Master Course Syllabus for EE 242 (ABET sheet)

Title: Signals, Systems, and Data I

Credits: 5

https://www.washington.edu/students/crscat/ee.html#ee242

UW Course Catalog Description

Introduction to signal processing, including continuous- and discrete-time signals and systems. Basic signals including impulses, unit steps, periodic signals, and complex exponentials. Convolution of signals. Fourier series and transforms. Linear, time-invariant filters. Computer laboratory. Prerequisite: either MATH 136, MATH 207 (or AMATH 351), any of which may be taken concurrently; EE 241 (may be taken concurrently) or CSE 163. Offered: Autumn/Winter/Spring

Coordinator: M. Ostendorf, S. Makhsous, Electrical and Computer Engineering

(Team) Faculty who have or are willing to teach this core course):
Akshay Gadre, Mahmood Hameed, Nathan Kutz, Sep Makhsous, Mari Ostendorf

Goals: To equip students with a comprehensive understanding and practical skills in signal processing, focusing on the analysis of signals and systems in both the time and frequency domains. Through detailed exploration of fundamental concepts such as basic signals (impulses, unit steps, periodic signals, and complex exponentials), convolution, Fourier series, and transforms, students will gain the ability to analyze and manipulate signals for a wide range of applications. This course emphasizes the application of these concepts through the use of Python, offering hands-on experience in signal analysis and implementation in a computer laboratory setting. By the end of the course, students will be prepared to apply their knowledge to more advanced topics in signal processing and related fields, including digital signal processing, communication systems, and machine learning applications

Learning Objectives: At the end of this course, students will be able to:

1. *Describe* signals in time and frequency domains using Fourier transforms and map characteristics in one domain to those in another.
2. *Understand t*he differences between discrete-time and continuous-time signals and the connections between digital and analog domains.
3. *Understand* the implications of different system properties and how to test for them;
4. Perform convolutions for arbitrary and closed-form signals.
5. *Analyze* Linear, Time-Invariant (LTI) systems given different system representations (including input-output equations, impulse response, and frequency response), and translate between these different representations.
6. *Use and understand* standard ECE terminology associated with filtering and LTI systems (e.g. LPF, HPF, impulse response, step response, etc.)
7. *Implement* simple programs in Python to synthesize, plot, play, analyze and filter time functions.

Laboratory learning objectives are optional, but recommended for courses where the laboratories target the development of specific skills.
For the Hands-on Course Laboratories:

8. *Use* a digital multimeter, breadboard, and an Arduino microcontroller (or similar device) to build circuits and collect data from various electronic and photonic devices (e.g., diodes, MOSFETs, LEDs, solar/photovoltaic cells).
9. *Apply* knowledge gained from lecture to extracting parameters, characteristic curves, and other relevant data from devices and interface circuits.

Textbook (required):
A. Oppenheim, A. Willsky and S. H. Nawab, Signals and Systems,Prentice Hall, 1996.

Referenced Textbooks:
S. K. Mitra, Signals and Systems, Oxford University Press, 2015. C. Phillips, J. Parr and E. Riskin, Signals, Systems and Transforms, Prentice Hall, 2003.

Prerequisite courses:
MATH 136, MATH 207 (or AMATH 351), any of which may be taken concurrently;
EE 241 (may be taken concurrently) or CSE 163

Prerequisites by Topic:
1. Calculus,
2. Complex numbers
3. Computer programming

Lecture Topics:
1. Introduction, analog vs. digital, discrete-time and continuous-time signals and signal transformations (1.5 weeks)
2. Systems and their properties (1 week)
3. Linear time-invariant systems analysis in the time domain: convolution (2 weeks)
4. Fourier series representations of periodic signals (series and transforms) (1.5 weeks)
5. Fourier transforms (CTFT, DTFT, DFT) (2.5 weeks)
6. Filtering applications, time vs. frequency domain (1.5 weeks)

Laboratory Topics:
- *Lab 1:* Time scale audio signals, time shift, and plotting.
- *Lab 2:* Removing noise from synthetic audio signals and Image edge detection.
- *Lab 3:* Building periodic signals and Frequency analysis with FFT.
- *Lab 4:* Filtering and filter design.

