ECE 4413/6413 — Digital Signal Processing — Fall 2022 Syllabus

Instructor: Dr. John E. Ball
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Email: jeball@ece.msstate.edu
Class Time: MW 3:00 - 4:15 In-person (all times Central Time)
Local students are expected to attend in person. Distance and Gulf Coast students attend asynchronously (videos provided after class).
Office Hours: By appointment. Please email me to set up.
Prerequisite: Grade of C or better in ECE 3443.

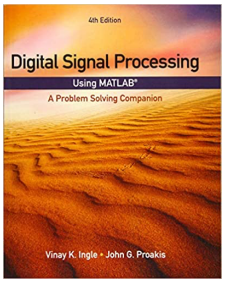
Description:
Discrete time signals, Z-Transform, Discrete Fourier Transform, digital filter design including IIR, FIR, and FFT synthesis. DSP is a major area of academic research and is used in many industrial applications including controls, sensor processing, radar, sonar, disk drives, cell phones, etc. Learning the basics of DSP will expand your academic portfolio and allow you to tackle more challenging engineering problems.

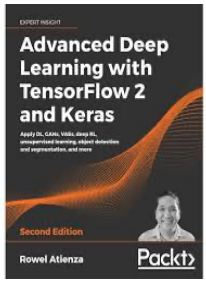
Objectives:
The student will be able to:

1. Understand and implement convolutional neural networks in Tensorflow.
2. Use MATLAB and Python for signal processing.
3. Understand digital filter specifications, FIR and IIR filters, and assess filter performance.
4. Understand filter structures and stability.
5. Use the FFT and STFT to analyze signal frequency content.
6. Understand sampling and aliasing.

Text: **Required:** V. K. Ingle, J. G. Proakis, *Digital Signal Processing using MATLAB (A Problem Solving Companion)*, 4th Ed., Cengage Learning, 2012, ISBN 9789386668110.

Optional: R. Atienza, Advanced Deep Learning with TensorFlow 2 and Keras, 2nd Ed., PACKT, 2020, ISBN 9781838821644.





Class Materials:
Class materials will be posted before class on Canvas.
For assistance with Canvas – call the helpdesk at 662-325-1403 or email help@ctl.msstate.edu.
Students are expected to ***check Canvas regularly***. Failure of students to note due dates is not an excuse.

Class Meetings:
Classes will meet in person unless the University mandates online learning. All class sessions will be recorded for the distance students. Non-distance (e.g., local students) are required to come to class.

Distance Technology Questions/Issues:
Email engr-dist-support@lists.msstate.edu for tech support.

Distance Videos:
Distance videos can be accessed via: https://oc-engage.engr.msstate.edu/engage/ui/index.html

Electronics:
Electronic devices are permitted in class (i.e., iPads for note taking). Turn all cell phones to silent. Please pay attention and do not surf the web during synchronous class!

Homework and Mini-Projects:
Homework assignments are part of the mini projects. HW0 is a review designed to see how much you remember from signals and systems. HW is graded on effort. In addition to the homework, three themed mini-projects are assigned during the semester. These projects will require reading and summarizing papers, working engineering problems related to the class material, running simulations, and technical writing.

Generative AI:
In Digital Signal Processing, students are permitted to use Generative AI tools such as ChatGPT for specific assignments, as designated by the instructor. Students must give credit and cite any AI-generated material according to IEEE citation rules, including in-text citations, quotations, and references. Submitted work may be filtered through turnitin.com AI Writing Detection. This review may initiate further discussion about the authenticity of the submission which could result in a more formal review through the Honor Code Council.

In no case is Generative AI to be used in exams, unless directed by the instructor.

Students must also include the following statement in assignments to indicate use of a Generative AI Tool: "The author acknowledges the use of [Generative AI Tool Name] in the preparation of this assignment for [brainstorming, grammatical correction, citation, etc.]."

Exams:
All exams are individual effort. All exams are offered on Canvas and require the Respondus Lockdown Browser. All exams are given via Canvas. A separate zero-point exam is also provided where students upload their written exam work (as a PDF). The written work is due 30 minutes after the exam period. **Distance and Gulf Coast Students**: Proctors are not required. Exams are to be completed by the student with no outside help (except clarifying questions from the instructor). Unless otherwise specified, only a formula sheet, blank paper, and a calculator are allowed. Graduate students will also have programming exercises, where a PC can be used.

Grading:
Students will be evaluated based on the three themed mini-projects; two in-semester exams, which cover the theory and implementation of the corresponding mini-projects; and a final exam, as shown in the table below. Graduate students will have extra problems on the projects and final exam. Participation points will be awarded for participating in class discussions, active learning exercises, and posting in discussion forums. There will also be participation points awarded based on how your teammates viewed your contributions to the group projects.

Grading Points

Area	Undergraduate Points	Graduate Points
HW0 & Get to Know Me	5	5
HW1 and Mini-Project 1 *	15	15
HW2 and Mini-Project 2 *	15	15
HW3 and Mini-Project 3 *	15	15

Exam 1	10	10
Exam 2	10	10
Final Exam ***	20	20
Participation	10	10
Total Possible Points	**100**	**100**

* Homework is part of the mini-project submissions.

