ECE-205
Exam 3
Fall 2013

Calculators and computers are not allowed. You must show your work to receive credit.

Problem 1 __________/20
Problem 2 __________/15
Problem 3 __________/15
Problem 4 __________/15
Problems 5 ________/14
Problems 6-12 ________/21

Total _______________
1) (20 points) For the following transfer functions, determine both

- the impulse response
- the unit step response

Do not forget any necessary unit step functions.

a) \( H(s) = \frac{4}{s^2 + 4s + 8} \)

b) \( H(s) = \frac{se^{-s}}{(s + 1)^2} \)
2) **(15 points)** Consider the following simple feedback control block diagram. The plant, the thing we want to control, has the transfer function $G_p(s) = \frac{3}{s + 5}$

![Block Diagram]

a) Determine the settling time of the plant alone (assuming there is no feedback)

b) Determine the steady state error for plant alone assuming the input is a unit step (simplify your answer as much as possible)

c) For a proportional controller, $G_c(s) = k_p$, determine the closed loop transfer function $G_o(s)$

d) Determine the settling time of the closed loop system, in terms of $k_p$

e) Determine the steady state error of the closed loop system for a unit step, in terms of $k_p$ (simplify your answer as much as possible)

f) For an integral controller, $G_i(s) = k_i$, determine the closed loop transfer function $G_o(s)$ and the steady state error for a unit step in terms of $k_i$
3) **(15 points)** For the following circuit

- Determine the ZIR
- Determine the ZSR
- Determine the transfer function
4) **(15 Points)** Determine the transfer function for the following circuit.
5) (15 points) Consider a linear time invariant system with impulse response given by

\[ h(t) = e^{-(t+1)}u(t+1) \]

The input to the system is given by

\[ x(t) = e^{-t}[u(t) - u(t-1)] + 2u(t-2) \]

Using **graphical evaluation**, determine the output \( y(t) \). Specifically, you must

- Flip and slide \( h(t) \), NOT \( x(t) \)
- Show graphs displaying both \( h(t - \lambda) \) and \( x(\lambda) \) for each region of interest
- Determine the range of \( t \) for which each part of your solution is valid
- Set up any necessary integrals to compute \( y(t) \). Your integrals must be complete, in that they cannot contain the symbols \( x(\lambda) \) or \( h(t - \lambda) \) but must contain the actual functions.
- Your integrals cannot contain any unit step functions
- **DO NOT EVALUATE THE INTEGRALS!!**
Problems 6 and 7 refer to the impulse responses of six different systems given below:

\[ h_1(t) = [1 + e^{-t}]u(t) \]
\[ h_2(t) = e^{-2t}u(t) \]
\[ h_3(t) = [2 + \sin(t)]u(t) \]
\[ h_4(t) = [1 - t^3 e^{-0.1t}]u(t) \]
\[ h_5(t) = [t \sin(t) + e^{-t}]u(t) \]
\[ h_6(t) = [te^{-t} \cos(5t) + e^{-2t} \sin(3t)]u(t) \]

6) The number of (asymptotically) **marginally stable systems** is a) 0 b) 1 c) 2 d) 3

7) The number of (asymptotically) **unstable systems** is a) 0 b) 1 c) 2 d) 3

8) Which of the following transfer functions represents a (asymptotically) **stable** system?

\[
G_a(s) = \frac{s-1}{s+1} \quad G_b(s) = \frac{1}{s(s+1)} \quad G_c(s) = \frac{s}{s^2-1} \\
G_d(s) = \frac{s+1}{(s+1+j)(s+1-j)} \quad G_e(s) = \frac{(s-1-j)(s-1+j)}{s} \quad G_f(s) = \frac{(s-1-j)(s-1+j)}{(s+1-j)(s+1+j)}
\]

a) all but \( G_c \)  
 b) only \( G_a, G_b, \) and \( G_d \)  
 c) only \( G_a, G_d, \) and \( G_f \)  
 d) only \( G_d \) and \( G_f \)  
 e) only \( G_a \) and \( G_d \)
For problems 9-12, consider the signal flow graph representation of the following block diagram.

9) How many paths are there?  a) 0  b) 1  c) 2  d) 3  e) 4

10) How many loops are there? a) 0  b) 1  c) 2  d) 3  e) 4

11) The determinant ($\Delta$) is  a) 1  b) $1 - H_2H_3H_4$  c) $1 + H_2H_3H_4$  d) none of these

12) The transfer function is  a) 1  b) $\frac{H_3H_5 + H_1H_2H_3}{1 + H_2H_3H_4}$  c) $\frac{H_3H_5 + H_1H_2H_3}{1 - H_2H_3H_4}$