EE 120 SIGNALS AND SYSTEMS, Spring 2013

Midterm # 1, March 4, Monday, 2:10-3:50 pm

Name ____________________

Closed book. Two letter-size cheatsheets are allowed. Show all your work. Credit will be given for partial answers.

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

1. (20 points) Consider a LTI system defined by the difference equation:

$$y[n] = -x[n] + 2x[n-1] - x[n-2].$$

a) (5 points) Determine the impulse response of this system.

b) (5 points) Determine if this system is causal and/or stable.

c) (5 points) Determine the frequency response $H(e^{j\omega})$ and its magnitude $|H(e^{j\omega})|$. Sketch $|H(e^{j\omega})|$ as a function of ω and determine the type of filter (lowpass, highpass, bandpass or bandstop) that this LTI system is.

d) (5 points) Determine the response $y[n]$ when the input is $x[n] = 1+(-1)^n$. Your answer should be of the form $y[n] = a + b(-1)^n$ where a and b are to be determined.

Additional workspace for Problem 1

2. (20 points) Consider a periodic signal $x(t)$ with period $T = 4$, described by:

$$x(t) = \begin{cases} \cos(0.5\pi t) & -1 \leq t \leq 1 \\ 0 & 1 \leq t \leq 3. \end{cases}$$

a) (5 points) Sketch $x(t)$ as a function of t.

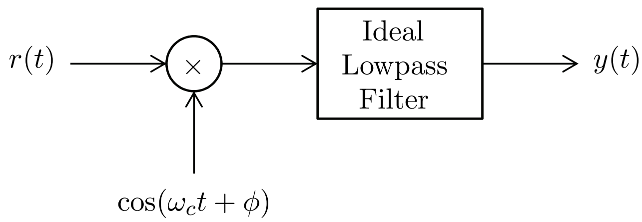
b) (15 points) Find the Fourier series coefficients of $x(t)$.

Additional workspace for Problem 2

3. (20 points) Let $s(t)$ be a real-valued signal for which $S(j\omega) = 0$ when $|\omega| > \omega_c$. Amplitude modulation is performed to produce the signal:

$$r(t) = s(t)\cos(\omega_c t)$$

and the demodulation scheme below is applied to $r(t)$ at the receiver. The constant ϕ represents a phase error that arises when the modulator and demodulator are not synchronized. Determine $y(t)$ assuming that the ideal lowpass filter has a cutoff frequency of ω_c and a passband gain of 2. Your answer should depend only on $s(t)$ and ϕ.



Additional workspace for Problem 3.

4. (20 points) Consider an LTI system with frequency response:

$$H(e^{j\omega}) = \frac{1 - 1.25e^{-j\omega}}{1 - 0.8e^{-j\omega}}.$$

a) (5 points) Write a difference equation that is satisfied by the input $x[n]$ and output $y[n]$.

b) (5 points) Draw a block diagram implementing this system with only one delay block.

c) (10 points) Determine the impulse response $h[n]$.

Additional workspace for Problem 4.

5. (20 points) Recall that any discrete-time signal $h[n]$ can be decomposed as:

$$h[n] = h_e[n] + h_o[n]$$

where $h_e[n]$ is even-symmetric: $h_e[-n] = h_e[n]$, and $h_o[n]$ is odd-symmetric: $h_o[-n] = -h_o[n]$.

a) (10 points) Assuming $h[n]$ is real, show that the Fourier Transform of $h_e[n]$ is $Re\{H(e^{j\omega})\}$, and the Fourier Transform of $h_o[n]$ is $j\,Im\{H(e^{j\omega})\}$.

b) (10 points) Let $h[n]$ be a real-valued impulse response for a <u>causal</u>, discrete-time LTI system. Show that the knowledge of $Re\{H(e^{j\omega})\}$ is enough to completely determine $h[n]$.

Additional workspace for Problem 5.