UNIVERSITY OF CALIFORNIA
UCMERCED

Syllabus for BIOE060-10: Signal, Sys & Digital Img Proc

Fall 2021
Instructor: Sushma Shrinivasan

Designation:	Lower division
Catalog Description:	This course is an introduction to the basic concepts and theory of analog and digital signal processing in bioengineering. The background assumed is calculus, experience in manipulating complex numbers, and some exposure to differential equations. Both for pedagogical reasons and as a reflection of the nature of modern signal processing systems, the concepts associated with continuous-time and with discrete-time signals and systems are treated together in a closely coordinated way. Among other things, this approach emphasizes both the similarities and the differences in the two classes of systems. Also introduces basic concepts of digital imaging processing.
Text Books and Other Required Materials:	Signals and Systems, 2nd edition, by Alan V. Oppenheim and Willsky, ISBN: 0-13-814757-4.
Course Objectives/ Student Learning Outcomes:	By the end of this course, students will be able to: 1. Explain the basic differences between Discrete-Time Signals and ContinuousTime signals. 2. Understand the concept of convolution. 3. Apply the Fourier series and Fourier transform to analyze linear systems. 4. Understand the concept of mathematical filtering. 5. Comprehend the importance of the sampling theorem. 6. Students will be able to communicate information and their knowledge in Signals and systems for bioengineers. 7. Basic concepts of digital image processing.
Program Learning Outcomes:	
Prerequisites by Topic:	MATH 24, BIOE 21
Course Policies:	Homeworks are typically assigned on Wednesday(check CatCourses) and will be due (via catcourse) on the date indicated (typically after one week). Late homeworks will be accepted till the following day (basically a 24-hour extension) but for a reduced credit of 75%. To iterate, feel free to discuss among yourselves to complete the homework problems, but reproducing another person's work is not acceptable. Syllabus for the exams will be announced in class as the course progresses. Review sessions may be held before the exams. Quizzes (~3) will be conducted. Make sure to stay updated with catcourse on course announcements/material posted. Any material that is posted is only for your benefit and should not be shared or posted online by you.
Academic Dishonesty Statement:	a. Each student in this course is expected to abide by the University of California, Merced's Academic Honesty Policy. Any work submitted by a student in this course for academic credit will be the student's own work. b. You are encouraged to study together and to discuss information and concepts

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covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an e mail, an e mail attachment file, a diskette, or a hard copy. Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Policy can also be extended to include failure of the course and University disciplinary action.
c. During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Disability Statement: Accommodations for Students with Disabilities: The University of California Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances. Students are encouraged to register with Disability Services Center to verify their eligibility for appropriate accommodations.

Topics: 1. INTRODUCTION
Introduction to Biological Signals and Systems.

2. SIGNALS
Transformations of the Independent Variable. Continuous-Time Complex Exponential and Sinusoidal Signals. Discrete-Time Complex Exponential and Sinusoidal Signals. Periodicity Properties of Discrete-Time Complex Exponentials. The Discrete-Time Unit Step and Unit Impulse Sequences. The Continuous-Time Unit Step and Unit Impulse Functions.

3. SYSTEMS. Properties of Systems. Convolution. Representation of Signals in Terms of Impulses, DiscreteTime LTI Systems: The Convolution Sum, Continuous-Time LTI Systems: The Convolution Integral. Properties of linear, time-invariant systems. Discrete-Time LTI Systems: The Convolution Sum. Continuous-Time LTI Systems: The Convolution Integral. Properties of Linear Time-Invariant Systems. Singularity Functions. Systems represented by differential and difference equations. Systems Described by Differential and Difference Equations. Block Diagram Representations of LTI Systems Described by Differential and Difference Equations. Physiological models. Hodgkin-Huxley Model. Lou-Rudy Model

4.CONTINUOUS-TIME FOURIER SERIES AND FOURIER TRANSFORMS
The Response of Continuous-Time LTI Systems to Complex Exponentials. Representation of Periodic Signals: The Continuous-Time Fourier Series. Approximation of Periodic Signals Using Fourier Series and the Convergence of Fourier Series. Continuous-time Fourier transform. Representation of Aperiodic Signals: The Continuous-Time Fourier Transform. Periodic Signals and the Continuous-Time Fourier Transform. Fourier transform properties. Properties of the Continuous-Time Fourier Transform. The Convolution Property, The

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Modulation Property, Tables of Fourier Properties and of Basic Fourier Transform and Fourier Series Pairs, The Polar Representation of Continuous-Time Fourier Transforms. Calculation of Frequency and Impulse Responses for LTI Systems Characterized by Differential Equations. Noise analysis in biological membranes. Fluorescence correlation spectroscopy in the frequency domain.

