MAT 599 Syllabus

Semester:	Fall 2020
Course title:	Mathematics of Digital Signal Processing I
Instructor:	Professor Matt Klassen
Email:	mklassen@digipen.edu
Phone:	(425) 895-4423
Office hours:	M,W 10:30-12:00, T,Th 3:00-4:00 or by appointment
Course Web Page:	http://azrael.digipen.edu/MAT320
Time/Place:	T,Th 10:30-11:50, online in Teams
Note:	This is a cross-listing of MAT 320 as graduate level course

WEB PAGES AND MOODLE:

The Moodle page for MAT599 will contain a link to the course web page. The web page is the central repository for all course documents, including homework assignments. Updates to homework will be posted on the web page only. Scores for quizzes, homework, exams, and projects, will be posted through perl scripts on the course web page.

The Moodle page will be primarily used for chat, forums, and for submission of projects.

MATERIALS:

Text: *A Digital Signal Processing Primer*, by Ken Steiglitz. The course is based on this text, lecture material, notes, and homework.

Reference Materials (not required) :

Notes on the Fourier Transform, by Brad Osgood:
(see https://see.stanford.edu/materials/lsoftaee261/book-fall-07.pdf)
Digital Signal Processing, by Oppenhiem and Schafer
The Audio Programming Book, by Boulanger and Lazzarini
Musimathics, Volumes 1 and 2, by Gareth Loy
Digital Filters for Everyone, by Rusty Allred
Music: A Mathematical Offering, by David Benson
Schaum's Outline: Digital Signal Processing, by Monson Hayes
On the Sensations of Tone, by Hermann Helmholtz
Real Sound Synthesis for Interactive Applications, by Perry Cook
Signals, Sound, and Sensation, by William Hartmann
Designing Sound, by Andy Farnell

BACKGROUND MATHEMATICS:

Calculus and Linear Algebra

COURSE DESCRIPTION:

This course explores the mathematical foundations of digital signal processing, with applications to digital audio programming. Topics include: digital signals, sampling and quantization, complex numbers and phasors, complex functions, feedforward filters, feedback filters, frequency response and transfer functions, periodic signals and Fourier series, discrete Fourier transform and fast Fourier transform, comb and string filters, Z-transform and convolution.

COURSE GOALS AND OBJECTIVES:

1) Students will learn some of the basic algorithms in digital signal processing using complex numbers, such as the Discrete and Fast Fourier Transforms, and various filters.

2) Students will become familiar with basic concepts of digital signal processing and will describe these from the mathematical perspective.

3) Students will solidify their knowledge of Linear Algebra and Calculus by using these subjects as tools to solve problems involving vector spaces of complex numbers, continuous functions, and discrete functions and signals.

QUIZZES AND EXAMS:

Quizzes will be given periodically to test comprehension of lecture material. There are no make up quizzes, but I do drop the lowest two quiz scores. The quizzes will last for approximately twenty minutes.

For multiplie choice quizzes and exams, please follow these procedures: Work out the quiz problems and circle your answers on the question sheet. When you are finished, transfer the answers to the answer sheet. Go to a web browser and enter the answers online. Under no circumstances are you allowed to discuss the quiz questions with any other student during the quiz or the data entry process. Your scores will be posted online by your student ID. For written format quizzes there will be a Moodle submission box, where you should submit your written answers at the end of the quiz.

There will be a midterm exam given during regular class hours, and a final exam. There are *NO* make up exams unless you have a *compelling and well documented reason* for missing a test.

Calculators are allowed on quizzes and exams.

HOMEWORK ASSIGNMENTS:

Homework will be assigned and posted on the web page and collected weekly. You are responsible for checking the web page and noting the assignments and the due date. You may work on homework together, as well as consult the tutors and the instructor. However, the final work that you turn in must be your own work.

COMPUTATIONAL RESOURCES:

You are encouraged to do linear algebra and other calculations for the homework using a calculator or symbolic package such as SciLab. The symbolic algebra package SciLab is free and open-source, and is similar to MATLAB.

