Quiz 4

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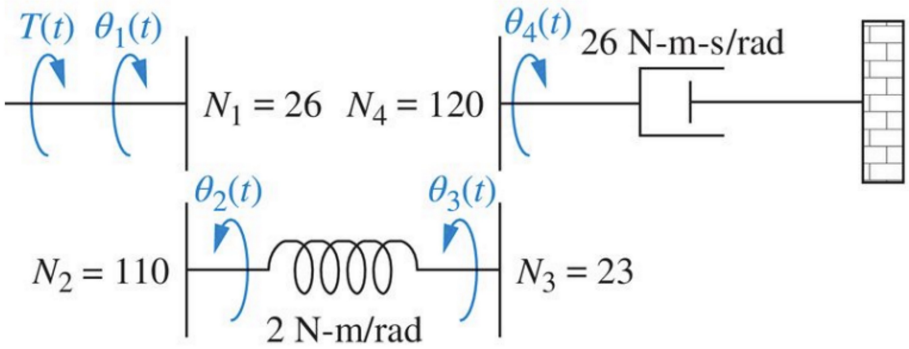
February 13, 2023 8:54 AM

1. **Rotational Mechanical Systems** (10 marks)

Consider the system show below:

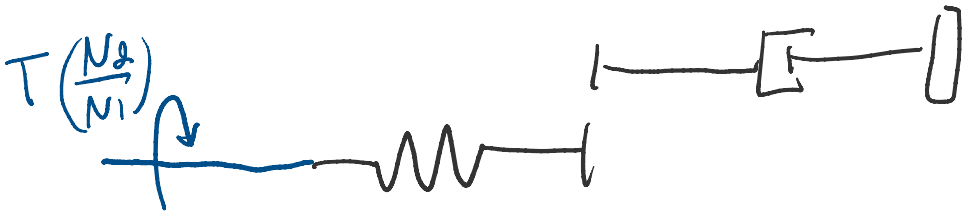


(a) (4 marks) How many degrees of freedom does the system have?

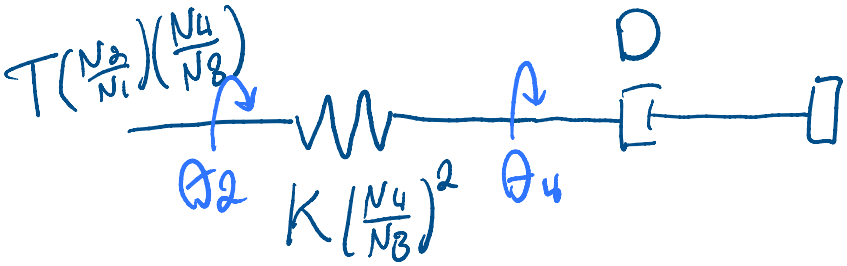
(b) (6 marks) Find the transfer function $G(s) = \frac{\theta_4(s)}{T(s)}$

a) 2 DOF

b) project θ_1 onto θ_2



project all into θ_4

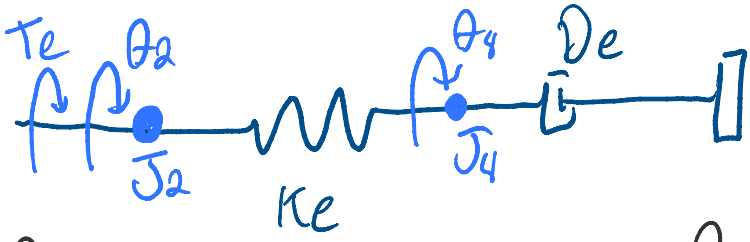


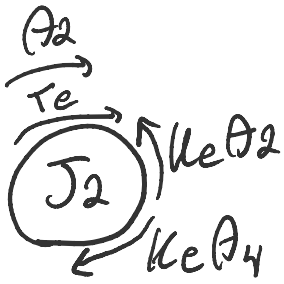
$$Te = T_1\left(\frac{N_2 N_4}{N_1 N_3}\right) = T_1\left(\frac{110}{26} \times \frac{120}{23}\right) = \frac{6600}{299} T_1$$

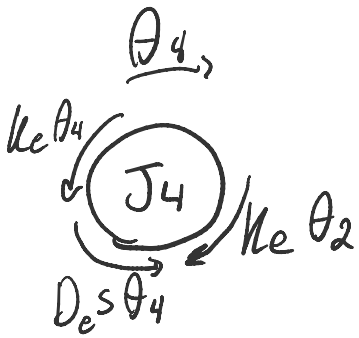
$$Te = T_1\left(\frac{N_2 N_4}{N_1 N_3}\right) = T_1\left(\frac{110}{26} \times \frac{120}{28}\right) = \frac{\omega}{299}\, I_1$$

$$Ke = K_2\left(\frac{N_4}{N_3}\right)^2 = 2\left(\frac{120}{28}\right)^2$$

$$De = D_4 = 26$$







$$\begin{bmatrix} Ke & -Ke \\ -Ke & Ke + DeS \end{bmatrix} \begin{bmatrix} \theta_2 \\ \theta_4 \end{bmatrix} = \begin{bmatrix} Te \\ \emptyset \end{bmatrix}$$

$$det(A) = Ke(Ke + DeS) - Ke^2$$

$$det(A_2) = \begin{vmatrix} Ke & Te \\ -Ke & \emptyset \end{vmatrix} = KeTe$$

$$\frac{det(A_2)}{det(A)} = \frac{KeTe}{Ke(Ke + DeS) - Ke^2} = \frac{Te}{Ke + DeS - Ke} = \theta_4$$

$$\frac{\Theta_4}{T_1} = \frac{6600/249}{26s} = \boxed{\frac{3300}{3887s}}$$

$$\boxed{\frac{\Theta_4}{T} = \frac{3300}{3887s}}$$