

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL of ELECTRICAL & COMPUTER ENGINEERING
FINAL EXAM

DATE: 7-May-10

COURSE: ECE-2025

NAME:

LAST,

FIRST

GT username:

(ex: gpburdell3)

3 points

3 points

3 points

Recitation Section: Circle the date & time when your **Recitation Section** meets (not Lab):

L05:Tues-Noon (Michaels)

L06:Thur-Noon (Bhatti)

L07:Tues-1:30pm (Michaels)

L08:Thur-1:30pm (Bhatti)

L01:M-3pm (Lee)

L09:Tues-3pm (Fekri)

L03:M-4:30pm (Lee)

L11:Tues-4:30pm (Fekri)

- Write your name on the front page **ONLY**. **DO NOT** unstaple the test.
- Closed book, but a calculator is permitted.
- One page ($8\frac{1}{2}'' \times 11''$) of **HAND-WRITTEN** notes permitted. OK to write on both sides.
- Justify your reasoning clearly to receive partial credit.
Explanations are also **required** to receive **FULL** credit for any answer.
- You must write your answer in the space provided on the exam paper itself.
Only these answers will be graded. Circle your answers, or write them in the boxes provided.
If space is needed for scratch work, use the backs of previous pages.

<i>Problem</i>	<i>Value</i>	<i>Score</i>
1	30	
2	30	
3	30	
4	30	
5	30	
6	30	
7	30	

PROBLEM Spring-10-F.1:

Pick the correct frequency response characteristic and enter the number in the answer box:

Time-Domain Description

(a) $h[n] = \sum_{k=0}^3 \delta[n-k]$

ANS =

(b) $y_n = \text{conv}([1, 0, 2, 0, 1], x_n)$

ANS =

(c) $y[n] = \frac{1}{2}y[n-1] + x[n]$

ANS =

(d) $h[n] = (-\frac{1}{2})^n u[n]$

ANS =

(e) $y_n = \text{filter}([1, 1], 1, x_n)$

ANS =

(f) $y[n] = x[n] + x[n-1] + x[n-2]$

ANS =Frequency Response Characteristic

1. $H(e^{j\hat{\omega}}) = \frac{\sin \hat{\omega}}{\sin(\frac{1}{2}\hat{\omega})}$

2. $H(e^{j\hat{\omega}}) = \frac{1}{1 - \frac{1}{2}e^{-j\hat{\omega}}}$

3. $H(e^{j\hat{\omega}}) = 1 - \frac{1}{2}e^{-j\hat{\omega}}$

4. $H(e^{j\hat{\omega}}) = e^{-j\hat{\omega}}(1 + 2\cos(\hat{\omega}))$

5. $H(e^{j\hat{\omega}}) = \frac{\sin 2\hat{\omega}}{\sin(\frac{1}{2}\hat{\omega})} e^{-j1.5\hat{\omega}}$

6. $|H(e^{j\hat{\omega}})|^2 = 2 + 2\cos(\hat{\omega})$ (Mag-squared)

7. $\angle H(e^{j\hat{\omega}}) = -2\hat{\omega}$

8. $H(e^{j\hat{\omega}}) = \frac{1}{1 + \frac{1}{2}e^{-j\hat{\omega}}}$

PROBLEM Spring-10-F.2:

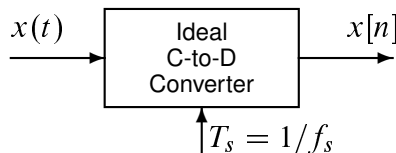
For each part, pick a correct frequency⁵ *from the list* and enter its value in the answer box.⁶

Write a brief explanation of your answers to receive any credit.

Frequency

- (a) If the output from an ideal C/D converter is $x[n] = A \cos(0.4\pi n)$, and the sampling rate is 8000 samples/sec, then determine one possible value of the *input frequency* of $x(t)$:

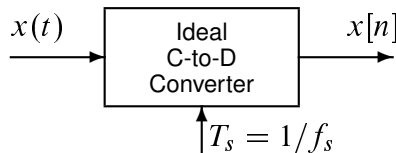
ANS =



- 8000 Hz
- 6400 Hz
- 4800 Hz
- 3200 Hz
- 2500 Hz
- 1250 Hz
- 1000 Hz
- 500 Hz
- 250 Hz

- (b) If the output from an ideal C/D converter is $x[n] = A \cos(0.4\pi n)$, and the input signal $x(t)$ defined by: $x(t) = A \cos(2000\pi t)$ then determine one possible value of the *sampling frequency* of the C-to-D converter:

