EE 120: SIGNALS AND SYSTEMS, FALL 2015

Midterm 1, September 30, Wednesday, 4:10-6:00 pm

Name: _____

SID #: _____

Important Instructions:

Closed book. Two letter-size cheatsheets are allowed.

Show all your work. An answer without explanation is not acceptable and does not guarantee any credit.

Only the front pages will be scanned and graded. If you need more space, please ask for extra paper instead of using the back pages.

Do not remove pages, as this disrupts the scanning. Instead, cross the parts that you don't want us to grade.

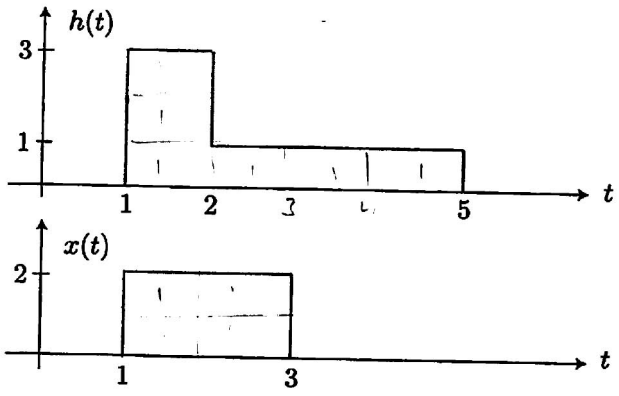
Problem	Points	Score
1	20	
2	20	
3	20	
4	20	
5	20	
Total	100	

1. Consider a LTI system with impulse response $h(t)$ depicted in the top plot below.

a) (5 points) Determine if this system is causal.

b) (5 points) Determine if this system is stable.

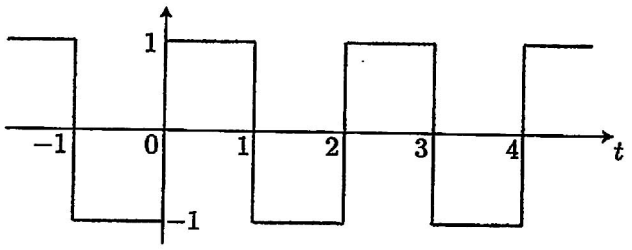
c) (10 points) Determine the output of the system when the input $x(t)$ is as depicted in the bottom plot.



Additional workspace for Problem 1

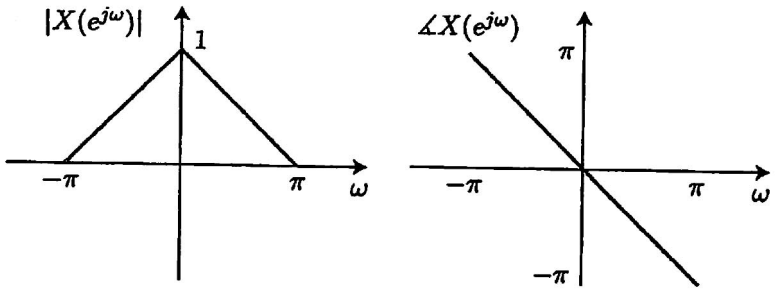
2. a) (10 points) Consider a general periodic signal $x(t)$ with period T and Fourier series coefficients a_k, $k = 0, \pm 1, \pm 2, \cdots$. Show that, if $x(t)$ has the additional property $x\left(t + \frac{T}{2}\right) = -x(t)$ for all t, then $a_k = 0$ when k is even.

b) (10 points) Find the Fourier series coefficients of the square wave below.



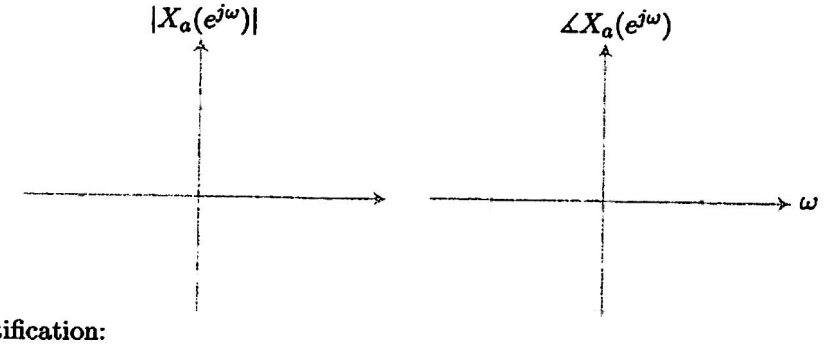
Additional workspace for Problem 2

3. Let $x[n]$ be a signal with DTFT $X(e^{j\omega})$ whose magnitude and phase are sketched below (only in the interval $[-\pi, \pi]$ because of periodicity).



