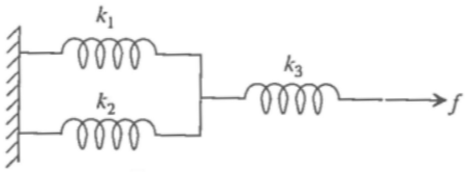
Homework 9

1. Determine the equivalent spring constant for the system shown below. (20 points)



Because k_1 and k_2 are in parallel

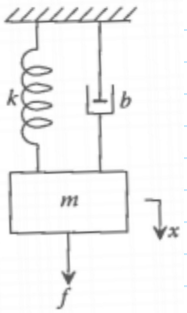
Therefore $k_{12} = k_1 + k_2 \Rightarrow k_{12} = k_1 + k_2$

Because k_{12} and k_3 are in series

Therefore $\frac{1}{k_{123}} = \frac{1}{k_{12}} + \frac{1}{k_3} = \frac{1}{k_1+k_2} + \frac{1}{k_3} = \frac{k_1+k_2+k_3}{(k_1+k_2)k_3}$

$$k_{eq} = \frac{(k_1 + k_2)k_3}{k_1 + k_2 + k_3}$$

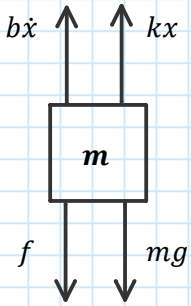
2. Consider a mechanical system that is shown by the figure on the right.



(a) Draw the free-body diagram. (10 points)

(b) Derive the equation of motion. (20 points)

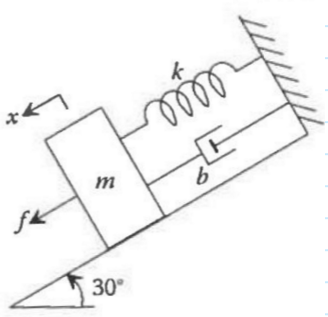
a).



b).

$$\sum F_x = m\ddot{x} = f + mg - b\dot{x} - kx \implies m\ddot{x} + b\dot{x} + kx = f + mg$$

3. Consider the system shown by the figure on the right.

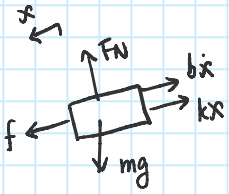


(a) Draw the free-body diagram. (15 points)

(b) Derive the equation of motion. (20 points)

(c) Determine the transfer function (assuming all initial conditions are zero). (15 points)

a).



b).

$$\sum F = m\ddot{x} = f + mg \cdot \sin 30° - b\dot{x} - k(x + x_{eq}) \quad \Rightarrow \quad m\ddot{x} + b\dot{x} + kx = f$$

c).

$$(ms^2 + bs + k)X(s) = U(s)$$

$$G(s) = \frac{X(s)}{U(s)} = \frac{1}{ms^2 + bs + k}$$