ANS =



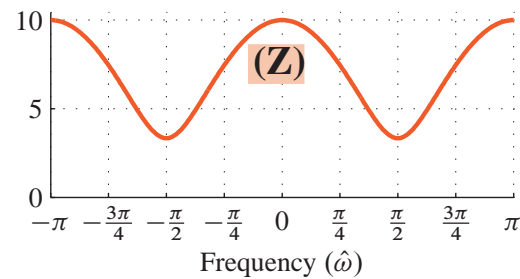
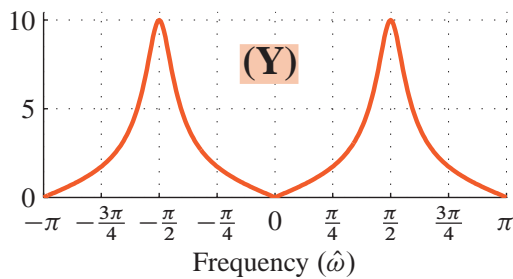
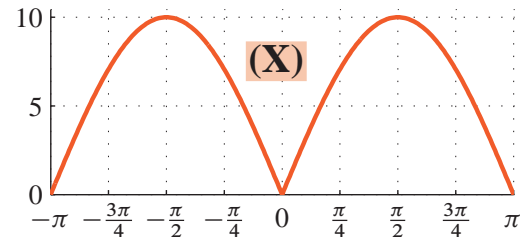
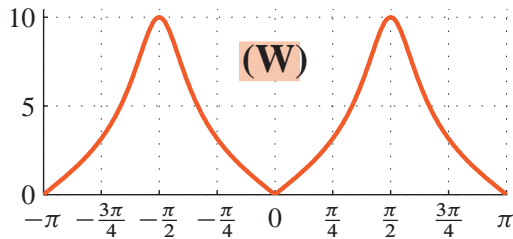
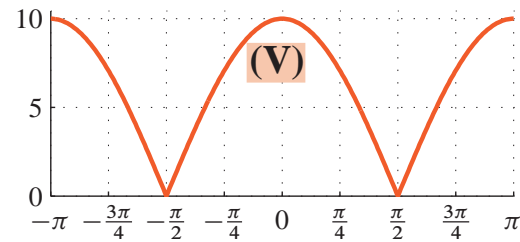
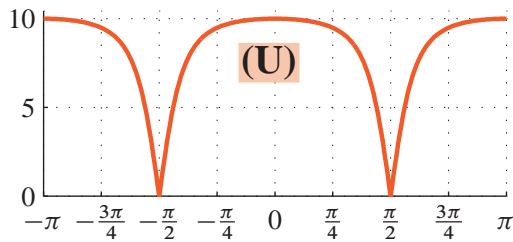
- (c) Determine the *Nyquist rate* for sampling the signal $x(t)$ defined by:
 $x(t) = (A - B \cos(900\pi t)) \sin(1600\pi t)$.

ANS =

⁵Some questions have more than one answer, but you *must pick your correct answer from the specified list*.

⁶It is possible to use an answer more than once.

PROBLEM Spring-10-F.3:



Each of the discrete-time systems below is described by its poles and zeros. Determine the matching frequency response (magnitude) plot for each one. Use the **letter** on the plot for your answer, or **None**.
 Note: The plots on the left are all IIR filters; the ones on the right are FIR.

ANS = Poles at the origin Zeros at: ± 1

ANS = Poles at: ± 0.837 Zeros at: $e^{\pm j\pi/2}$

ANS = Poles at the origin Zeros at: $e^{\pm j\pi/2}$

ANS = Poles at: $0.707e^{\pm j\pi/2}$ Zeros at: $e^{\pm j\pi/2}$

ANS = Poles at the origin Zeros at: $0.707e^{\pm j\pi/2}$

ANS = Poles at: $0.837e^{\pm j\pi/2}$ Zeros at: ± 1

ANS = Poles at: $0.707e^{\pm j\pi/2}$ Zeros at: ± 1

PROBLEM Spring-10-F.4:

For each of the following time-domain signals, select the correct match from the list of Fourier transforms below. *Write your answers in the boxes next to the question.* (The operator * denotes convolution.)

(a) $x(t) = \int_{-\infty}^t e^{-t+\tau} \delta(\tau) d\tau$

(b) $x(t) = \cos(\pi t) * \delta(t - 4)$

(c) $x(t) = \delta(t) - \delta(t - 8)$

(d) $x(t) = -e^{-t}u(t) + \delta(t)$

(e) $x(t) = u(t - 3) - u(t - 5)$

(f) $x(t) = \delta(t - 2) * e^{-t+1}u(t - 1) * \delta(t - 1)$

(g) $x(t) = u(t + 4) - u(t - 4)$

(h) $x(t) = e^{-(t-4)}\delta(t - 4)$

Each of the time signals above has a Fourier transform that should be in the list below.

