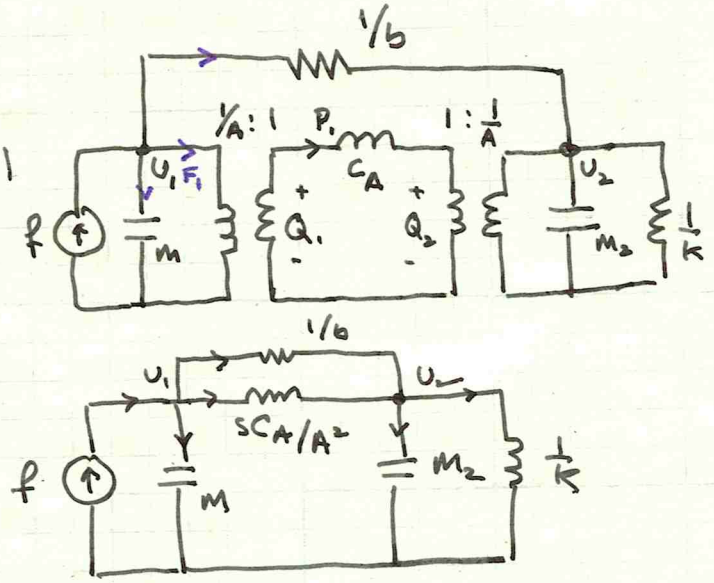
1.

(a)



assume $f + \int u_2 dt \approx f$

$$C_A = \frac{Al}{\rho_0 c^2}$$

(b) $$F = \frac{U_1 - U_2}{\frac{1}{b}} + \frac{U_1}{\frac{1}{ms}} + \frac{U_1 - U_2}{\frac{sC_A}{A^2}} \Rightarrow f = b(\dot{u}_1 - \dot{u}_2) + m\ddot{u}_1 + (u_1 - u_2)\frac{A^2}{C_A}$$

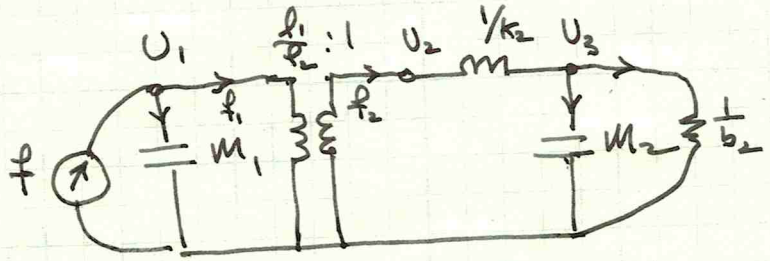
$$\frac{U_1 - U_2}{\frac{sC_A}{A^2}} + \frac{U_1 - U_2}{\frac{1}{b}} = \frac{U_2}{\frac{1}{M_2 s}} + \frac{U_2}{\frac{s}{K}} \Rightarrow (u_1 - u_2)\frac{A^2}{C_A} + b(\dot{u}_1 - \dot{u}_2) = \ddot{u}_2 M_2 + u_2 K$$

(c) $$U_1\left[\frac{A^2}{C_A} + bs\right] = U_2\left[s^2 M_2 + bs + K + \frac{A^2}{C_A}\right]$$

$$\frac{U_2}{U_1} = \left[\frac{\frac{A^2}{C_A} + bs}{s^2 M_2 + bs + K + \frac{A^2}{C_A}}\right]$$

(2)

(a)



(b) node U_1: $F = \frac{U_1}{\frac{1}{M_1 s}} + F_1$

unknows: U_1, U_2, U_3
F_1, F_2

transformer: $F_1 \frac{l_1}{l_2} = F_2$

$U_1 \frac{l_2}{l_1} = U_2$

$F_2 = \frac{U_2 - U_3}{\frac{s}{k_2}}$

node U_3: $F_2 = \frac{U_3}{\frac{1}{M_2 s}} + \frac{U_3}{\frac{1}{b_2}}$

$f = M_1 \dot{u}_1 + f_1$

$f_1 \cdot \frac{l_1}{l_2} = f_2$

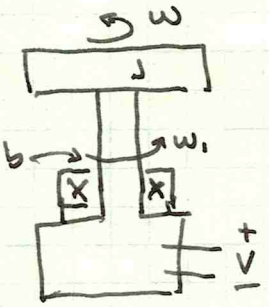
$u_1 \frac{l_2}{l_1} = u_2$

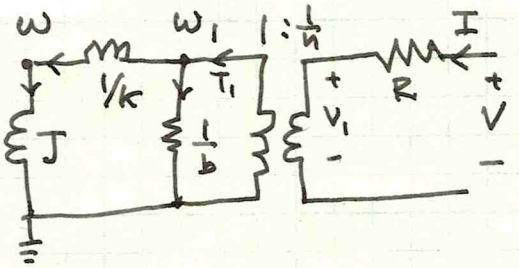
$\dot{f}_2 = k_2 (u_2 - u_3)$

$f_2 = \dot{u}_3 M_2 + b_2 u_3$

3.

(a)





(b)

$$I = \frac{V_s - V_1}{R} \qquad i = \frac{V_s - V_1}{R}$$

$$I\frac{1}{n} = T_1 \qquad i\frac{1}{n} = \tau_1$$

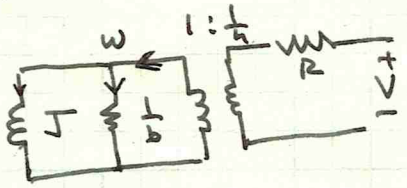
$$V_1 n = W_1 \qquad v_1 n = w_1$$

$$T_1 = \frac{W_1}{\frac{1}{b}} + \frac{W_1 - W}{\frac{s}{K}} \qquad \dot{\tau}_1 = b\dot{w}_1 + [w_1 - w]K$$

$$(w_1 - w)K = \dot{w}J$$

$$\frac{W_1 - W}{\frac{s}{K}} = \frac{W}{Js}$$

(c) $K \to \infty$



$$\dot{w}J + bw = 0 \qquad \Rightarrow J[s\bar{W} - w(0)] + b\bar{W} = 0$$

$$Vn = w$$

$$\Downarrow$$

$$[Js + b]\bar{W} - Jw(0) = 0$$

$$\bar{W} = \frac{w(0)}{s + \frac{b}{J}}$$

$$\boxed{w(t) = w(0)e^{-\frac{b}{J}t} \quad t \geq 0}$$

$$\Rightarrow V = \frac{w}{n} = \frac{w(0)}{n}e^{-\frac{b}{J}t}$$