New Mexico State University
Klipsch School of Electrical Engineering

EE312 - Signals and Systems I
Spring 2015
Final Exam

Name: ____________________

Solve problems 1–3 and two from problems 4 – 6.
Circle below which two of problems 4 – 6 you wish to be graded.

Prob. 1	/ 20 points
Prob. 2	/ 20 points
Prob. 3	/ 20 points
Prob. 4	/ 20 points
Prob. 5	/ 20 points
Prob. 6	/ 20 points
Total	/ 100 points

Prob. 1

An input signal, $x[n]$ is fed into a causal, stable, linear, time-invariant (LTI) system and we observe the output signal, $y[n]$ where

$$x[n] = \left(-\frac{1}{2}\right)^n u[n] + \left(-\frac{1}{8}\right)\left(-\frac{1}{2}\right)^{n-1} u[n-1]$$

and

$$y[n] = 2\left(\frac{1}{4}\right)^n u[n] - \left(\frac{1}{4}\right)\left(\frac{1}{4}\right)^{n-1} u[n-1].$$

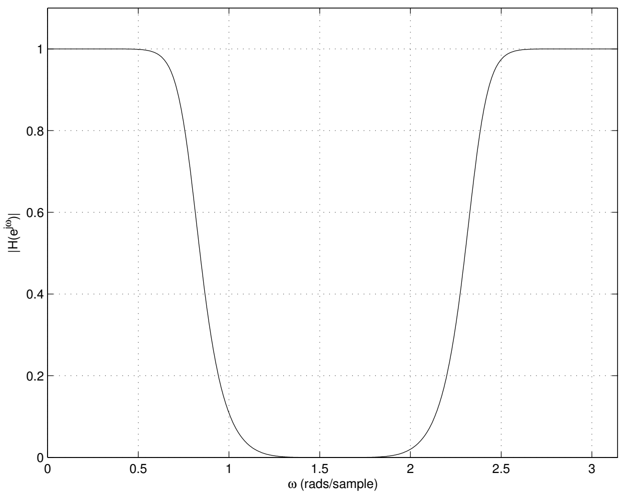
(a) Determine the frequency response of the system, $H(e^{j\omega})$.

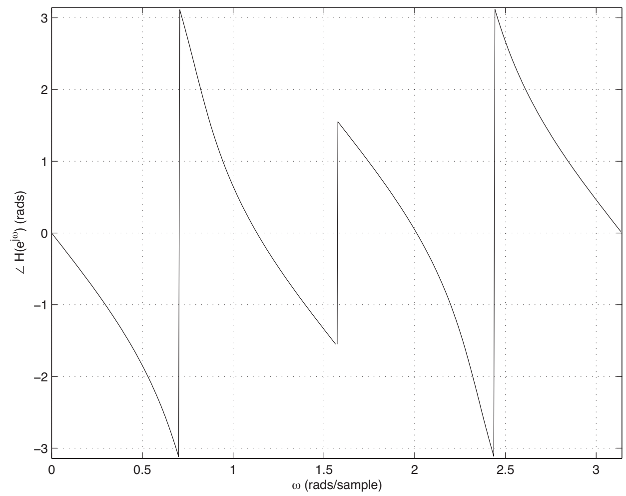
Hints: (1) The input frequency spectrum is given by $X(e^{j\omega}) = \dfrac{1 - \frac{1}{8}e^{-j\omega}}{1 + \frac{1}{2}e^{-j\omega}}$ and (2) because of cancellation, the system is a first-order system.

(b) Use your result in (a) to determine the impulse response of the system, $h[n]$.

Prob. 2

A DT system with real-valued impulse response $h[n]$, has the following magnitude and phase responses. Note that since $h[n] \in \mathbb{R}$, $|H(e^{j\omega})| = |H(e^{-j\omega})|$ and $\angle H(e^{j\omega}) = -\angle H(e^{-j\omega})$.





(a) From the graphs, fill in the table below. Express the frequency response in polar form, i.e. $H(e^{j\omega}) = |H(e^{j\omega})|e^{j\angle H(e^{j\omega})}$.

ω	$\|H(e^{j\omega})\|$	$\angle H(e^{j\omega})$	$H(e^{j\omega})$
$\pi/8 \approx 0.4$			
$\pi/4 \approx 0.8$			
$\pi/2 \approx 1.6$			
$\pi \approx 3.1$			

Prob. 2 (cont.)

(b) Suppose the input signal to the system is given by

$$x[n] = 3.12e^{j\pi n/8} + 11.2e^{j\pi n}.$$

Use your values in (a) and *eigenfunction* theory to determine the output signal, $y[n]$.

(c) Suppose the input signal to the system is given by

$$x[n] = 3.58\cos(\pi n/4) + 13.21\sin(\pi n/2).$$

Use your values in (a) and *eigenfunction* theory to determine the output signal, $y[n]$.