[0] $X(j\omega)$ not in the list below.

[1] $X(j\omega) = 2e^{-j4\omega} \frac{\sin(4\omega)}{\omega}$

[2] $X(j\omega) = e^{-j4\omega} [u(\omega) - u(\omega - 8)]$

[3] $X(j\omega) = \frac{j\omega}{1 + j\omega}$

[4] $X(j\omega) = \frac{e^{-j4\omega}}{1 + j\omega}$

[5] $X(j\omega) = \frac{1}{1 + j\omega}$

[6] $X(j\omega) = \frac{\sin(4\omega)}{\omega/2}$

[7] $X(j\omega) = j2e^{-j4\omega} \sin(4\omega)$

[8] $X(j\omega) = e^{-j4\omega} [\pi\delta(\omega - \pi) + \pi\delta(\omega + \pi)]$

[9] $X(j\omega) = 2e^{-j4\omega} \frac{\sin(\omega)}{\omega}$

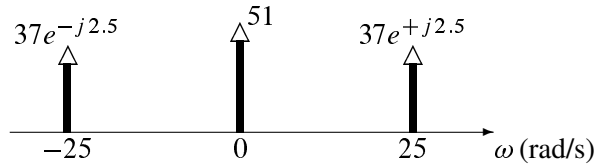
[10] $X(j\omega) = 0$

PROBLEM Spring-10-F.5:

- (a) A real signal $x(t)$ has a Fourier Transform that consists of the impulses shown below.

The frequency axis has units of rad/s.

Define a new signal by squaring $x(t)$, i.e., $y(t) = x^2(t)$. The Fourier transform of $y(t)$ consists of impulses; determine the locations of all the impulses in $Y(j\omega)$. Only the locations in ω .



Deltas located at $\omega =$

- (b) Define a continuous-time rectangular pulse via $p(t) = 3[u(t - 100) - u(t - 200)]$. Then convolve the pulse with itself to get $q(t) = p(t) * p(t)$ which is a triangle. Determine the location of the maximum value of $q(t)$, $t_{q\max}$, and also the maximum value q_{\max} .

$q_{\max} =$

$t_{q\max} =$

- (c) Suppose that the Fourier series coefficients of a periodic signal $s(t)$ are defined via the integral:

$$a_k = \frac{1}{10} \int_0^{10} s(t) e^{-j(2\pi/10)kt} dt \quad \text{where } s(t) = \begin{cases} 0 & 0 \leq t < 3 \\ 500\pi & 3 \leq t < 10 \end{cases}$$

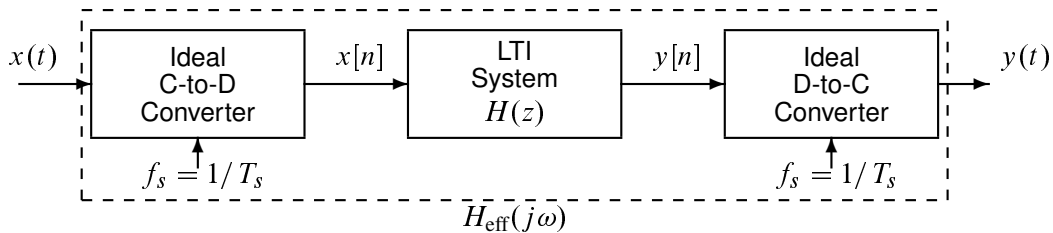
Evaluate a_k for $k = 4$; express your answer as a complex number in polar form, i.e., $r_k e^{j\theta_k}$.

$r_k =$

$\theta_k =$

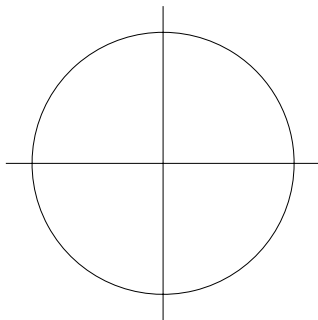
PROBLEM Spring-10-F.6:

Consider the following system for discrete-time filtering of a continuous-time signal:



The system function $H(z)$ of the discrete-time IIR system can be derived from the following MATLAB code:
`yn = filter([1, alf, 1], [1, 0.75*alf, 0.5625], xn);`

- (a) For the case where $\mathbf{alf} = -0.5$, determine the poles and zeros of the system, and then give your answer as a pole-zero plot. Account for *all* poles and zeros.



