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

Problem 1 _________/20
Problem 2 _________/20
Problem 3 _________/20
Problem 4 _________/20
Problem 5 _________/20

Total ______________
1) (20 points) For the following impulse responses and system inputs, determine the system output using Laplace transforms.

a) \( h(t) = e^{-2(t-1)}u(t-1), \ x(t) = u(t-2) - u(t-4) \)

b) \( h(t) = te^{-3t}u(t), \ x(t) = u(t) \)

*Do not forget any necessary unit step functions.*
2) (20 points) Consider the following simple feedback control block diagram. The plant, the thing we want to control, has the transfer function \( G_p(s) = \frac{2}{s + 3} \) and the controller is a proportional controller, so \( G_c(s) = k_p \).

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

b) Determine the closed loop transfer function, \( G_c(s) \).

c) Determine the value of \( k_p \) so the settling time of the system is \( \frac{4}{25} \) seconds.

d) Determine the value of \( k_p \) so the steady state error of the system for a unit step is \( \frac{3}{23} \).
3) **(20 points)** For the following circuit, determine the transfer function and the corresponding impulse response.
4) (20 points) For the following circuit, determine and expression for the output $V_{out}(s)$ in terms of the ZSR and ZIR. Do not assume the initial conditions are zero. Also determine the system transfer function.

![Circuit Diagram]

$V_{in}(t)$

$R$

$L$

$v_{out}(t)$
5) (20 points) Consider the following closed loop system, with plant $G_p(s)$ and controller $G_c(s)$.

One way to choose the controller is to try and make your closed loop system match a transfer function that you choose (hence the name model matching). Let’s assume that our desired closed loop transfer function $G_o(s)$, our plant can be written in terms of numerators and denominators as $G_p(s) = \frac{N_p(s)}{D_p(s)}$.

Determine an expression for the required controller $G_c(s)$ in terms of $N_p(s), D_p(s), N_o(s), D_o(s)$. For full credit you must simplify your answers as much as possible.
Name _____________________________________________  Mailbox __________________