SYLLABUS: EC401 SPRING 2021
Signals & Systems: The Language for Designing and Understanding Perceiving Machines

Lecturer: Prof. S. Hamid Nawab
Office: PHO 433
Office Hours: Tuesdays 5:30pm-6:30pm starting the week of Feb 1, 2020 (On Zoom, Not Recorded)

WEEKLY LECTURE STRUCTURE AND SCHEDULE:

Zoom-Only NARRATIVE Lectures: On Mondays 12:20pm-2:05pm broadcast live on Zoom. Recording will be made available for later viewing. Each week, the Narrative lecture introduces a “story” to be followed that week.

In-Person-Only PROBLEM-SOLVING Lectures: On Wednesdays 12:20pm-1:05pm in GSU AUD. (In-Person-Only, No Zoom delivery). Each week, the Problem-Solving lecture presents “tricks-of-the-trade” for that week’s story.

Zoom-Only PROBLEM-SOLVING Lectures: On Wednesdays 1:10pm-1:55pm broadcast live on Zoom (also Recorded and made available for later viewing). These lectures are the same as the In-Person-Only Problem-Solving Lectures and thus speak to the “tricks-of-the-trade” for that week’s story. You should plan on attending only one or the other each week.

Zoom-Only Recorded ELABORATION Lectures: These 45-minute recorded lectures will be available toward the end of each week (Friday) for viewing that weekend as part of course homework. Each week, the Elaboration lecture presents “finer points” of the story of that week using the tricks-of-the-trade introduced earlier in the week.

DISCUSSIONS/LABS:

This semester discussions to help with homework and the laboratory component of the course will be delivered via Zoom by the Course GTF.

Graduate Teaching Assistant: Xiaowei Ge
Live Zoom Discussions to Help with Homework/Labs: Start Week of Feb 1, 2020 via sections C1 and C2 of the course.

Section C1: Mondays 6:30pm to 8:15pm (On Zoom, Not Recorded)
Section C2: Tuesdays 6:30pm to 8:15pm (On Zoom, Not Recorded)

The laboratory component of the course this semester is incorporated within the homework assignments and consists of MATLAB assignments using real-world
audio and image signals. Familiarity with MATLAB is assumed. However, the GTA will be available during discussion sections (C1 and C2) to help with any MATLAB questions you might have in the weeks that there is a laboratory assignment within the homework.

TEXTBOOK POLICY:

The course has no required textbook. It is very important to attend lectures or to make sure someone takes notes for you. Lecture recordings, OneNote records of Prof. Nawab’s lecture notes, important formulas, and practice exams will be periodically posted on the Blackboard Learn site for the course to help you stay updated and to verify the accuracy of your own lecture notes. There are many good Signals and Systems textbooks available on the market. Any could serve as a reference.

COURSE DESCRIPTION:

This course introduces a language that enables you to learn how to efficiently and systematically think about, analyze, design, or even invent sensor-equipped electrical/computing machines that can perceive their external surroundings. For the purposes of this course, we say that a machine perceives its external surroundings if it can do something useful on the basis of physical activities that take place in its external surroundings. Examples of useful things a perceiving machine may do includes using as few bits/second as practically possible to digitally store (or transmit) music or videos, separating radio waves or television waves originating from different broadcasting sources, recognizing what is being said or who is speaking from the sound of a speaker’s voice (think Alexa, Hey Google, Bixby or Siri), using ultrasound reflections to detect obstacles in the path of a robot, using the measured instantaneous position of an elevator to help control its movements, analyzing electrocardiogram signals for signs of arrhythmia, combining ultrasound reflections/echoes to compute images of internal organs etc.

The sensors of a perceiving machine are conceptualized in this course as physical units that can convert variations in physical quantities outside the machine (e.g. variations in light, sound, pressure, temperature, density, or electromagnetic field) to analogous (but not necessarily identical) variations in electrical or computer-represented quantities inside the machine. These electrical or computer-represented quantities inside the machine are abstracted in our designer’s language as mathematical functions called signals. Beyond the sensors, the perceiving machines (whether they are physical devices, circuits, communication media, microcontrollers, robots, computers, or computer networks) may be abstracted in our designer’s language as systems that perform mathematical transformations on the signals acquired through the sensors. The purpose of such abstractions is to harness the power of mathematics to help us understand, design, and invent perceiving machines of practical use in the real world. A centerpiece of this mathematical power is how it helps us to understand the conditions under which
digital machines can be made to perceive instantaneously changing (analog) activities in our everyday physical world.

