The University of Texas at Austin
Dept. of Electrical and Computer Engineering
Midterm #2

Date: April 8, 2009 Course: EE 313 Evans

Name: ____
Last, First

- The exam is scheduled to last 50 minutes.
- Open books and open notes. You may refer to your homework assignments and the homework solution sets.
- Calculators are allowed.
- You may use any standalone computer system, i.e. one that is not connected to a network. ***Please disable all wireless connections on your computer system.***
- Please turn off all cell phones, pagers, and personal digital assistants (PDAs).
- All work should be performed on the quiz itself. If more space is needed, then use the backs of the pages.
- **Fully justify your answers.**

Problem	Point Value	Your score	Topic
1	20		Difference Equation
2	20		Discrete-Time Convolution
3	40		Transfer Functions
4	20		Potpourri
Total	100		

Problem 2.1 Difference Equation. *20 points*.

A causal discrete-time linear time-invariant filter with input $x[n]$ and output $y[n]$ is governed by the following difference equation

$$y[n] = a\, y[n-1] + x[n-1]$$

where $|a| < 1$.

(a) Draw the block diagram for this filter. *4 points*.

(b) What are the initial conditions? What values should they be assigned and why? *4 points*.

(c) What is (are) the values of the characteristic root(s)? *4 points*.

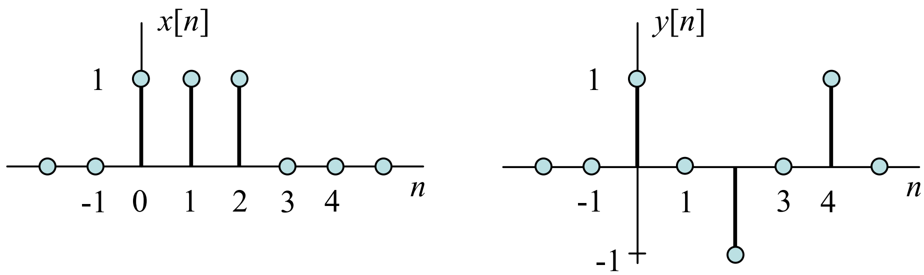
(d) Is the system bounded-input bounded-output stable? Why or why not? *4 points*.

(e) Let the input $x[n] = \delta[n]$. Compute $y[0]$, $y[1]$ and $y[2]$. Infer a formula for the impulse response. *4 points*.

Problem 2.2 Discrete-Time Convolution. *20 points*.

(a) In discrete time, convolve the unit step function $u[n]$ and the function $\delta[n] - \delta[n\text{-}N]$, where $\delta[n]$ is the Kronecker impulse and N is a positive integer. *10 points.*

(b) Consider a discrete-time linear time-invariant system. For input $x[n]$ given below, the system gives output $y[n]$ below. What is the impulse response of the system? *10 points.*



Problem 2.3 Transfer Functions. *40 points*.

A causal linear time-invariant (LTI) continuous-time system has the following transfer function in the Laplace transform domain:

$$H(s) = \frac{s}{s+1}$$

(a) Find the corresponding differential equation using $x(t)$ to denote the input signal and $y(t)$ to denote the output signal. Give the minimum number of initial conditions, and their values. *8 points*.

(b) Give the pole location(s) and the region of convergence. *8 points.*

(c) Compute the impulse response by taking the inverse Laplace transform of $H(s)$. *8 points*.

(d) Give a formula for the frequency response. *8 points*.

(e) Plot the magnitude of the frequency response and describe the system's frequency selectivity (lowpass, highpass, bandpass, or bandstop). *8 points*.

Problem 2.4 Potpourri. 20 points.

(a) *Either prove the following statement to be true, or give a counterexample to show that the following statement is false*: The convolution of two continuous-time signals $x(t)$ and $y(t)$ may always be computed by taking the Laplace transforms of $x(t)$ and $y(t)$, multiplying the Laplace transforms, and applying the inverse Laplace transform to the result.. *5 points*.

(b) Consider wanting to map a transfer function in the Laplace domain into an implementation. The transfer function is a ratio of two polynomials. When would you recommend using a parallel implementation over a cascaded implementation? *5 points.*

(c) Give one application that uses a differentiator in continuous time and give one application that uses a differentiator in discrete time. *5 points.*

(d) *Either prove the following statement to be true, or give a counterexample to show that the following statement is false*: Given a system governed by a linear constant-coefficient differential equation, the zero-state solution is always bounded-input bounded-output unstable if the zero-input solution is unstable. *5 points*.