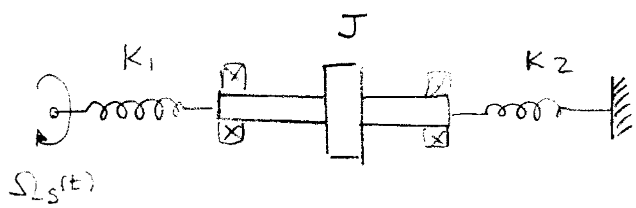

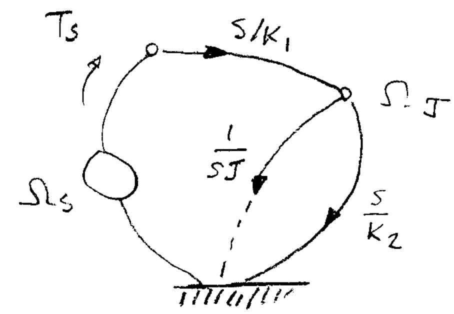

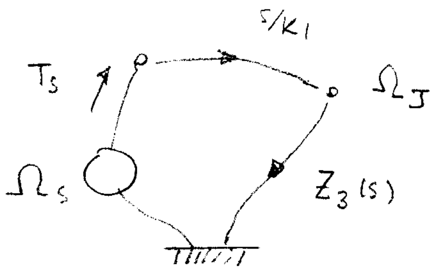

$$\frac{1}{Z_3} = \frac{1}{1/sJ} + \frac{1}{s/k_2} = sJ + \frac{k_2}{s} = \frac{s^2 J + k_2}{s}$$

$$Z_3(s) = \frac{s}{s^2 J + k_2}$$

(a)

Impedance $\quad Z(s) = \dfrac{\Omega_s}{T_s} = \dfrac{s}{k_1} + \dfrac{s}{s^2 J + k_2} = \dfrac{s(s^2 J + k_2) + s k_1}{k_1(s^2 J + k_2)}$

(b) Transfer function from Ω_s to Ω_J

$$H(s) = \frac{\Omega_J}{\Omega_s} \; ; \quad \Omega_J = \Omega_s - \Omega_{k_1} = \Omega_s - \frac{s}{k_1} T_s$$

Hence $\quad H(s) = 1 - \dfrac{s}{k_1}\dfrac{T_s}{\Omega_s} = 1 - \dfrac{s}{k_1}\dfrac{1}{Z(s)}$

(c) $\quad H(s) = 1 - \dfrac{s}{k_1} \cdot \dfrac{k_1(s^2 J + k_2)}{s(s^2 J + k_2) + s k_1} = \dfrac{s k_1}{s(s^2 J + k_2) + s k_1}$

Pole-zero cancellation with $s = 0$

Physical meaning:

- pole @ $s=0$ implies $\Omega_s(t)$ = constant, response of part of the system (e.g., the spring force f_{k_2}) goes to infinity.
- zero @ $s=0$ implies response Ω_J (angular velocity) remains finite (and constant), because it cancels with the pole.

(d) The poles of $H(s)$ are zeros of $Z(s)$. So find zeros of $Z(s)$ instead.