EE 20N Fall 2013 — Structure and Interpretation of Signals and Systems — Midterm 2

- You have 1 hours and 30 minutes.
- The exam is closed book, closed notes except a one-page cheat sheet.
- Write your answers ON THE EXAM ITSELF.
- Note that the test is out of 108 points, meaning that you have a slack of 8 points and can still get a 100 on the test even if you drop 8 points!

First name	
Last name	
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First and last name of student to your left	
First and last name of student to your right	

For staff use only:

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Q2.	I've Seen Better Phase	/12
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Q6.	They Only Differ by a T	/14
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Q8.	Extreme Makeover: Comb Edition	/17
	Total	/108

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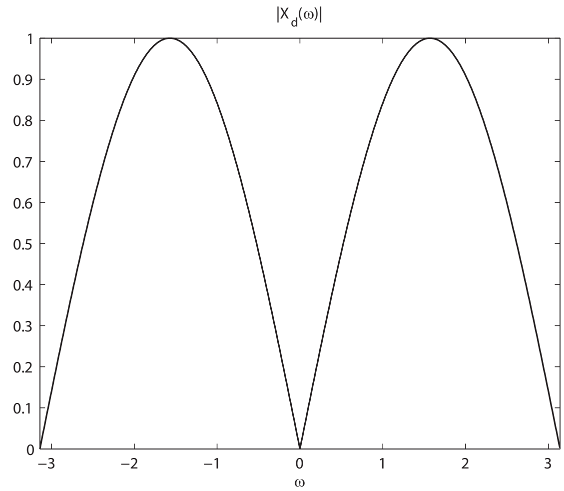
Q1. [14 pts] Warm-up

(a) [7 pts]

Below is a plot of $|X_d(\omega)|$ where $X_d(\omega)$ is the DTFT of $x[n]$. Bubble in all possible choices of $x[n]$. You must explain your answer to get credit.



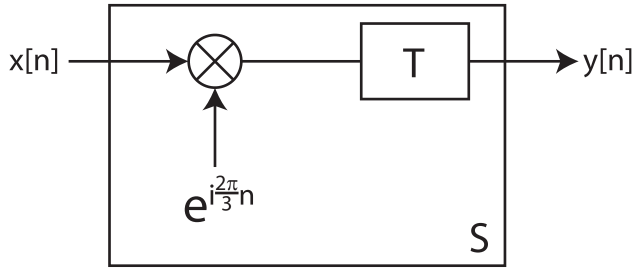
○ $\frac{1}{2}\delta[n-1] + \frac{1}{2}\delta[n+1]$ ○ $\frac{1}{2}\delta[n-1] - \frac{1}{2}\delta[n+1]$ ○ $\frac{1}{2}\delta[n+1] - \frac{1}{2}\delta[n-1]$ ○None of the given choices

(b) [7 pts] The unit-step response of a discrete time LTI system is

$$y_s[n] = u[n+1] - u[n-2].$$

Find and sketch the impulse response of the system.

Q2. [12 pts] I've Seen Better Phase



Shown above is a discrete time system S with input $x[n]$ and output $y[n]$. The LTI system T inside S is causal and has impulse response $h[n]$.

Are the following statements true of false? Explain.

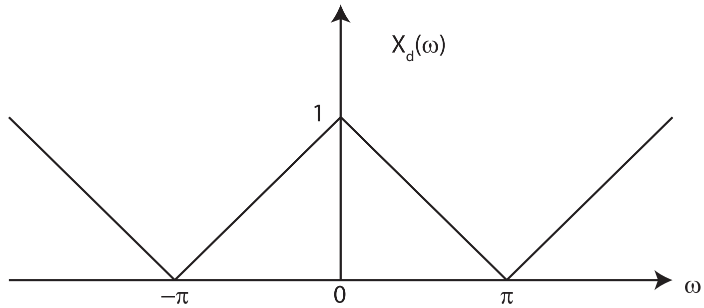
(a) [4 pts] S is causal.

(b) [4 pts] S is linear.

(c) [4 pts] S is time-invariant.

Q3. [14 pts] Proctor & Upsample

The DTFT $X_d(\omega)$ of a discrete time sequence $x[n]$ is shown below (assuming the phase, $\angle X_d(\omega) = 0 \ \forall \omega$):



Suppose

$$y[n] = \begin{cases} x[\frac{n}{4}] & \text{if } n \text{ is a multiple of 4} \\ 0 & \text{otherwise} \end{cases}$$

What is $Y_d(\omega)$, the DTFT of $y[n]$, in terms of $X_d(\omega)$? Find the expression and plot $Y_d(\omega)$.

Q4. [17 pts] Bob the Filter

Let a discrete time, LTI system be given by the following LCCDE:

$$y[n] - y[n-1] + \frac{1}{4}y[n-2] = x[n].$$

(a) [5 pts] Draw a block diagram of the LTI system with $x[n]$ as input and $y[n]$ as output.

(b) [8 pts] Find the frequency response of the system and plot the magnitude response. What kind of filter does your system represent?