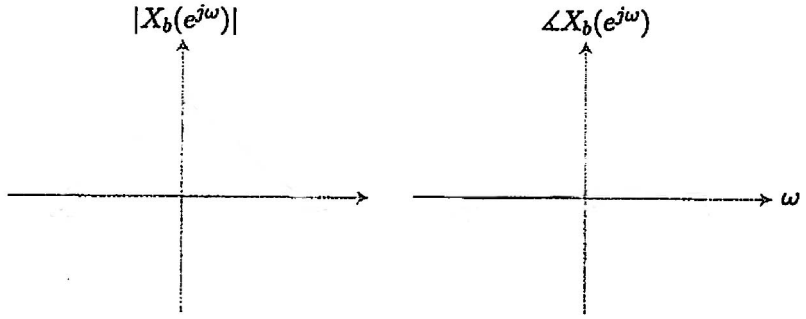
Plot the magnitude and phase for the DTFT of the following signals in the interval $[-\pi, \pi]$ and clearly label your plots. (Each part is worth 4 points.)

a) $x_a[n] = x[-n]$



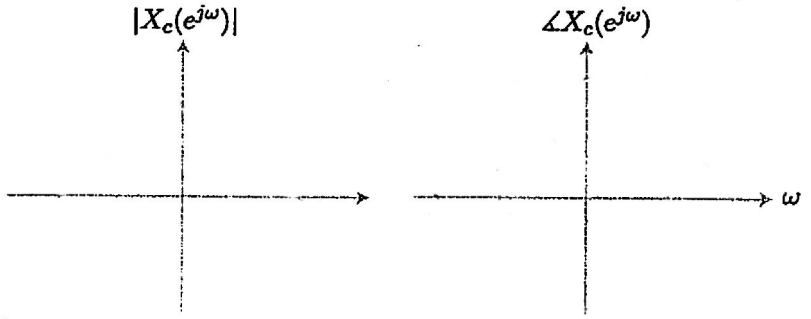
Justification:

b) $x_b[n] = x[n+1]$



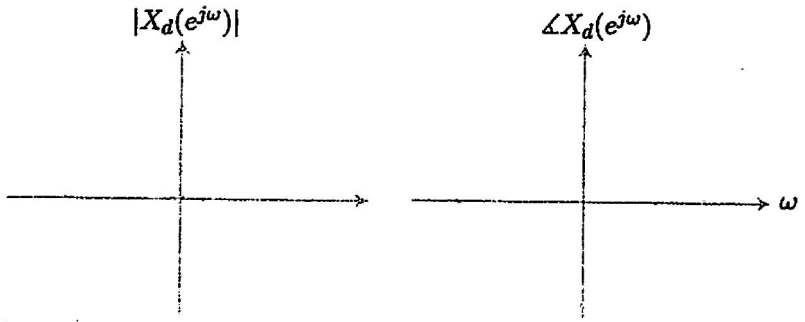
Justification:

c) $x_c[n] = x[n-1]$



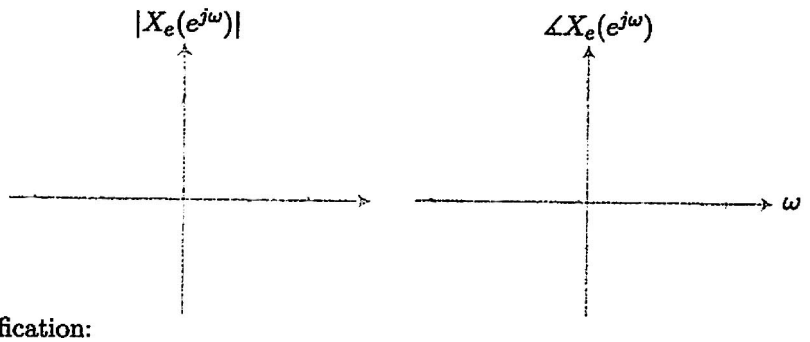
Justification:

d) $x_d[n] = (-1)^n x[n]$



Justification:

e) $x_e[n] = \begin{cases} x[n/2] & \text{if } n = 0, \mp 2, \mp 4, \ldots \\ 0 & \text{otherwise.} \end{cases}$



Justification:

4. Consider the causal 8th order FIR filter:

$$y[n] = b_0 x[n] + b_1 x[n-1] + \cdots + b_8 x[n-8].$$

a) (6 points) What constraint must the coefficients $b_0, b_1, \cdots, b_8$ satisfy so that the DC gain of the filter is one?

b) (7 points) Show that, if $b_k = b_{8-k}$ for $k = 0, 1, 2, 3$, then the filter is generalized linear phase.

c) (7 points) Find the coefficients $b_0, b_1, \cdots, b_8$ obtained with a rectangular window from an ideal low pass filter with cutoff frequency 0.4π.

Additional workspace for Problem 4

5. Consider a LTI system with frequency response:

$$H(e^{j\omega}) = \frac{e^{-j\omega} - 0.6}{1 - 0.6e^{-j\omega}}.$$

a) (5 points) Determine and plot the magnitude $|H(e^{j\omega})|$ as a function of ω.

b) (10 points) Determine the output $y[n]$ for the input:

$$x[n] = \cos\left(\frac{\pi}{3}n\right) + \cos(\pi n).$$

c) (5 points) Write a difference equation representation of this system.

Additional workspace for Problem 5.