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 _______/20
Problems 5 _______/30

Total ____________
1) (20 points) For the following transfer functions, determine the *unit step response* of the system. *Do not forget any necessary unit step functions.*

a) \( H(s) = \frac{e^{-2s}}{s} \)

b) \( H(s) = \frac{1}{(s+1)^2} \)

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

![Control System 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)

c) For a proportional controller, $G_c(s) = k_p$, determine the closed loop transfer function $G_0(s)$

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)

f) For an integral controller, $G_c(s) = \frac{k_i}{s}$, determine the closed loop transfer function $G_0(s)$ and the steady state error for a unit step in terms of $k_i$
3) (15 points) For the following block diagram

For the following interconnected systems,

i) determine the overall impulse response (the impulse response between input $x(t)$ and output $y(t)$) and

ii) determine if the system is causal.

![Block diagram]

a) $h_1(t) = \delta(t - 2), \, h_2(t) = \delta(t + 1)$

b) $h_1(t) = u(t + 1), \, h_2(t) = u(t - 2) + \delta(t - 2)$

Series Connections:

Parallel Connections:
4) (20 points) Consider a linear time invariant system with impulse response given by

\[ h(t) = t^2[u(t+1) - u(t-2)] \]

The input to the system is given by

\[ x(t) = [u(t) - u(t-1)] + [u(t-2) - u(t-4)] \]

The impulse response and input are shown below:

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!!**
5) (30 points) The following figure shows three different circuits, which are subsystems for a larger system. We can write the transfer functions for these systems as

\[
G_a(s) = \frac{-K_{\text{low}} \omega_{\text{low}}}{s + \omega_{\text{low}}} \quad G_b(s) = \frac{-K_{\text{high}} s}{s + \omega_{\text{high}}} \quad G_c(s) = -K_{ap}
\]

Determine the parameters \(K_{\text{low}}, \omega_{\text{low}}, K_{\text{high}}, \omega_{\text{high}},\) and \(K_{ap}\) in terms of the parameters given (the resistors and capacitors).