ENG EC516 (Fall 2022)
Digital Signal Processing (DSP)

Lecturer: Prof. S. Hamid Nawab **Office:** PHO 433
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Office Hours: Thursdays 11AM-NOON (Zoom), Fridays 11AM-NOON (Zoom). Invites to the Zoom office hours will be posted on *Blackboard®.* The Thursday office hour will be *Video recorded* and posted on Blackboard® for viewing during the weekend that follows. **Please plan to attend one of the two office hours per week if you want to influence the issues addressed during office hours**.

GTF: Guorong Hu **MATLAB-Help Office Hour**: Wednesdays, 7-8pm (REMOTE)
grhu@bu.edu Zoom invite will be posted on *Blackboard®*
The MATLAB-Help Office Hour will focus on the MATLAB assignment for the current homework assignment.

Course Announcements: See *Blackboard®* site for ENG EC516.

Lectures: MW 10:10am-11:55am in PSY B33 (Notes made available on *One Note®*)

Lecture Structure:
10:10am to 10:25am – *Concepts and Applications* (15 mins)
10:25am to 10:55am – *Theory and Mathematics* (30 mins)
10:55am to 11:05am – *Break* (10 mins)
11:05 am to 11:25am – *Algorithms and Computations* (20 mins)
11:25am to 11:55am – *Problems and Solutions* (30 mins)

According to feedback from previous semesters, lecture attendance is *critical* to student success in EC516. **It is advisable to attend every lecture**. If for some reason you have to miss a lecture, please make sure to consult the posted notes/slides for the missed lecture and plan to attend an office hour to ask for clarification and/or insight into the missed lecture content.

Course Description:
In this course, we will explore the foundational depths and structural breadth of digital signal processing (DSP) from a **data patternization perspective**. In this perspective, we view DSP as a *computational* means for transforming raw patterns of *receive-only sensor and sensor array data* into **alternative patternizations** for use in domains such as **pattern recognition**, **pattern authentication**, **machine learning**, **machine/robot perception,** and **enhancement of human perception**. The goal of such a patternization capability is to *enable* the practical implementation of application **use-cases** such as speech-to-text conversion on a smartphone, efficient video communication for HD television, directional voice enhancement in a digital hearing aid, ultrasound imaging of the heart, or accelerometer-based physical

activity monitoring on a smartphone. The job of the DSP engineer is to come up with an *appropriate* **patternization alternative** for any given use-case application. As we shall discuss, the vast majority of patternization frameworks available to present-day DSP engineers have a *convolutional* basis in time, space, frequency, or wavenumber domains. In this course, we shall examine the variety of such patternization frameworks available to the DSP engineer and the type of expertise it takes to develop the right patternization for a given application. In EC516, we will also study how selection among patternization alternatives often involves considerations of **resolution tradeoffs, blindness tradeoffs, representational efficiency** and **inferential efficiency**. In particular, we will examine these issues in the context of specific patternization frameworks such as *decimation and interpolation*, *discrete Fourier transforms, time-dependent and space-dependent Fourier transforms, homomorphic deconvolution, and parametric signal modeling.*

Learning Outcomes:

This course is designed to achieve certain learning outcomes. As such, you may expect that as a result of taking this course you would be able to:

1) Understand and describe the major classes of **patternization design options** available in modern DSP

2) Understand and describe a diverse set of application **use-cases** for which modern DSP is called upon to provide appropriate patternization capabilities.

3) Understand and describe the underlying **convolutional themes** in many patternization capabilities provided by DSP.

4) Understand and describe the importance of **resolution tradeoffs** in the context of data patternization use cases of DSP.

5) Understand and describe the importance of **blindness tradeoffs** in the context of data patternization use cases of DSP.

6) Design, implement, and analyze **sampling, decimation and interpolation** in the context of data patternization use cases of DSP.

