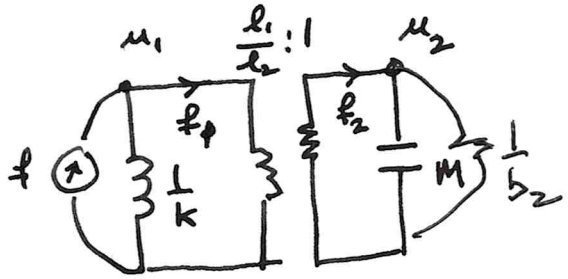
1

(a)



(b) u_1 :

$$F = \frac{U_1}{\frac{s}{k}} + F_1$$

u_2 :

$$F_2 = \frac{U_2}{\frac{1}{sM} + \frac{1}{b_2}}$$

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

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

$$F_1 \frac{l_1}{l_2} = U_2(Ms + b_2)$$

$$F = \frac{U_1}{s} k + \frac{l_2}{l_1}(Ms\,U_2 + b_2 U_2)$$

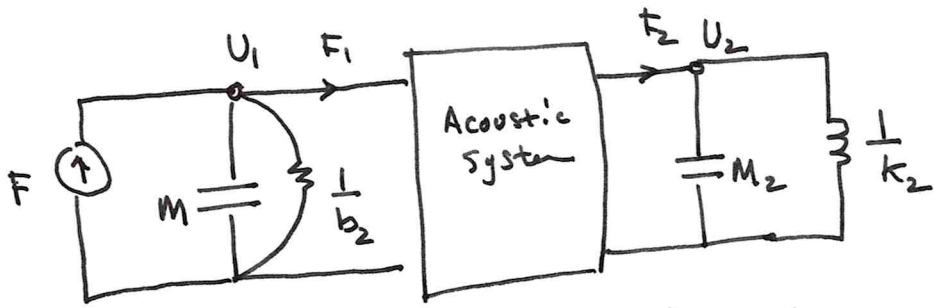
$$F = \frac{U_1}{s} k + \left(\frac{l_2}{l_1}\right)^2 (Ms\,U_1 + b_2 U_1)$$

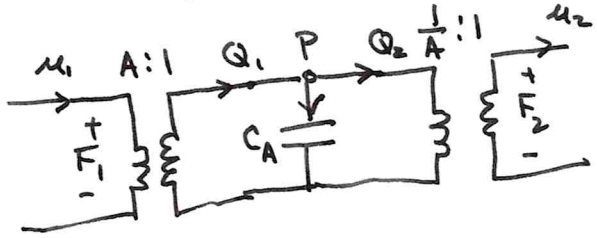
$$F = U_1 \left[\frac{k}{s} + \left(\frac{l_2}{l_1}\right)^2 (Ms + b_2) \right]$$

(c) $$\frac{U_2}{U_1} = \frac{l_2}{l_1}$$

(2)

(a)





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

$u_1 A = Q_1$

$\frac{F_1}{A} = P$

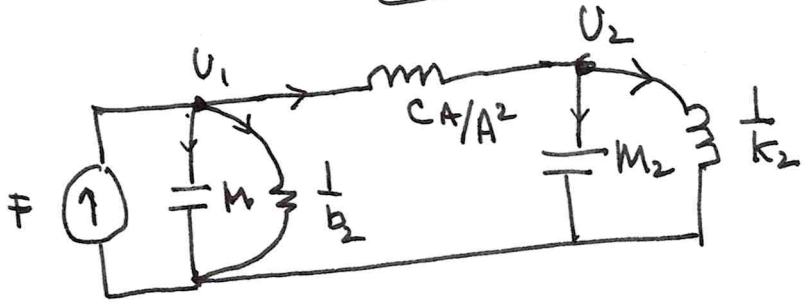
$u_2 A = Q_2$

$\frac{F_2}{A} = P \Rightarrow F_1 = F_2$

$$Q_1 = P C_A s + Q_2$$

$$A u_1 = \frac{F_1}{A} C_A s + A u_2$$

$$\boxed{\frac{u_1 - u_2}{\frac{C_A s}{A^2}} = F_1 = F_2}$$



(b)

