1. 

\[ C_A = \frac{AL}{\rho_0 c^2} \]

\[ P_2 = \frac{F_2}{A} = \frac{E_2}{\mu_2 A^2} \]

\[ P_2 = \frac{M_2 s U_2}{A^2} \]

\[ \frac{P_2}{Q_e} = \frac{1}{A^2} M_2 s \]

\[ M_{th} = \frac{P_0 L}{A} \]

\[ C_A = \frac{\rho L}{\rho_0 c^2} \]
Acausal model (impedance)
transformed to Mechanical model (mobility)

\[ \frac{Q_1}{M} = \frac{1}{C_A} \cdot \frac{Q_2}{P_2} \]

\[ Q_1 = \frac{1}{C_A} \cdot Q_2 \]

\[ f \left( \frac{1}{A} \right) = f \left( \frac{1}{A} \right) \]

\[ u A \cdot f = u A \cdot f \]

\[ \frac{u}{1} = \frac{u}{1} \]

\[ f A = f A \]

\[ u_1, f_1 = u_1', f_1' \]

\[ \frac{u_1}{1} = \frac{u_1'}{1} \]

\[ f_1 A = f_1 A \]

\[ u_1 f_1 = u_1 f_1 \]

\[ \frac{u_2}{1} = \frac{u_2}{1} \]

\[ f_1 A = f_1 A \]

\[ u_1 f_1 = u_1 f_1 \]

\[ \frac{u_2}{1} = \frac{u_2}{1} \]

\[ f_1 A = f_1 A \]

\[ f = \frac{u_2 - u_1}{\frac{1}{k}} \]

b) at \( u_1 \) node:

\[ \frac{u_0 - u_1}{\frac{1}{k}} = \frac{u_1}{1} \cdot \frac{1}{b} + \frac{u_1}{1} \cdot \frac{1}{5m_1} + f_1 \]

at transformer \( T_2 \):

\[ u_1 f_1 = u_1 f_1 \]

\[ \frac{u_2}{1} = \frac{u_2}{1} \]

\[ f_1 A = f_1 A \]

at \( u_1 \) node:

\[ f_1 = \frac{u_2}{1} \cdot \frac{1}{5m_1} \]

at \( u_0 \) node:

\[ f = \frac{u_2 - u_1}{\frac{1}{k}} \]
c) at node:

\[ \begin{align*}
    s_i &= k (u_0 - u_i) \\
    i &= k (u_0 - u_i)
\end{align*} \]

at node:

\[ \begin{align*}
    k (u_0 - u_i) &= b s u_i + s M u_i + s f_i \\
    k (u_0 - u_i) &= b u_i + M u_i + f_i
\end{align*} \]

at node:

\[ \begin{align*}
    C_A (u'_1 - u'_2) &= s M_A u'_1 + s f'_1 \\
    C_A (u'_1 - u'_2) &= M_A u'_2 + f'_2
\end{align*} \]

d) Using transformer \( T_1 \) equation:

\[ \frac{u_i}{A} = u_1 \Rightarrow u_i = u_1 A \]

[Diagram showing circuit model]

\[ \frac{u_2 A}{u'_1} = \frac{M_A}{C_A + M_A} \Rightarrow u'_1 = \frac{u_2 A (C_A + M_A)}{M_A} \]

Using transformer \( T_1 \) equation:

\[ u_1 A = u'_1 \]

\[ u_1 = \frac{u'_1}{A} \]

where \( u'_1 = \frac{u_2 (C_A + M_A)}{M_A} \)
Wing nodal equation at u node:

\[ k(u_1 - u_1) = bsu_1 + \frac{s^2}{m_1} u_1 + sf_1 \]

\[ ku_0 = ku_1 + sBu_1 + \frac{s^2}{m_1} u_1 + sf_1 \]

\[ = (k + sb + \frac{s^2}{m_1}) u_1 + sf_1 \]

\[ f_1 \frac{1}{A} = f_1' \]

\[ u_1' = \frac{u_1'}{sM_A} + f_2' \text{ where } f_2' = \frac{f_2}{A} \text{ and } f_1 = \frac{u_2}{sM_k} \]

and \[ \frac{u_2'}{A} = u_1', \text{ or } u_2' = u_2 A \]

\[ f_1 = A f_1' \]

\[ = A \left( sM_A u_1' + f_2' \right) \]

\[ = A \left( sM_A u_1 + \frac{f_2}{A} \right) \]

\[ = A \left( sM_A u_1 + \frac{sM_k u_2}{A} \right) \]

\[ = sM_A u_1 + sM_k u_2 \]

\[ = (sM_A^2 + sM_k) u_2 \]

Plug this into the expression at top of page:

\[ u_0 = \frac{k + sb + \frac{s^2}{m_1}}{k} u_1 + \frac{s}{k} (sM_A^2 + sM_k) u_2 \]

Plug in expression for \( u_1' \):

\[ u_0 = \frac{k + sb + \frac{s^2}{m_1}}{k} \frac{c_A + m_A}{m_A} u_2 + \frac{sM_A^2 + sM_k}{k} u_2 \]

\[ \frac{u_0}{u_2} = \left[ \frac{k + sb + \frac{s^2}{m_1}}{k} \frac{c_A + m_A}{m_A} + \frac{sM_A^2 + sM_k}{k} \right] \]
2. \[ P_1 \quad \frac{1}{C_A} \quad P_2 \quad \frac{R_A}{3} \quad \text{C}_A = \frac{V}{\theta c^2} \]

\[ (a) \]

\[ (b) \quad \frac{P_2}{P_1} = \frac{R_A}{\frac{1}{C_A^2} + R_A} = \frac{R_A C_A}{1 + R_A C_A} = \frac{5}{s + \frac{1}{R_A C_A}} \]

\[ (c) \quad R_A \to \infty \quad \frac{P_2}{P_1} = 1 \]

\[ (d) \quad \text{gain} \quad \frac{6 \text{dB}}{\omega c} \quad \text{hi pass} \quad \frac{1}{R_A C_A} \quad \text{frequency} \]
3. \text{loop:}

\begin{align*}
L_1 &= -1 \\
L_2 &= -2 \\
L_3 &= -1
\end{align*}

$L_1$ and $L_3$ are not touching,

$$
\Delta = 1 - (-1)(-2)(-1) + (-1)(-1) = 1 - (-4) + 1 = 6
$$

\text{for } x_2/u:

\text{path 1:}

$$U \rightarrow x_1 \rightarrow x_2$$

\text{path 1 gain:}

$$p_1 = (1)(1) = 1$$

\text{cofactor 1:}

Since $L_1, L_2$ and $L_3$ are all touching, path 1, \( \Delta = 1 \)

$$
\frac{x_2}{u} = \frac{p_1 \cdot \Delta}{\Delta} = \frac{(1)(1)}{6} = \frac{1}{6}
$$

\text{for } x_1/u:

\text{path 1:}

$$U \rightarrow x_1$$

\text{path 1 gain: 1}

\text{cofactor 1: remove } L_2 \text{ will gain } = -2, L_1 \text{ and } L_3 \text{ remain.}

Since they touch, \( \Delta_1 = 1 - (-1-1) = 3 \)

$$
\frac{x_1}{u} = \frac{(1)(3)}{6} = \frac{3}{6}
$$