Conversions	Ch. 11.4-11.8	HW #10
WED	Nov	10	Two-Channel Filter Banks	Ch. 11.10-11.11	
FRI	Nov	12	M-Channel Filter Banks	Ch. 11.12	
Chapter 11,14: Multirate Digital Signal Processing					
MON	Nov	15	Wavelets	--	HW #11
WED	Nov	17	Discrete Wavelet Transform	--	
FRI	Nov	19	Power Spectrum Estimation	Ch. 14	
Chapter N/A: Speech Enhancement Methods					
MON	Nov	22	Signal Enhancement Methods	--	HW #12
WED	Nov	24	*(Thanksgiving)*	--	
FRI	Nov	26	*(Thanksgiving)*	--	
Chapter 7-11: Multirate Digital Signal Processing					
MON	Nov	29	Review	--	
WED	Dec	01	Exam 2	--	
FRI	Dec	03	Linear Algebra and Signal Processing	--	
Chapter NA: Modern Signal Processing					
MON	Nov	06	Compressive Sensing	--	
WED	Dec	08	Graphical Signal Processing	--	
FRI	Dec	10	*(No Class)*	--	
MON	Dec	13	*(No Class)*	--	Take Home #2

Attendance and Participation Policies

Attendance & Participation:
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.

Slack Page:
We have a Slack page for the course: https://uf-eee5502-fa2021.slack.com/. This is an *optional* resource for students to discuss the course amongst each other and occasionally with the Professor and TAs. This resource is intended to supplement office hours and student interactions. **No official communication / submission happens over Slack.** No assignments submissions will be accepted over Slack.

Online Course Recording:
Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

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: Three parts: (1) Analytical problems that can be solved by hand, (2) theory assignments that can be solved by hand, and (3) implementation problems solve thru MATLAB.
Why: Homework guides you through course material and presents you with questions that will require time to think about and complete. Homework assignments are not meant to be completed in a single day.
Grading: Each of the three 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 (4:00 PM) on the due date. Please ensure that your submission is readable.

In-Class 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.

Take-Home 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 implementation problems
Why: Exams are an opportunity to show what you know about the course.
Calculators: No calculators are allowed or necessary
Grading: Exams are graded on a 100-percentage scale.
Late policy: Late take-home exams will receive a 0 grade. Please turn everything in on time.

Evaluation of Grades

Assignment	Percentage of Final Grade (EEL 4750)	Percentage of Final Grade (EEE 5502)
Concept Problems	10% (best 11 out of 12)	10% (best 11 out of 12)
Theory Problems	10% (best 9 out of 12)	10% (best 11 out of 12)
Implementation Problems	10% (best 11 out of 12)	10% (best 11 out of 12)
Midterm Exam 1	20%	20%
Midterm Exam 1 (Take home)	15%	15%
Midterm Exam 2	20%	20%
Midterm Exam 2 (Take home)	15%	15%
Final Exam	See section on exams	See section on exams
	100%	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
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

Modifying Syllabus by Class Vote
When: If you and/or other students believe the course would be improved by a change in the syllabus and I agree that it would be a reasonable change. **What:** The proposed change will be put to an anonymous vote with the entire class. If the majority of the class agrees to this change, it becomes part of the syllabus. **Why:** In previous years, changes to the syllabus have been necessary due to unforeseen consequences of certain policies. The class vote ensures the entire class agrees with the change.

Collaboration
Healthy collaboration: To solve homework assignments, healthy discussion and collaboration amongst classmates is encouraged. Healthy collaboration includes:
- Discussing and explaining general course material
- Discussing 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.

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy
UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Conduct Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment
The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

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 Program Coordinator
• Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use
All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy
There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Health and Wellness

Covid-19 Protocols:
You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated. Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus. UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the UF Health Screen, Test & Protect website for more information.

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*: https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/ ; https://care.dso.ufl.edu*.

On-Line Students Complaints*: http://www.distance.ufl.edu/student-complaint-process*.