$$F = U_1 M s + U_1 b_2 + \frac{U_1 - U_2}{s \frac{C_A}{A^2}}$$

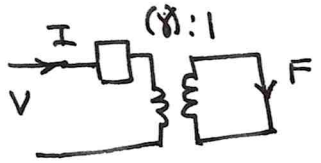
$$\frac{U_1 - U_2}{s \frac{C_A}{A^2}} = U_2 M_2 s + \frac{U_2}{s} K_2$$

$$\dot{f} = m \ddot{u}_1 + b_2 \dot{u}_1 + (u_1 - u_2) \frac{A^2}{C_A}$$

$$\left[\frac{u_1 - u_2}{C_A} \right] A^2 = \ddot{u}_2 M_2 + u_2 K_2$$

3

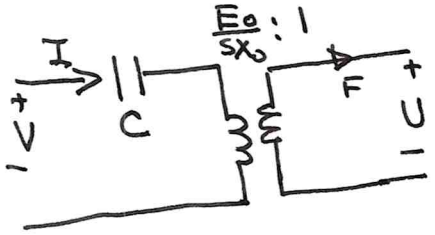
(a) Short circuit $U = 0$



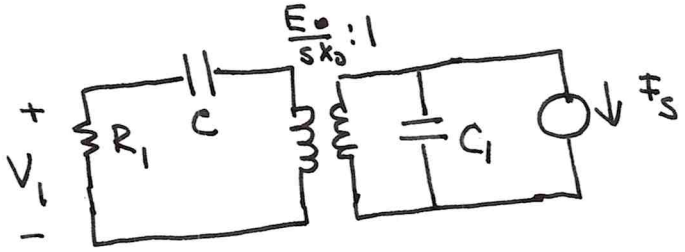
$$V = \frac{1}{sC} I + \frac{E_0}{sX_0} U \to 0$$

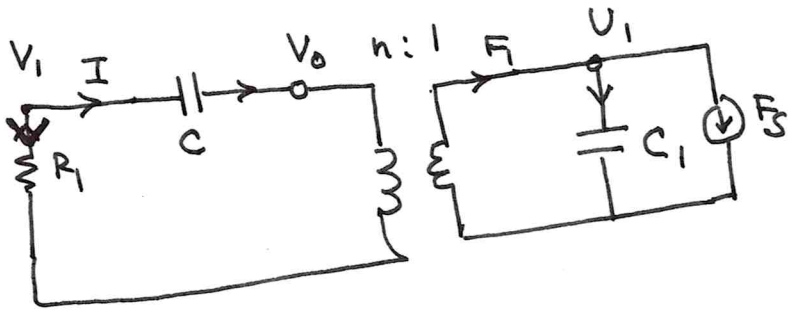
$$F = \frac{E_0}{sX_0} I$$

$\therefore$



(b)





$$n \equiv \frac{E_0}{sX_0}$$

$$\frac{V_1 - V_0}{\frac{1}{Cs}} = I$$

$$\frac{V_1}{R_1} + I = 0$$

$$V_0 \frac{1}{n} = U_1$$

$$In = F_1$$

$$F_1 = \frac{U_1}{\frac{1}{C_1 s}} + F_S$$

$$V_1 \left[\frac{R_1 Cs + 1}{R_1 Cs} \right] = V_0$$

$$-\frac{V_1}{R_1} n = C_1 s \frac{V_0}{n} + F_S$$

$$\frac{F_S}{n} = -\frac{V_1}{R_1 C n^2} \left\{ C n^2 + C_1 (R_1 Cs + 1) \right\}$$

$$\boxed{\frac{V_1}{F_S} = -\frac{n R_1 C}{\left[C n^2 + C_1 (R_1 Cs + 1) \right]}}$$