The University of Texas at Austin
Dept. of Electrical and Computer Engineering
Midterm #1

Date: October 2, 2025 Course: EE 313 Evans

Name: _____
Last, First

- **Exam duration**. The exam is scheduled to last 75 minutes.
- **Materials allowed**. You may use books, notes, your laptop/tablet, and a calculator.
- **Disable all networks**. Please disable all network connections on all computer systems. You may not access the Internet or other networks during the exam.
- **No AI tools allowed**. As mentioned on the course syllabus, you may not use GPT or other AI tools during the exam.
- **Electronics.** Power down phones. No headphones. Mute your computer systems.
- **Fully justify your answers**. When justifying your answers, reference your source and page number as well as quote the content in the source for your justification. You could reference homework solutions, test solutions, etc.
- **Matlab**. No question on the test requires you to write or interpret Matlab code. If you base an answer on Matlab code, then please provide the code as part of the justification.
- **Put all work on the test**. All work should be performed on the quiz itself. If more space is needed, then use the backs of the pages.
- **Academic integrity.** By submitting this exam, you affirm that you have not received help directly or indirectly on this test from another human except the proctor for the test, and that you did not provide help, directly or indirectly, to another student taking this exam.

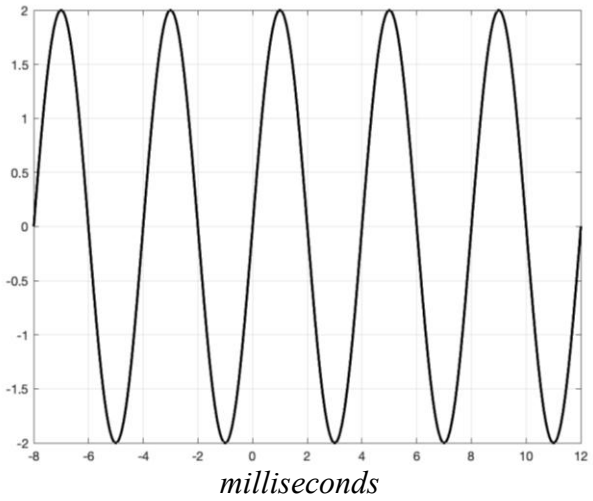
Problem	*Point Value*	*Your score*	*Topic*
1	24		Sinusoidal Signals
2	26		Fourier Series
3	26		Sampling and Aliasing
4	24		Time-Frequency Analysis
Total	100		

Problem 1.1 *Sinusoidal Signals*. 24 points.

Consider the sinusoidal signal
$x(t) = A \sin(2\,\pi\, f_0\, t\, +\, \theta)$ with

- amplitude A
- continuous-time frequency f_0 in Hz
- phase θ in radians

From the plot of $x(t)$ on the right,



milliseconds

Note: 1 millisecond = 10^{-3} seconds

(a) Estimate the amplitude A. Explain how you estimated the value of this parameter. *6 points.*

(b) Estimate the continuous-time frequency f_0 in Hz. Explain how you estimated the value of this parameter. *6 points.*

(c) Estimate the phase θ in radians. Explain how you estimated the value of this parameter. *6 points*.

(d) What is the phase of the signal $x(t - 0.001)$? Please show your intermediate steps. *6 points*.

Problem 1.2. *Fourier Series Properties.* 26 points.

The continuous-time Fourier series has several properties.

In this problem, $x(t)$ is periodic with fundamental frequency f_0 and Fourier series coefficients a_k.

For example, if $y(t) = A\,x(t)$, the Fourier series coefficients b_k for $y(t)$ can be found using $b_k = A\,a_k$:

$$y(t) = A\,x(t) = A\sum_{k=-\infty}^{\infty} a_k\,e^{j2\pi(kf_0)t} = \sum_{k=-\infty}^{\infty} A\,a_k\,e^{j2\pi(kf_0)t}$$

For the following expressions, derive the relationship between the Fourier series coefficients b_k for $y(t)$ and the Fourier series coefficients a_k for $x(t)$ where

$$a_k = \frac{1}{T_0}\int_0^{T_0} x(t)\,e^{-jk\omega_0 t}\,dt$$

(a) $y(t) = x_1(t) + x_2(t)$ where $x_1(t)$ has a fundamental frequency f_0 and Fourier series coefficients c_k and $x_2(t)$ has a fundamental frequency f_0 and Fourier series coefficients d_k. *8 points*.

(b) $y(t) = e^{-j\,2\,\pi\,f_0\,t}\,x(t)$. This is a type of amplitude modulation. *9 points*.

(c) $y(t) = x\left(\frac{t}{2}\right)$. *9 points*.

Problem 1.3. *Sampling and Aliasing.* 26 points.

A frequency of 46 kHz is higher than the normal audible range of 20 Hz to 20 kHz for a human being.

Consider a continuous-time signal $x(t) = \cos(2 \pi f_0 t)$ where $f_0 = 46$ kHz.

Sample the signal using a sampling rate of $f_s = 48$ kHz.

(a) Derive a formula for the discrete-time signal $x[n]$ that results from sampling $x(t)$. *6 points*.

(b) Determine the discrete-time frequency to which the continuous-time frequency of f_0 will alias. *9 points*.

(c) What is the equivalent continuous-time frequency for the aliased discrete-time frequency in (b)? *9 points*.

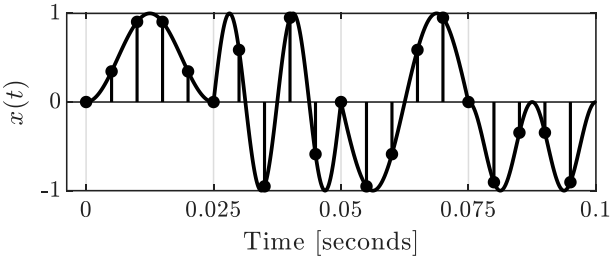
(d) Is the aliased frequency audible? *2 points*.

Problem 1.4. *Time-Frequency Analysis.* 24 points.

This problem is related to mini-project #1. Please justify your answers.

The continuous-time signal $x(t)$ is defined between $0 \le t \le 0.1$. The discrete-time signal $x[n]$ is obtained by sampling $x(t)$ at a rate $f_s = 200$ Hz. The plot of $x(t)$ and $x[n]$ are provided below.

$$x(t) = \begin{cases} \cos^2(2\pi\, 20\, t) & 0 \le t < 0.025 \\ \sin(2\pi\, 80\, t) & 0.025 \le t < 0.05 \\ -\sin(2\pi\, 40\, t) & 0.05 \le t < 0.075 \\ -\cos^2(2\pi\, 40\, t) & 0.075 \le t \le 0.1 \end{cases}$$



A complex image signal $S[m,k]$ is obtained by taking the short-time Fourier transform of $x[n]$ using non-overlapping rectangular windows $w[n]$ of length $N = 5$ samples:

$$\mathbf{S}[m,k] = \mathbf{STFT}\{x[n]\}[m,k] = \sum_{n=0}^{N-1} x[n]w[n-m]e^{-j2\pi\frac{k}{N}n}$$

The plots below visualize the components of $\mathbf{S}[m,k]$. Label each plot as one of the four options:

A. Magnitude: $|\mathbf{S}[m,k]|$

B. Phase: $\angle\mathbf{S}[m,k]$

C. Real part: $\mathrm{Re}\{\mathbf{S}[m,k]\}$

D. Imaginary part: $\mathrm{Im}\{\mathbf{S}[m,k]\}$