5. DISCRETE-TIME FOURIER SERIES AND FOURIER TRANSFORMS. The Response of Discrete-Time LTI Systems to Complex Exponentials. Representation of Periodic Signals: The Discrete-Time Fourier Series. Representation of Aperiodic Signals: The Discrete-Time Fourier Transform. Periodic Signals and the Discrete-Time Fourier Transform. Discrete-time Fourier transform. Properties of the Discrete-Time Fourier Transform. The Convolution Property. The Modulation Property. Basic Fourier Transform and Fourier Series Pairs. Duality. The Polar Representation of Discrete-Time Fourier Transforms. Calculations of Frequency and Impulse Responses for LTI Systems Characterized by Difference Equations.

6. FILTERING Ideal Frequency-Selective Filters. Nonideal Frequency-Selective Filters. Examples of Continuous-Time Frequency-Selective Filters Described by Differential Equations. Examples of Discrete-Time Frequency-Selective Filters Described by Difference Equations. Electric and mechanical systems as filters. Biological systems as filters.

7. SAMPLING AND INTERPOLATION Representation of a Continuous-Time Signal by Its Samples: The Sampling Theorem, The Effect of Undersampling: Aliasing. Sampling with a Zero-Order Hold. Reconstruction of a Signal from Its Samples Using Interpolation. Discrete-Time Processing of Continuous-Time Signals. Discrete-time processing of continuous-time signals. Discrete-time sampling. Sampling of Discrete-Time Signals. Discrete-Time Decimation and Interpolation. . Sampling in the Frequency Domain,

8. THE LAPLACE TRANSFORM The Region of Convergence for Laplace Transforms. The Inverse Laplace Transform. Continuous-time second-order systems. Properties of the Laplace Transform. Analysis and Characterization of LTI Systems Using the Laplace Transform. First-Order and Second-Order Systems. Geometric Evaluation of the Fourier Transform from the Pole Zero Plot. The z transform. The Region of Convergence for the z-Transform. The Inverse z-Transform.

9. Introduction to digital image processing

If time permits,

10. MAPPING CONTINUOUS-TIME FILTERS TO DISCRETE-TIME FILTERS Properties of the z-Transform. Analysis and Characterization of LTI Systems Using z-Transforms. Geometric Evaluation of the Fourier Transform from the Pole Zero Plot. Transformations between Continuous-Time and Discrete-Time Systems. Butterworth filters. The Class of Butterworth Frequency-Selective Filters. Butterworth Filters. The Bilinear Transformation. Feedback. Linear Feedback Systems. Some Applications and Consequences of Feedback, Root-Locus Analysis of Linear Feedback Systems. Control systems in physiology.

Designation:	Lower division 11. CONTINUOUS-TIME MODULATION Continuous-Time Sinusoidal Amplitude Modulation. Some Applications of Sinusoidal Amplitude Modulation. Single-Sideband Amplitude Modulation. Demonstration of amplitude modulation. Time and Frequency Scaling. Continuous-Time Sinusoidal Amplitude Modulation. Sinusoidal Amplitude Modulation for Communications: Frequency-Division Multiplexing. Continuous-Time Frequency Modulation. Discrete-time modulation. Pulse Amplitude Modulation and Time-Division Multiplexing.
Class/laboratory Schedule:	Lecture: MW 12:00-1:15pm 12:00-1:15pm SSB 130, No labs
Midterm/Final Exam Schedule:	Midterm 1: Tentative date Oct 4th, SSB 130 Midterm 2: Tentative date Nov 8th, SSB 130 Finals: Dec 17th, 8:00-11:00am, SSB 130 Quizzes: Quiz 1: Tentative date : Sep 27th (syllabus covered up to and including Sept 22nd lecture). Quiz 2:Tentative date : Nov 1st (syllabus covered up to and including Oct 27th lecture). Quiz 3: Tentative date : Dec 6th (syllabus covered up to and including Dec 1st lecture).
Course Calendar:	
Professional Component:	
Assessment/Grading Policy:	Homework- 15% Midterm 1- 25% Midterm 2- 25% In-class quiz- 5% Finals- 30%
Coordinator:	Prof. Sushma Shrinivasan
Contact Information:	Email: sshrinivasan@ucmerced.edu TA & Discussion sessions: Yibing Zhang Email: yzhang291@ucmerced.edu
Office Hours:	Instructor: Monday & Wednesday Instructor: 1:30-2:30pm via zoom (zoom link will be posted in catcourse announcement) or by appointment. TA: Thursday 10am-12 noon via zoom ((zoom link will be posted in catcourse announcement) or by appointment.