GRADING:

Homework	20%
Quizzes	20%
Project	20%
Class Participation	20%
Midterm Exam	10%
Final Exam	10%

Grades will be determined based on total course percentage. Percentage scores will determine letter grades according to the scale: (in the worst case)

A: $93-100$, A-: $90-92.9$, B+: $87-89.9$, B: $83-86.9$, B-: $80-82.9$,

C+: $77-79.9$, C: $73-76.9$, C-: $70-72.9$, D: $60-69.9$, F: < 60

CLASS PARTICIPATION:

Class participation is an important part of the course, so it is assigned a weight of 20%. Class participation credit will be given for the following types of activities: volunteering to answer a question posed by the instructor, asking a relevant question during lecture, participating in a combinatorial game demo, volunteering to work out a homework problem for the class, or other types as they come up in class. Basic credit is one point for a brief but relevant participation. More substantial participation is two points. 10 points is full credit for the semester. Participation grades will be posted weekly.

PROJECTS:

The full description of the programming project can be found on the course web page. Submission of projects should be in a zipped folder which contains source and executable and which can be uploaded on the Moodle page.

The programming project is in five parts worth equal weights:

1. I Complex numbers – due Friday 9/18,
2. II Discrete Fourier Transform – due Friday 10/9,
3. III Fast Fourier Transform – due Friday 10/30,
4. IV Low Pass Filter – due Friday 11/13,
5. V Plucked String Filter – due Friday 12/4

ACADEMIC INTEGRITY:

Academic dishonesty in any form will not be tolerated in this course. Cheating, copying, plagiarizing, or any other form of academic dishonesty (including doing someone elses individual assignments) will result in, at the extreme minimum, a zero on the assignment in question, and could result in a failing grade in the course or even expulsion from DigiPen.

All students are asked to help in promoting a culture of academic integrity by discouraging cheating in all forms.

GRADUATE STUDENTS:

Graduate students will be required to do a report which will be factored in as part of their homework grade. The subject matter will involve an in depth analysis of a particular problem, or an application, and will require some synthesis of current work and contributions in the field. This will form part of the graduate student exposure to research methods in course work.

DISABILITY STUDENT SERVICES:

If students have disabilities and will need formal accommodations in order to fully participate or effectively demonstrate learning in this class, they should contact the Disability Support Services Office at (425)629-5015 or dss[at]digipen[dot]edu. The DSS Office welcomes the opportunity to meet with students to discuss how the accommodations will be implemented. Also, if you may need assistance in the event of an evacuation, please let the instructor know.

RELIGIOUS ACCOMMODATION: DigiPen Institute of Technology provides reasonable accommodations to students who may be absent from activities or incur significant hardship due to religious holidays or observances. These holidays or observances must be part of a religious denomination, church, or religious organization, and the course instructor must be notified in writing during the first two weeks of the course. The institutes policy for grievances is published in the course catalog.

TENTATIVE WEEKLY TOPICS:

Week	Dates	Topics
1	Aug 31 - Sep 4	Introduction to Complex Numbers: rectangular and polar forms, norm, conjugate, complex vectors, complex dot product.
2	Sep 7 - 11	Phasors, complex functions, linear algebra review: linear independence, bases, discrete Fourier Transform.
3	Sep 14 - 18	Strings, Pipes, Wave Equation; Frequency Ratios. Introduction to Fast Fourier Transform: FFT.
4	Sep 21 - 25	Sampling and Quantization, Aliasing, Decibels. Bit reversal for FFT implementation.
5	Sep 28 - Oct 2	Feedforward Filters: Delay and Transfer function.
6	Oct 5 - 9	Feedforward Filters: stability, phase, inverse comb
7	Oct 12 - 16	Feedback filters: poles and zeros
8	Oct 19 - 23	Feedback filters: resonance, filter design
9	Oct 26 - Oct 30	Periodic sounds, Fourier series and transforms. Zero crossings, periodicity and nonlinear wave equation.
10	Nov 2 - 6	Intro to Comb and string filters
11	Nov 9 - 13	Resonance and tuning, first-order allpass filter.
12	Nov 16 - 20	z-transform and convolution.
13	Nov 23 - 25	orthogonality, impulse and step, inverse z-transform
14	Nov 30 - Dec 4	Continuous Fourier Transform, Summary of Transforms and Inverses, Time-Frequency Correspondences
15	Dec 7 - 11	Final Exams