1. The impulse responses of several linear systems are given below. For each case determine if the impulse response represents a stable or an unstable system. Please give your reasons for each case. (10%)

(a) $C(t) = e^{-t}$, (b) $C(t) = te^{-2t}$, (c) $C(t) = 1$, (d) $C(t) = e^{-t} \sin 4t$, (e) $C(t) = \sin 4t$.

2. Find the transfer function, $G(s) = X(s)/F(s)$, for the translational mechanical system shown below. $K$, $f_s$, $M$ and $f(t)$ are spring constant, coefficient of viscous friction, mass, and external force, respectively. (10%)

3. Given the unity feedback system shown below with

$$G(s) = \frac{K(s-1)(s-2)}{(s+2)(s^2+2s+2)}$$

Find the following:
(a) The range of $K$ that keeps the system stable. (5%)
(b) The value of $K$ that makes the system oscillate. (3%)
(c) The frequency of oscillation when $K$ is set to the value that makes the system oscillate. (2%)

4. Solve for $x(t)$ in the system shown below, i.e., $f(t)$ is a unit step. $K_s$, $f_s$, $M$, and $f(t)$ are spring constant, coefficient of viscous friction, mass, and external force, respectively. (10%)

$M = 1 \text{ kg}$
$K_s = 5 \text{ N/m}$
$f_s = 1 \text{ N-s/m}$
$f(t) = 1 \text{ N}$
5. For each of the unit step responses shown below, find the transfer function of the system. (5% for each) (15%)

(a)

(b)

(c)
6. For the following response functions, determine if pole-zero cancellation can be approximated. If it can, find percent overshoot, settling time, rise time, and peak time. (5% for each) (15%)
   
   (a) \[ C(s) = \frac{(s + 3)}{s(s + 2)(s^2 + 3s + 10)} \]
   
   (b) \[ C(s) = \frac{(s + 2.5)}{s(s + 2)(s^2 + 4s + 20)} \]
   
   (c) \[ C(s) = \frac{(s + 2.1)}{s(s + 2)(s^2 + s + 5)} \]

7. Shows the root loci of the equation
   
   \[ s(s + 4)(s^2 + 4s + 20) + K = 0 \]
   \[ K > 0 \]
   
   (15%)

8. For the system shown below:

   ![System Diagram]

   Find the steady state error for (a) a unit step input, (b) a unit ramp input, (c) a unit parabolic input. (5% for each) (15%)