Homework#2 (2/1) Answers
ME 3600 Control Systems

1. E2.2: \[ \Delta R = -135.3 \Delta T \]

2. E2.11:  
   a) \[ \Delta f = \left( \frac{50}{0.015} \right) \Delta x = 3333 \Delta x, \text{ so } k = 3333 \text{ (N/m)} \]
   b) \[ \Delta f = \left( \frac{40}{0.02} \right) \Delta x = 2000 \Delta x, \text{ so } k = 2000 \text{ (N/m)} \]
   c) \[ \Delta f = \left( \frac{14}{0.04} \right) \Delta x = 350 \Delta x, \text{ so } k = 350 \text{ (N/m)} \]

3. E2.18:  
   a) \( (x_0 = 1, y_0 = 2.4), (x_0 = 2, y_0 = 13.2) \)
   b) \( \{x_0 = 1, \Delta y = 5.2\Delta x\}, \{x_0 = 2, \Delta y = 17.8\Delta x\} \)

4. P2.5:  
   a) Define \( R = P_1 - P_2 \); Operating point = \( R_0 = (P_1-P_2)_o \)
      \[ \Delta Q = \left[ \frac{K}{2\sqrt{P_1 - P_2}} \right] \Delta R \]
      \( R = R_0 \)
   b) When \( R_0 = (P_1-P_2)_o = 0 \), no linear model exists.

5. E2.26: 
   \[ m_1 \ddot{x}_1 + kx_1 - kx_2 = F(t) \]
   \[ m_2 \ddot{x}_2 + kx_2 - kx_1 = 0 \]
   (\( x_1 \) and \( x_2 \) are measured from the equilibrium positions.)

6. P2.2:  
   \[ M_1 \ddot{y}_1 + b\dot{y}_1 + (k_1 + k_{12})y_1 - k_{12}y_2 = F(t) \]
   \[ M_2 \ddot{y}_2 - k_{12}y_1 + k_{12}y_2 = 0 \]
   (\( y_1 \) and \( y_2 \) are measured from the equilibrium positions.)

7. P2.3:  
   \[ M \dddot{x}_1 + (2K)x_1 - Kx_2 = F(t) \]
   \[ M \dddot{x}_2 + b\dot{x}_2 - Kx_1 + Kx_2 = 0 \]
   (\( x_1 \) and \( x_2 \) are measured from the equilibrium positions.)

8. P2.34:  
   \[ m_1 \dddot{y}_1 + b(\dot{y}_1 - \dot{y}_2) + k_1(y_1 - y_2) = 0 \]
   \[ m_2 \dddot{y}_2 + b(\dot{y}_2 - \dot{y}_1) + (k_1 + k_2)y_2 - k_1y_1 = k_2x(t) \]
   (\( y_1 \) and \( y_2 \) are measured from the equilibrium positions on level ground.)
   (\( x(t) \) is measured from level ground.)