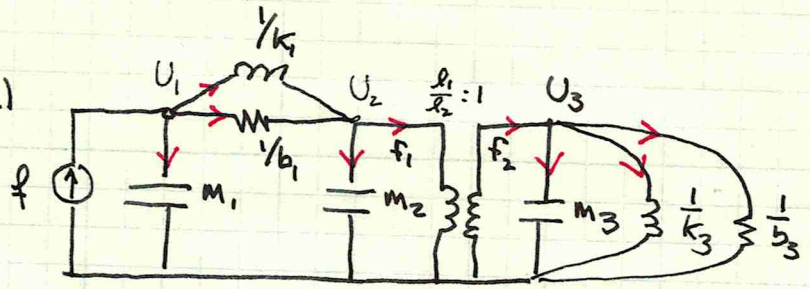
1.

(a)



(b)

node U_1: $$F = \frac{U_1}{\frac{1}{M_1 s}} + (U_1 - U_2)\left[\frac{1}{\frac{s}{K_1}} + \frac{1}{\frac{1}{b_1}}\right] \quad (1)$$

node U_2: $$[U_1 - U_2]\left[\frac{1}{\frac{s}{K_1}} + \frac{1}{\frac{1}{b_1}}\right] = \frac{U_2}{\frac{1}{M_2 s}} + F_1 \quad (2)$$

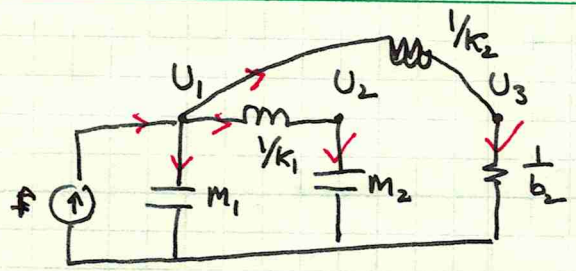
node U_3: $$F_2 = U_3\left[\frac{1}{\frac{1}{M_3 s}} + \frac{1}{\frac{s}{K_3}} + \frac{1}{\frac{1}{b_3}}\right] \quad (3)$$

$$F_1 \frac{l_1}{l_2} = F_2 \quad (4)$$

$$U_2 \frac{l_2}{l_1} = U_3 \quad (5)$$

2.

(a)



(b)

node U_1: $$F = \frac{U_1}{\frac{1}{M_1 s}} + \frac{U_1 - U_3}{\frac{s}{K_2}} + \frac{U_1 - U_2}{\frac{s}{K_1}} \quad (1)$$

node U_2: $$\frac{U_1 - U_2}{\frac{s}{K_1}} = \frac{U_2}{\frac{1}{M_2 s}} \quad (2)$$

node U_3: $$\frac{U_1 - U_3}{\frac{s}{K_2}} = \frac{U_3}{\frac{1}{b_2}} \quad (3)$$

(c) find U_3/U_1 means U_3 given U_1

$$\frac{U_1 - U_3}{\frac{s}{K_2}} = \frac{U_3}{\frac{1}{b_2}} \Rightarrow \frac{U_1}{\frac{s}{K_2}} = U_3 \left[\frac{1}{\frac{s}{K_2}} + \frac{1}{\frac{1}{b_2}} \right]$$

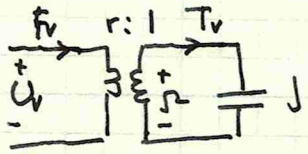
$$\frac{U_3}{U_1} = \left[\frac{\frac{1}{\frac{s}{K_2}} + \frac{1}{1/b_2}}{\frac{s}{K_2}} \right]$$

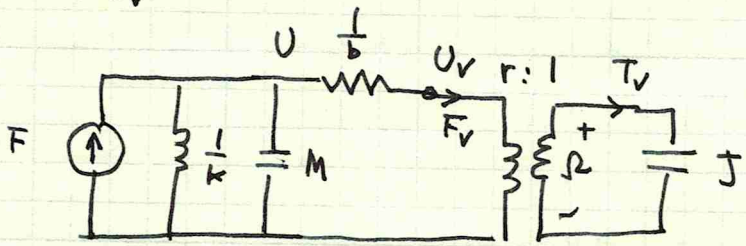
3

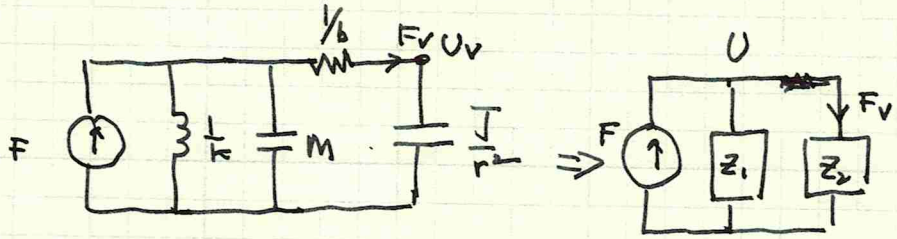
$$J\ddot{\theta} = T \Rightarrow U_v = r\dot{\theta} = r\Omega$$

$$T_v = r F_v$$

$$Js\Omega = T_v$$







$$Z_1 = \left[\frac{1}{\frac{s}{K}} + \frac{1}{Ms}\right]^{-1}$$

$$Z_2 = \left[\frac{1}{b} + \frac{1}{\frac{J}{r^2}s}\right]$$

$$\Big\} \quad F_v = F\left[\frac{Z_1}{Z_1+Z_2}\right]$$

$$U_v = \frac{1}{\frac{1}{\frac{sJ}{r^2}}} F_v = \frac{1}{\frac{1}{\left(\frac{sJ}{r^2}\right)}} F\left[\frac{Z_1}{Z_1+Z_2}\right]$$

since

$$U_v = rs\theta$$

$$\theta = \frac{1}{rs}\left(\frac{1}{\frac{1}{\left(\frac{sJ}{r^2}\right)}}\right)\left[\frac{Z_1}{Z_1+Z_2}\right] F$$

$$\frac{\theta}{F} = \frac{1}{rs}\left[\frac{sJ}{r^2}\right]\left[\frac{Z_1}{Z_1+Z_2}\right]$$