(d) Suppose the input signal to the system is given by

$$x[n] = e^{j7\pi n/4} + e^{j33\pi n/8}.$$

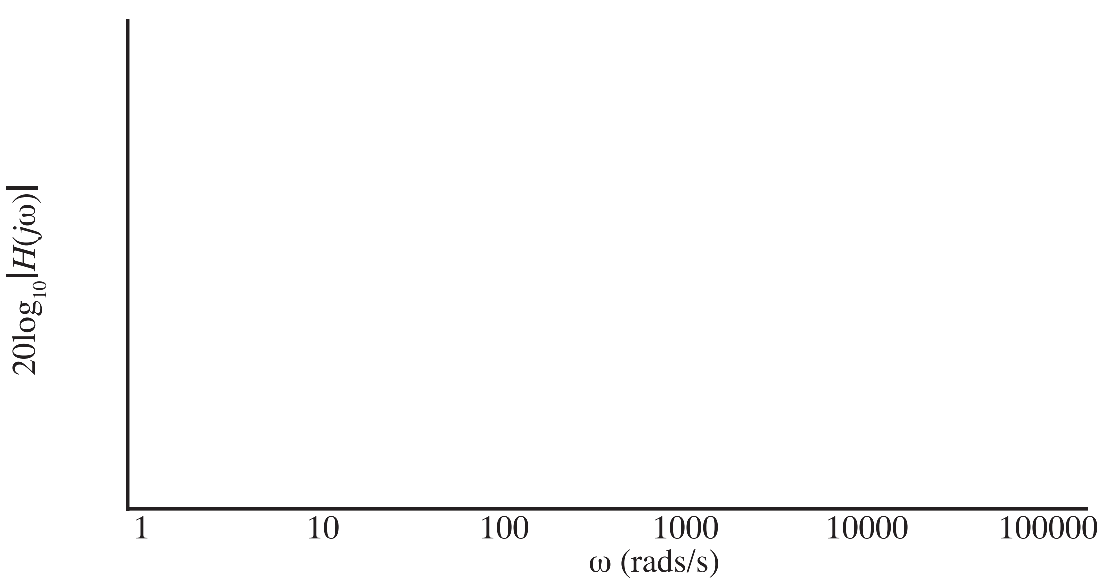
Use your values in (a) and *eigenfunction* theory to determine the output signal, $y[n]$.

Prob. 3

The frequency response of a causal, LTI system is given as

$$H(j\omega) = \frac{1}{(20 + j\omega)(2000 + j\omega)} = \frac{1}{40000 + 2020j\omega + (j\omega)^2}. \tag{3.1}$$

(a) Graph the straight-line approximation of the Bode plot (magnitude response only).



Prob. 3 (cont.)

(b) Determine the linear, constant-coefficient differential equation (LCCDE) of the system.

(c) Draw a block diagram of the system using differentiators and not integrators.

(d) Determine the impulse response, $h(t)$ of the system.

Prob. 4

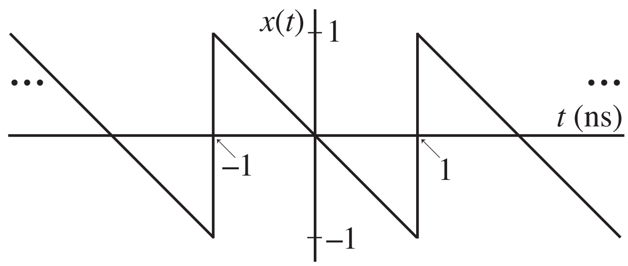
Let $x[n] = u[n] - u[n-10]$ and $h[n] = 2^n u[n]$. Determine $y[n] = h[n] * x[n]$.
Express your answer in a closed-form and not with summations, integrals, or a list of numbers.

Is the system causal (YES / NO)? Why?

Is the system BIBO stable (YES / NO)? Why?

Prob. 5

A periodic signal, $x(t)$ is shown below.



Determine the Fourier Series (FS) coefficients, a_k.

Note: 1 ns equals 10^{-9} s.

Hint: This integral may be useful $\int te^{at}dt = \frac{te^{at}}{a} - \frac{e^{at}}{a^2}$

Prob. 6

For parts (a) – (c), you may wish to use Tables 4.1 (p. 328) and 4.2 (p. 329).

(a) Determine the total energy, E_∞ of the signal,

$$x(t) = \frac{\sin t}{\pi t}.$$

(b) Compute the inverse Fourier Transform of

$$X(j\omega) = \frac{1 + e^{-j10\omega}}{(10 + j\omega)^2}.$$

Prob. 6 (cont.)

(c) Compute the Fourier Transform of

$$x(t) = 2 + \cos(100t) + \sin(100t)$$