1. Find $x(t)$ for the following using:
   (a) the Laplace transform method
   (b) the trial-solution method

   
   
   $2\ddot{x} + 6x = 0$

   where $x(0) = 1$ and $\dot{x}(0) = 2$

2. Derive the equations of motion for the system below. Generate the simulink block diagram.

3. Presuming a model given by

   
   $10\dddot{x} + \dot{x}(1 - y^2) + 3x - 2y = f(t)$  \hspace{1cm} (1)
   
   $\ddot{y} + 3\dot{y} + 3y - 2x = 0$  \hspace{1cm} (2)

   with a nominal force of $f(t) = 10u(t - 3)$, generate the simulink simulation for the system with results for the first 10 seconds.

4. The parameter values of a certain armature-controlled motor are $K_T = K_b = 0.2 \text{ Nm/A}$, $c = 5 \times 10^{-4}$ Nms/rad, and $R_a = 0.8 \Omega$. The manufacturer's data states that the motor's maximum speed is 3500 rpm, and the maximum armature current it can withstand without demagnetizing is 40 A. Compute the no-load speed, the no-load current, and the stall torque. Determine whether the motor can be used with an applied voltage of $u_a = 15 \text{ V}$. Note:

   $I_a(s) = \dfrac{I_b + c}{L_m(s^2 + (R_a + cL_m)s + cR_a + K_bK_t)}$

   $V_a(s) = \dfrac{K_b}{L_m(s^2 + (R_a + cL_m)s + cR_a + K_bK_t)}$

   $\omega_a(s) = \dfrac{K_T}{L_m(s^2 + (R_a + cL_m)s + cR_a + K_bK_t)}$

   $\Omega(s) = \dfrac{L_m(s^2 + (R_a + cL_m)s + cR_a + K_bK_t)}{L_m(s^2 + (R_a + cL_m)s + cR_a + K_bK_t)}$

   $\dfrac{T_L(s)}{T_a(s)} = -\dfrac{1}{L_m(s^2 + (R_a + cL_m)s + cR_a + K_bK_t)}$
1) \[ T = 0 \]
\[ f_0 = \frac{kT}{I_2} (\theta_3 - \theta_2) \]
\[ I_1 \ddot{\theta}_1 = I_1 \ddot{\theta}_1 = T - \frac{kT}{I_2} (\theta_3 - \theta_2) \]
\[ I_2 \ddot{\theta}_2 = -C_1 \dot{\theta}_2 - k_T (\theta_3 - \theta_2) \]
\[ 0 = -F_0 \frac{\gamma}{I_2} + k_T (\theta_3 - \theta_2) \]
\[ F_0 = \frac{kT}{I_2} (\theta_3 - \theta_2) \]
\[ \theta_3 = \frac{C_1}{I_2} \theta_1 \]
\[ \theta_2 = \frac{C_1}{I_2} \theta_1 \]
4) From eqn 3

a) \[ N = 15 \frac{0.2}{5 \times 10^{-4} \cdot 0.8 + (0.2)^2} = 74 \text{ rad/sec} \]
\[ = 709 \text{ RPM (ok)} \]

b) No load current
\[ I = 15 \frac{5 \times 10^{-4}}{0.8 + (0.2)^2} = 0.186 \text{ A} \]

c) Stall torque
From 3 and 7
\[ N = \frac{V_a E_s + R_o T_L}{5 \times 10^{-4} \cdot 0.8 + (0.2)^2} = 0 \]
\[ T_L = \frac{15 \cdot 0.2}{0.8} = 3.75 \text{ Nm} \]

d) Current is (add 1 and 2)
\[ I_a = \frac{V_a C_1 + K_v T}{5 \times 10^{-4} \cdot 0.8 + (0.2)^2} = 187.5 \text{ A} \]
This exceeds the 40 A limit.