** The final exam is comprehensive but will focus on module four.

Overall grade:

The overall grade is based on points earned.

≥ 90	A
80 – 89.9	B
70 – 79.9	C
60 – 69.9	D
< 60	F

Turning in work and late work:

All work is turned in **via Canvas as a PDF** or other file formats as specified in the assignment instructions. Late work will *not be accepted*, barring extenuating circumstances, and then *only if approved by the instructor*.

Programming and Computer Support:

Python and MATLAB will be utilized for in-class examples, homework, and the mini-projects. Python and MATLAB exercises can include problems where students code the entire project, problem, or simulation, partially developed code that students finish, and fully developed code where students run the code and analyze the results. Python 3.7 or later is to be used. Octave is fine assuming you do not use extensions that are not supported in MATLAB. Note: *The MATLAB signal processing toolbox is used later in class*.

The instructor will support questions for *Windows 10*. Linux or MAC or other operating systems can be used but are not supported by the instructor.

MSU Class Policies:

The Mississippi State University Syllabus contains all policies and procedures that are applicable to every course on campus and online. The policies in the University Syllabus describe the official policies of the University and will take precedence over those found elsewhere. It is the student's responsibility to read and be familiar with every policy. The University Syllabus may be accessed at any time on the Provost website under Faculty and Student Resources and https://www.provost.msstate.edu/faculty-student-resources/university-syllabus.

Topics

1. **Introduction to DSP, Code install (Modules 1.1 - 1.3)**
   Goal: Install software tools and introduce the course
   - 1.1. Review Syllabus
   - 1.2. Software install - Anaconda, Python, MATLAB, TensorFlow, etc.
   - 1.3. Software install part 2

2. **Convolutional Neural Networks (Modules 2.1 - 2.6)**
   Goal: Introduce CNN, develop CNN for image object detection (Tensorflow/Python)
   - 2.1. Mini-Project 1 introduction: CNN image object detection with Tensorflow
   - 2.2. CNN inspiration, CNN architectures, 2D convolution, max pooling
   - 2.3. Fully connected layer, softmax layer, loss functions
   - 2.4. Backpropagation
   - 2.5. MNIST NN, CNN
   - 2.6. State-of-the-art CNNs

3. **Spectral Analysis (Modules 3.1 - 3.6)**
   Goal: Perform time-frequency signal analysis (MATLAB)
   - 3.1. Mini-Project 2 introduction: Radar analysis
   - 3.2. Sampling and Aliasing, Nyquist Criteria, The Discrete Fourier Transform (DFT), and the Fast Fourier Transform (FFT) part 1
   - 3.3. FFT part 2
   - 3.4. The Short-Time Fourier Transform (STFT)
   - 3.5. The Support Vector Machine (SVM)
   - 3.6. Micro-Doppler Analysis

4. **Digital Filters (Modules 4.1 - 4.10)**
   Goal: Design filters for music analysis (MATLAB & Digital Signal Processing Toolbox)
   - 4.1. Mini-Project 3 introduction: Music analysis and effects
   - 4.2. Forward Z transform
   - 4.3. Inverse Z transform
   - 4.4. Sampling rate conversion
   - 4.5. Filter specifications, structures, stability
   - 4.6. FIR filters: Kaiser, Parks-McClellan part 1
   - 4.7. FIR filters: Parks-McClellan part 2
   - 4.8. Butterworth IIR filter
   - 4.9. Chebyshev and Elliptic IIR filters
   - 4.10. Filter comparisons and the bilinear transform

5. **Review**
   - 5.1. Review for Final Exam

Tentative Calendar – Revised 19 August 2024

Monday's Date	MON	TUES	WED	THUR	FRI	SAT	SUN
8/19			1.1 HW0 & GTKM Posted				
8/26	1.2		1.3 MP1/HW1 Posted				HW0 & GTKM Due
9/2	Labor Day Holiday		2.1				SW Install Due
9/9	2.2		2.3				
9/16	2.4		2.5				
9/23	2.6 HW1 & MP1 Due	Exam 1 Posted (1.1 – 2.6)	3.1 MP2/HW2 Posted				Exam 1 Due
9/30	3.2		No Class				
10/7	3.3		No Class	Fall Break	Fall break		
10/14	3.4		3.5				
10/21	3.6		4.1 MP3/HW3 Posted				
10/28	4.2 HW2 & MP2 Due	Exam 2 Posted (3.1 - 3.6)	4.3				Exam 2 Due
11/4	4.4		4.5				
11/11	4.6		4.7				
11/18	4.8		4.9				
11/25	4.10		Thanksgiving break	Thanksgiving break	Thanksgiving break		
12/2	5.1 (Final Review) HW3 & MP3 Due	Last Day of MSU Classes Final Exam Posted (Comprehensive)	MSU Reading Day				
12/9	Final Exam Due 6:30 PM						

DSP Final exam will be given via Canvas. It is due on **December 9 at 6:30 PM Central Time**.

Unless otherwise assigned by the instructor, all assignments are due one minute before midnight Central time on the due date.

Final exam is comprehensive, but will also focus on material in 4.1 - 4.10.