

# MAT 320 Syllabus

<b>Semester:</b>	Fall 2023
<b>Course title:</b>	Mathematics of Digital Signal Processing I
<b>Instructor:</b>	Professor Matt Klassen
<b>Email:</b>	mklassen@digipen.edu
<b>Phone:</b>	(425) 895-4423
<b>Office hours:</b>	M,Th 3:00-4:00, or by appointment
<b>Course Web Page:</b>	<a href="http://azrael.digipen.edu/MAT320">http://azrael.digipen.edu/MAT320</a>
<b>Time/Place:</b>	M,W 4:30-5:50, in Carr

## WEB PAGES AND MOODLE:

The Moodle page for MAT320 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, as well as on the Moodle page. Additionally, the Moodle page will be used for chat, forums, and for submission of homework, projects, and quiz and exam scratch work.

## MATERIALS:

Required 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/lsoftae261/book-fall-07.pdf>)  
*Digital Signal Processing*, by Oppenheim and Schaffer  
*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. The lowest two quiz scores are dropped for the purpose of final grading. If a quiz is missed for any reason, the quiz will receive a zero. This way it is possible to miss two quizzes and not be penalized. The quizzes will last for approximately twenty minutes.

For multiple 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 and then 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. Finally, there will be a Moodle submission box, where you should submit your written scratch work at the end of the quiz or exam.

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%
Midterm Exam	20%
Final Exam	20%

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

**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 Monday 9/11,
2. II Discrete Fourier Transform – due Monday 9/25,
3. III Fast Fourier Transform – due Monday 10/23,
4. IV Low Pass Filter – due Monday 11/13,
5. V Plucked String Filter – due Monday 11/27

**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 else's 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.

**TEAMS and STREAMING:**

Students may request that an individual class be streamed to accommodate an illness which requires that they be off campus. Such a request must be documented and be sent to the instructor before class starts. Streaming is not for convenience or for other situations than those which are officially documented. If a student has questions about this they should contact Student Services for the description and requirements for official accommodations which can be used to justify requests for streaming of classes. At the beginning of each class, I will check to see if there are any official accommodations for streaming to be in effect. If there are not, then I will not stream.

If a student misses class without an accommodation, there are still ways to recover the course content. For example, a student may have a classmate who takes notes, or records the lecture as audio or video or a sequence of photos during the class. All recording methods are approved by the instructor, for the purpose of personal study, and may be shared between students. The only request is to please not post such materials online with public access.

In the case that a lecture is being streamed, students are welcome to record in Teams or to use OBS to record the live stream for later viewing. The Teams recordings can be very poor quality, both video and audio, so OBS is recommended.

### 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](mailto:dss@digipen.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 28 - Sep 1	Introduction to Complex Numbers: rectangular and polar forms, norm, conjugate, complex vectors, complex dot product.
2	Sep 5 - 8	Phasors, complex functions, linear algebra review: linear independence, bases, discrete Fourier Transform.
3	Sep 11 - 15	Strings, Pipes, Wave Equation; Frequency Ratios. Introduction to Fast Fourier Transform: FFT.
4	Sep 18 - 22	Sampling and Quantization, Aliasing, Decibels. Bit reversal for FFT implementation.
5	Sep 25 - Sep 29	Feedforward Filters: Delay and Transfer function.
6	Oct 2 - 6	Feedforward Filters: stability, phase, inverse comb
7	Oct 9 - 13	Midterm Exam, Feedback filters: poles and zeros
8	Oct 16 - 20	Feedback filters: resonance, filter design
9	Oct 23 - Oct 27	Periodic sounds, Fourier series and transforms. Zero crossings, periodicity and nonlinear wave equation.
10	Oct 30 - Nov 3	Intro to Comb and string filters
11	Nov 6 - 9	Resonance and tuning, first-order allpass filter.
12	Nov 13 - 17	$z$ -transform and convolution.
13	Nov 20 - 22	orthogonality, impulse and step, inverse $z$ -transform
14	Nov 27 - Dec 1	Continuous Fourier Transform, Summary of Transforms and Inverses, Time-Frequency Correspondences
15	Dec 4 - 8	Final Exams