The fluency gained in the language of Signals and Systems through this course will enable you to carry on further study in many aspects of electrical and computer engineering, including (but not limited to) machine vision, machine audition, telecommunication, wireless communication, radar, sonar, seismology, radio science, robotics, cyber-physical systems, biomedical imaging, brain-machine interfaces, human-machine interfaces, virtual reality and gaming, and financial engineering.

COURSE PREREQUISITES EXPLAINED:

You must have mathematical preparation up to and including Multivariate Calculus (CAS MA 225) and some basic familiarity with differential equations (CAS MA 226), although you will not be asked to solve any differential equations in this course. Also, a background in EK307 is helpful but not strictly necessary.

COURSE LEARNING OUTCOMES:

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

1) Mathematically understand, use and describe the abstraction of electrical or computer representations of external physical activities by a perceiving machine as signals.
2) Mathematically understand, use and describe the abstraction of perceiving machines (devices, circuits, computers, and networks) as systems that apply transformations on signals.
3) Mathematically understand, use and describe fundamental properties of analog and digital signals from real-world environments.
4) Mathematically understand, use and describe how digital systems (computers, smartphones, internet etc.) can process analog signals (audio, video, gestures etc.) in the real world without loss of information.
5) Mathematically understand, use and describe fundamental behaviors of analog systems (physical circuits, biological circuits etc.) and digital systems (computers, smartphones, internet etc.).
6) Mathematically understand and describe how simpler systems may be used as building blocks for more complex systems.
7) Design linear, time-invariant systems for desired input-output relationships of systems in the real world.
8) Design linear, time-invariant systems that are compatible with analog circuit implementations.
9) Design linear, time-invariant systems that are compatible with digital hardware and software implementations.
10) Mathematically understand, use and describe how the behavior of linear, time-invariant systems can be conceptually understood as representing natural or engineered phenomena of reverberation, blurring, smoothing, trending, and modulation.

11) Mathematically understand, use and describe how the behavior of linear, time-invariant systems can be conceptually understood as representing natural or engineered phenomena such as dereverberation, deblurring, sharpening, detrending and demodulation.

12) Mathematically understand, use and describe how the behavior of an engineered digital or analog system may differ from the intended behavior of its conceptual design.

**GRADING POLICY:**

Open Book Test 1: 25% (Performance Based)
Open Book Test 2: 25% (Performance Based)
Open Book Final: 25% (Performance Based)
Homework (including Labs): 25% (Participation Based)

**HOMEWORK POLICY:**

Homework will be posted online by Friday of the week that it is assigned. Your homework will be due on Friday before midnight in the week that follows the week in which it is assigned. Homework and Laboratories will be graded on the basis of seriousness of attempt rather than the accuracy of the answers. While collaboration is encouraged, copying of others’ homework is considered cheating in this course. Three lowest homeworks will be dropped when calculating the homework average.

**TEST DATES:**

Test 1: Wednesday **February 24th** on Zoom, open book, no collaboration
Test 2: Monday **March 29th** on Zoom, open book, no collaboration
Final: Date **TBA by Registrar**, on Zoom, open book, no collaboration.

**SPECIAL DATES:**

Monday February 15: No class (**President’s Day**)
Tuesday February 16: BU and EC401 follow **Monday schedule**
Thursday March 18: No classes (Wellness Day)
Wednesday March 31: No classes (Wellness Day)
Monday April 19: No Class (**Patriots Day**)
Wednesday April 21: BU and EC401 follow **Monday schedule**
Wednesday April 28: **Last Lecture**
ACADEMIC MISCONDUCT POLICY:

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 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 homeworks.

The two tests and the final exam in this course are open book. Collaboration with others during any of these three exams is strictly forbidden. The course instructor (Prof. Nawab or his representative) will provide you a detailed formula sheet during each exam.

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.