- (b) This filter is a notch filter, so its frequency response has a null and passband regions that are nearly flat. For the case where $\mathbf{alf} = -0.5$, determine the maximum value of the frequency response magnitude in the passbands.

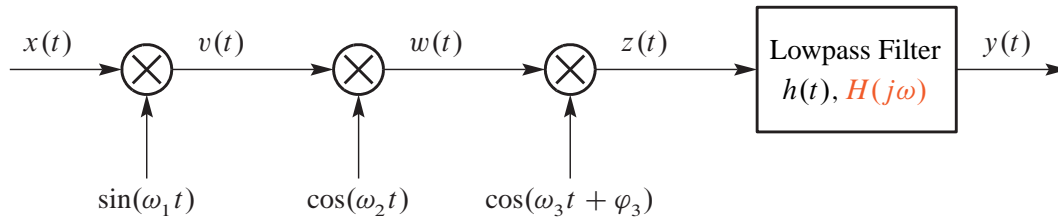
- (c) *Note: In this part the value of \mathbf{alf} is no longer -0.5 .*

The effective frequency response of this system (using the $H(z)$ above) is able to null out one sinusoid. It is similar to the system used in the lab to remove a sinusoidal interference from an EKG signal. The value of the filter coefficient parameter \mathbf{alf} controls the (frequency) location of the null. If the sampling rate is $f_s = 360$ Hz, determine the value of \mathbf{alf} so that the overall effective frequency response has a null at 120 Hz.

alf =

PROBLEM Spring-10-F.7:

The system below involves the cascade of several modulators followed by a filter:



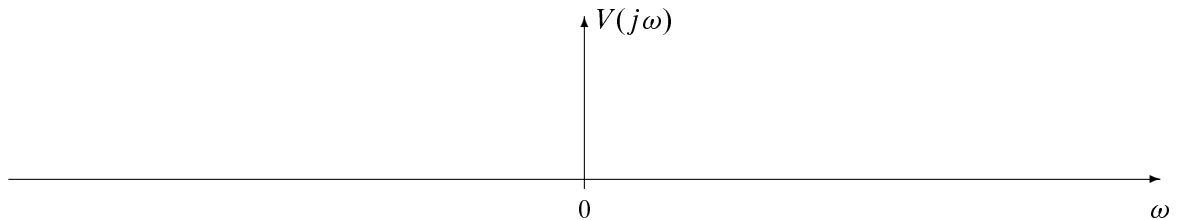
The signals are defined by

$$v(t) = x(t) \sin(100t) \quad w(t) = v(t) \cos(25t) \quad z(t) = w(t) \cos(\omega_3 t + \varphi_3)$$

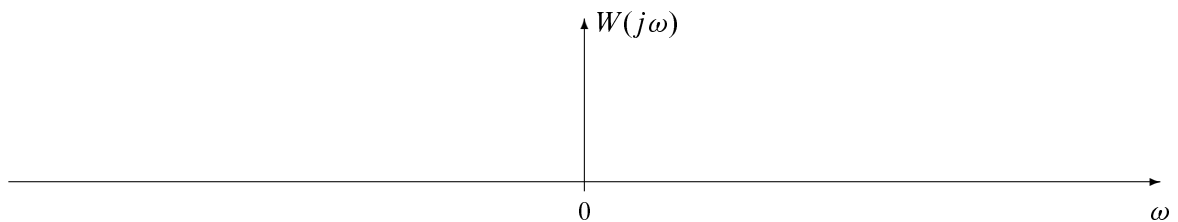
Suppose that the Fourier transform of $x(t)$ is

$$X(j\omega) = |\omega| \{u(\omega + 10) - u(\omega - 10)\}$$

- (a) Determine the Fourier transform, $V(j\omega)$, giving your answer as a plot. Sketch the magnitude of $V(j\omega)$, but label the sketch with the complex amplitude, i.e., keep track of the magnitude and phase.



- (b) Determine the Fourier transform, $W(j\omega)$, giving your answer as a plot. Sketch the magnitude of $W(j\omega)$, but label the sketch with the complex amplitude, i.e., keep track of the magnitude and phase.



- (c) Determine the phase φ_3 and the frequency ω_3 , so that the input signal can be recovered with an ideal LPF whose cutoff frequency is $\omega = 10$ rad/s and whose passband gain is 4. Recovery means that the output signal $y(t)$ would be equal to the input $x(t)$.

Note: There are two possible answer sets, but you only have to give one.