(c) [4 pts] For $x[n] = (-1)^n$, find $y[n]$.

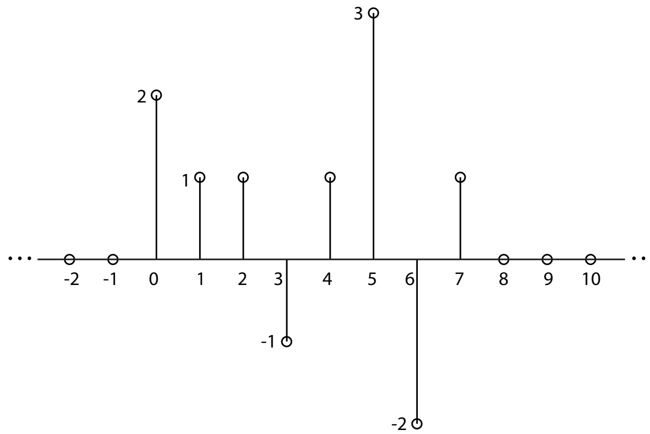
Q5. [10 pts] The Matrix: Evaluations

The 4-point DFT of $\underline{x} = \{a, b, c, d\}$ is $\underline{X} = \{A, B, C, D\}$.

(a) [5 pts] Write down the 4-point IDFT matrix that maps $\underline{X}$ to $\underline{x}$. Use complex notation in rectangular coordinates of the form $(r + is)$ for the entries.

(b) [5 pts] Suppose $A = 0$, $B = 0$,$C = 1$,$D = 0$. What are a, b, c, and d?

Q6. [14 pts] They Only Differ by a T



Given a discrete time sequence $x[n]$ shown above (note $x[n]$ is non-zero only for $0 \leq n \leq 7$):

- $X_d(\omega)$ is the DTFT of $x[n]$.
- Let $Y[k]$ for $k = 0, 1, \ldots, 7$ represent the samples of $X_d(\omega)|_{\omega=\frac{2\pi}{8}k}$
- Suppose $\{y[n]\}_{n=0}^{7}$ is the 8-point IDFT of $\{Y[k]\}_{k=0}^{7}$

(a) [6 pts] Find and sketch $y[n]$.

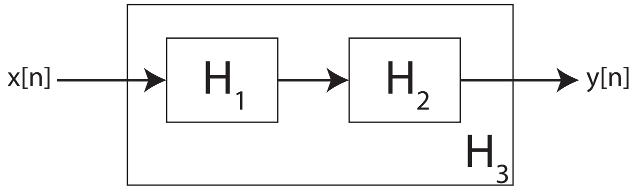
(b) [8 pts] Suppose $Z[k]$ for $k = 0, 1, \ldots, 15$ represent the samples of $X_d(\omega)|_{\omega = \frac{2\pi}{16}k}$, and $\{z[n]\}_{n=0}^{15}$ is the 16-point IDFT of $\{Z[k]\}_{k=0}^{15}$. Sketch $z[n]$.

Q7. [10 pts] Periodicity Makes the World Go 'Round

One period of a periodic discrete time signal $x[n]$ is given by $\{1, -1\}$. The signal is input to an LTI system having impulse response $h[n] = \{1, 2, 3\}$ to produce the output $y[n]$. Is $y[n]$ periodic? What is its period? Find $y[n]$.

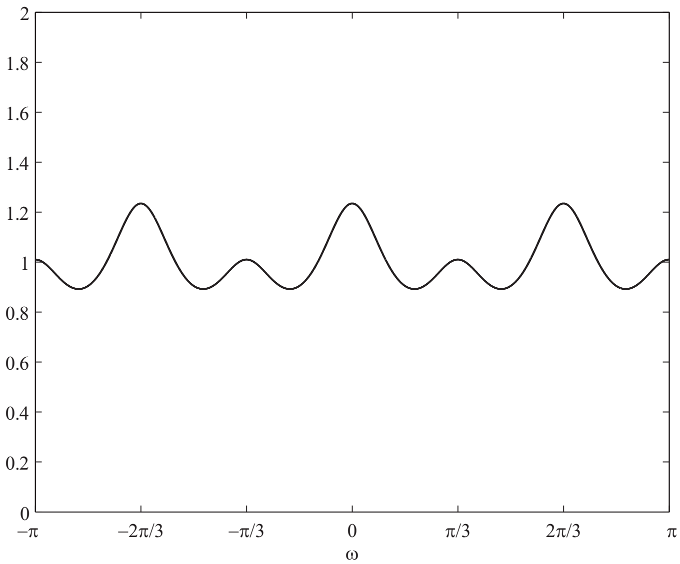
Q8. [17 pts] Extreme Makeover: Comb Edition

Consider the system H_3, produced by cascading two comb filters, as shown in the figure below.