Note: Labs are unlikely to always directly follow the content presented in class, but content for each lab is covered prior to students beginning the lab, even if the lab lags 1-2 weeks behind the lecture material.

Course Structure: The class meets for four lectures a week for a 50-minute lecture and has a weekly 2-hour computer lab section with a Teaching Assistant. There are weekly homework assignments and several laboratory exercises that must be done in Python. Most instructors also offer an optional 1-hour problem-solving discussion session weekly to provide the opportunity for students to work through additional examples.
The organization and delivery style of EE242 lectures is at the discretion of the instructor. Lecture sessions typically consist of lectures interspersed with (a) examples that illustrate the application of important concepts; (b) demonstrations that illustrate these principles at work in real devices; or (c) student-centered activities, including small group problem-solving activities and think/pair/share exercises designed to reinforce understanding of basic concepts and resolve misconceptions.

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Implement Signal Processing Algorithms in Python
Construct and Analyze Digital Filters Using Python
Visualize Signal Characteristics and System Responses in Python
Simulate and Evaluate LTI Systems Using Python

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Note: The quiz section is not intended to allow students to fully complete each lab. At-home (out-of-class) work will be needed following the student's quiz section.

Assignments in the course consist of homeworks, lab assignments (based on scaffolded laboratory reports), and exams/quizzes.

Computer Resources: The course uses Python for the laboratory exercises and optionally for checking homework problems. Students are expected to use their personal computers in the labs. Outside of the two-hour lab section, students spend an additional hour per week on average to complete the labs, including prelab assignments and lab reports.

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Laboratory Resources: (see Computer Resources)

Grading: Formative assignments include homeworks, in-class exercises, and (in part) laboratory reports. Summative assignments include midterms and final exams. The course syllabus and grading rubrics will clearly identify the goal of each assignment (formative or summative).
Homework: 15%
In-Class Exercises (which may include some take-home time): 10%
Laboratory Reports: 25%
Exams: 30%
Comprehensive Final Exam: 20%

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It is highly recommended that part of the lab assignment grading include a direct, face-to-face laboratory demonstration that verifies that each student is learning the hands-on laboratory skills for which the course is designed and minimizes academic dishonesty. If students work in teams to complete the laboratories, a means for ensuring that each student contributes something meaningful to each laboratory report is strongly recommended. Homeworks may be completed in teams or solo (at the discretion of the instructor), while summative assignments (exams, quizzes, etc.) should be completed solo.

ABET Student Outcome Coverage: This course addresses the following outcomes:
H = high relevance, M = medium relevance, L = low relevance to course.

(1) *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.* **(H)**
The course introduces fundamental mathematical principles used for the analysis of continuous-time signals and systems. Students routinely solve problems in systems analysis using mathematical tools of convolution and transforms. They are introduced to computer analysis methods via Python-based computer lab assignments.

(3) *An ability to communicate effectively with a range of audiences (M)*
Students are expected to provide clear, concise answers to questions in exams that include only information relevant to the question. In addition, they answer questions about lab assignments orally during laboratory sections and provide written lab reports in electronic notebook format. Some instructors include a brief writing assignment where students are asked to pick an example of modern technology and explain how some aspect of signal processing plays a role in this technology.

(5) *An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.* (M)
The computer labs are conducted in teams. Labs constitute about 1020% of their grade (depending on the instructor).

(7) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies*. (M) Students are expected to use online documentation to learn the Python programming language for use in lab exercises, building on their knowledge of programming in other languages.

Prepared By: Mari Ostendorf, Sep Makhsous
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Additional information and resources regarding teaching ECE courses (e.g., links to course repositories for materials from previous course offerings; guidelines for using AI tools in courses; syllabus language for course accommodations, etc.) can be found on the UW ECE Intranet:
https://peden.ece.uw.edu/academic-ops/