7) Design, implement, and analyze **Time-Dependent (or space-dependent) Discrete Fourier Transforms** in the context of data patternization use cases of DSP

8) Design, implement, analyze **Homomorphic Deconvolution** in the context of data patternization use cases of DSP

9) Design/implement/analyze **Parametric Signal Modeling** in the context of data patternization use cases of DSP

Grading:
The grading will be based on your performance relative to the *mean* performance of the class as a whole. The weights of the different assessment components of the course are as follows:

- **Test 1:** 25% (Closed Book, Performance Based)
- **Test 2**: 25% (Closed Book, Performance Based)
- **Final Exam**: 25% (Closed Book, Performance Based)
- **Homework**: 25% (Open Book, Participation Based)

Typical *mean* score is 70/100 for each of Test 1, Test 2, and Final Exam. Typical *mean* Score for Homework is 100/100 (after dropping the three lowest-scoring homework assignments for each student in the class)

Homework Policy:
Each homework assignment will be posted on the course's Blackboard® site on *Sunday evening* and it will be due the following *Sunday evening* (before Midnight).

Your attempt on each homework assignment must be submitted as a *single* pdf file on Blackboard Learn at the location of the assignment.

Your homework attempt on each assignment will be checked to make sure there is no plagiarism but it will **not** be graded.

Prof. Nawab's office hours on Thursday 11am-12noon and on Friday 11am-12noon will generally be dedicated to helping students understand how to approach the assigned homework problems for the coming Sunday. It is highly *recommended* (though, not required) that students make an initial attempt on the current week's homework assignment before attending Prof. Nawab's office hours.

The first homework assignment will be posted on Sunday September 11.

The official solution to each homework assignment will be posted on Blackboard soon after its due date.

Test Dates:

- **Test 1:** Wednesday, **October 19** in PSY B33.
- **Test 2**: Wednesday, **November 16** in PSY B33
- **Final**: Thursday, **December 15** in PSY B33.

Special Dates:

Monday, October 10: No class **(Indigenous Peoples' Day)**

Tuesday, October 11: Remote EC516 Lecture (Prof. Nawab out of town). Zoom invite will be posted on Blackboard®

Wednesday, October 12: Remote EC516 Lecture (Prof. Nawab out of town). Zoom invite will be posted on Blackboard®

Wednesday, November 23: No class (Thanksgiving Recess begins).

Wednesday, November 23 to Sunday, November 27: Thanksgiving Break

Last Class Meets: **Monday, December 12**.

Academic Misconduct:

BU takes academic integrity very seriously. Academic misconduct is conduct by which a student misrepresents his or her academic accomplishments, or impedes other students' opportunities of being judged fairly for their academic work. Knowingly allowing others to represent your work as their own is as serious an offense as submitting another's work as your own. More information on BU's Academic Conduct Code, with examples, may be found at http://www.bu.edu/academics/policies/academic-conduct-code .

Collaboration Policy:

In this class you may use any textbooks or web sources when completing your homework, and/or any number of human collaborators (from class) per homework, subject to the following strictly enforced conditions:

- You must clearly acknowledge all your sources (including your collaborators) on the top of your homework.
- You must write all homework answers in your own words.
- You must be able to fully explain your answers upon demand.
- You may not use any human resource outside of class (including web-based help services, outside tutors, etc.) in doing your homework assignments.

The two tests and the final exam in this course are closed book and the use of any electronics is strictly forbidden during each exam. Collaboration with others during

any of these three exams is also strictly forbidden. The course instructor (Prof. Nawab or his representative) will provide you a detailed formula sheet during each exam. You are not to bring any other written material (such as "cheat sheets") to any of the three exams.

Failure to meet any of the above conditions would constitute plagiarism and will be considered cheating in this class. If you are not sure whether something is permitted by the course policy, please ask Prof. Nawab.

Extra Reference:

A.V. Oppenheim and R.W. Schafer, *Discrete-Time Signal Processing* (3rd Edition), 2010, Pearson, Prentice Hall Signal Processing Series, ISBN: 860-1419506941. This reference is **recommended but you are not required to buy it**. It is Prof. Nawab's opinion that the reference material posted on the EC516 Blackboard Learn site along with (1) serious attempts on the assigned homeworks, (2) attendance of lectures, (3) attendance/viewing of office hours when needed should be *sufficient* to achieve the learning outcomes of EC516.