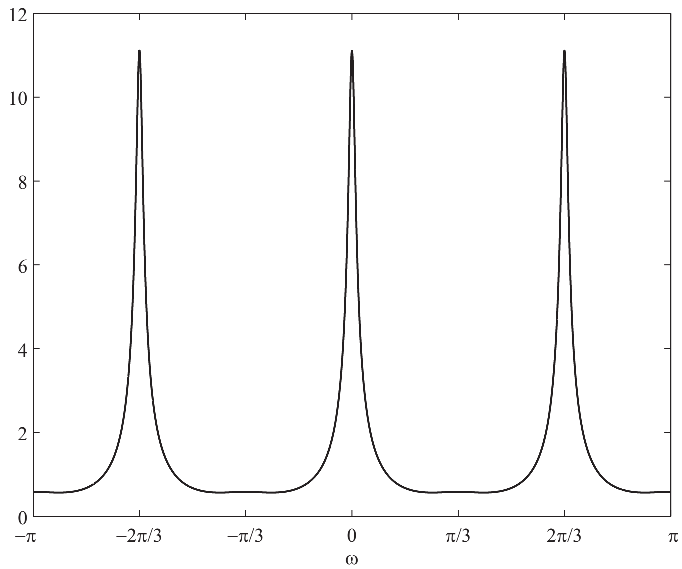


System H_1 has the LCCDE $y[n] = \alpha_1 y[n-3] + x[n]$. System H_2 has the LCCDE $y[n] = \alpha_2 y[n-6] + x[n]$.

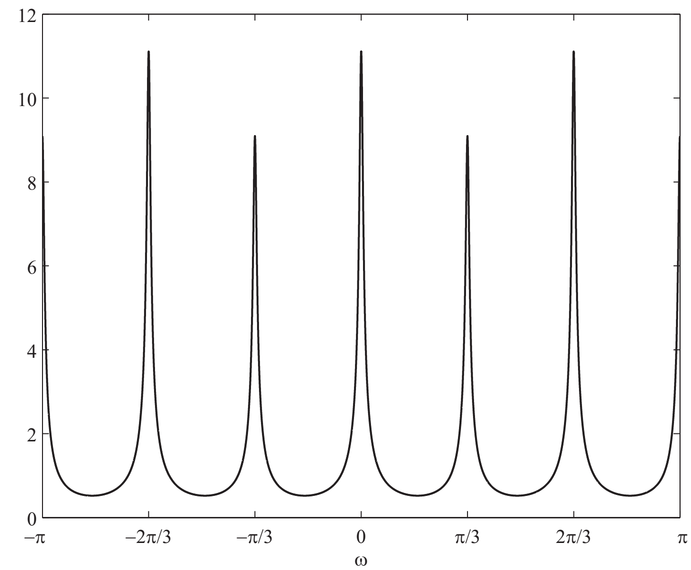
(a) [8 pts] The following are plots of $|H_3(\omega)|$ with different values of α_1 and α_2. Match the plots with the corresponding values for α_1 and α_2.



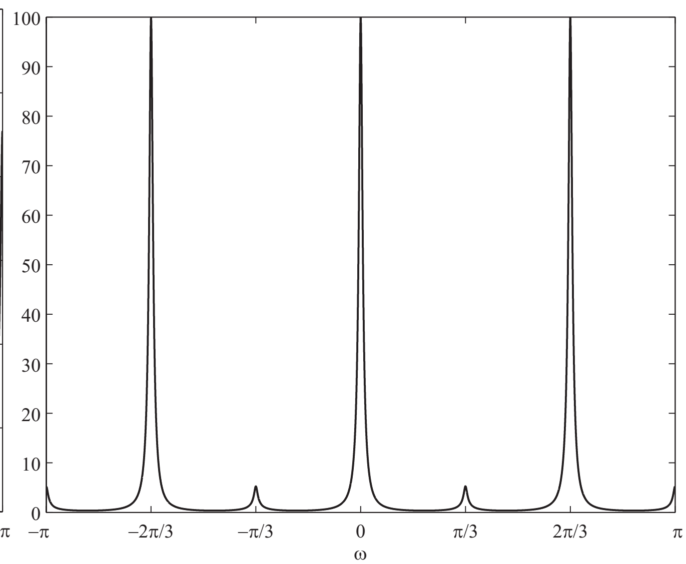
(a) ______



(b) ______



(c) ______



(d) ______

I. $\alpha_1 = 0.1, \alpha_2 = 0.1$ **II.** $\alpha_1 = 0.1, \alpha_2 = 0.9$ **III.** $\alpha_1 = 0.9, \alpha_2 = 0.1$ **IV.** $\alpha_1 = 0.9, \alpha_2 = 0.9$

(b) [9 pts] If you sample the continuous-time signal:

$$x(t) = \cos(8000\pi t) + e^{-20000i\pi t} + \sin(16000\pi t) + 16$$

with sampling frequency $f_s = 24kHz$, and input the sampled signal into the system H_3, with α_1 and α_2 such that $|H_3(\omega)|$ is as shown in plot (d) in the previous part, what will be, approximately, the output signal?

You need to show work to get credit.