The University of Texas at Austin
Dept. of Electrical and Computer Engineering
Midterm #1

Date: October 6, 2005 Course: EE 313 Evans

Name: ____
Last, First

- The exam is scheduled to last 75 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.
- 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 unless instructed otherwise.**

Problem	Point Value	Your score	Topic
1	20		Differential Equation
2	20		Stability
3	24		Tapped Delay Line
4	24		Continuous-Time System Responses
5	12		Potpourri
Total	100		

Problem 1.1 Differential Equation. 20 points.

For a continuous-time system with input $x(t)$ and output $y(t)$ governed by the differential equation

$$\frac{d^2}{dt^2}y(t)+4\frac{d}{dt}y(t)+3y(t)=x(t)$$

for $t \geq 0^+$.

(a) What are the characteristic roots of the differential equation? 4 points.

(b) Find the zero-input response assuming non-zero initial conditions. Please leave your answer in terms of C_1 and C_2. 8 points.

(c) Find the zero-input response for the initial conditions $y(0^+) = -4$ and $y'(0^+) = 0$. 8 points.

Problem 1.2 Stability. 20 points.

In this problem, the input signal is denoted by $x(t)$ and the output signal is denoted by the output signal $y(t)$.

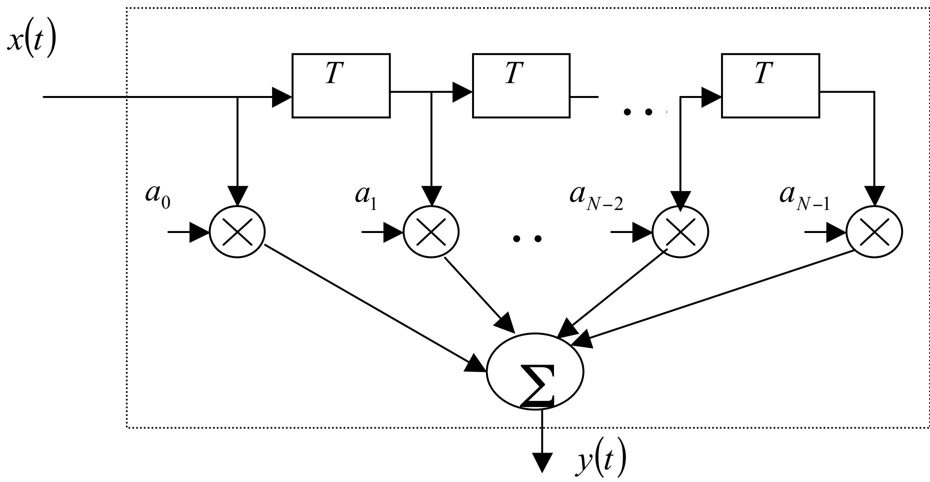
(a) Is the system defined by $\frac{d^2}{dt^2} y(t) + 4\frac{d}{dt} y(t) + 3y(t) = x(t)$ asymptotically stable, marginally stable, or unstable? Why? 8 points.

(b) Let K be a real-value constant. For what values of K is the following system asymptotically stable? $\frac{d^2}{dt^2} y(t) - K\frac{d}{dt} y(t) - (K+1)y(t) = x(t)$. Why? 8 points.

(c) *Either prove the following statement to be true, or give a counterexample to show that the following statement is false*: The output of an LTI system in resonance is always unstable. 4 points

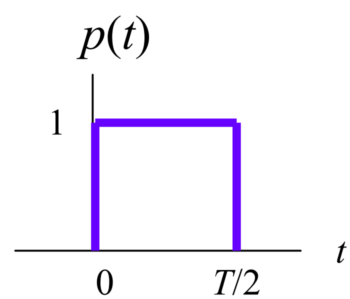
Problem 1.3 Tapped Delay Line. 24 points.

A linear time-invariant (LTI) continuous-time tapped delay line with input $x(t)$, output $y(t)$, and N-1 delay elements is shown below as a block diagram (from slide 2-4):



(a) Plot by hand the impulse response $h(t)$. 4 points.

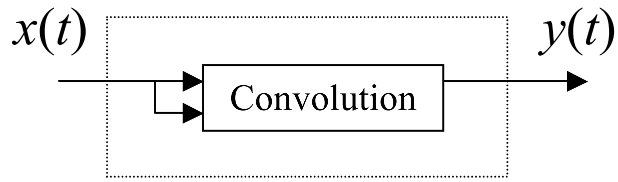
(b) Plot by hand the output $y(t)$ when the input $x(t)$ is the pulse $p(t)$ shown on the right. 10 points.



(c) Plot by hand the output $y(t)$ when the input $x(t)$ is $\sin\left(\frac{2\pi}{T}t\right)u(t)$. 10 points.

Problem 1.4 Continuous-Time System Properties. 24 points.

Consider the continuous-time system with input $x(t)$ and output $y(t)$ that is shown on the right. The input-output relationship is



$$y(t) = x(t) * x(t)$$

where * means the convolution operation.

(a) Prove that the system has the linearity property, or give a counterexample that shows that the system does not have the linearity property. 12 points.

(b) Prove that the system has the time-invariant property, or give a counterexample that shows that the system does not have the time-invariant property. 12 points.

Problem 1.5 Potpourri. 12 points.

(a) *Either prove the following statement to be true, or give a counterexample to show that the following statement is false*: The continuous-time convolution of two finite duration signals always produces a finite duration result that is longer than either of the signals being convolved. 4 points.

(b) Give one signal processing or communication system that uses each of the following subsystems and describe the role that the subsystem plays in the function of the overall system:

i. Sinusoidal signal generator. 4 points.

ii. Integrator. 4 points.