MECH 370 Summer 2009 Final
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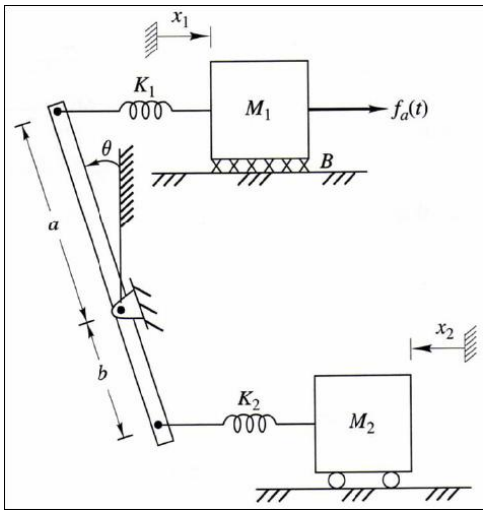
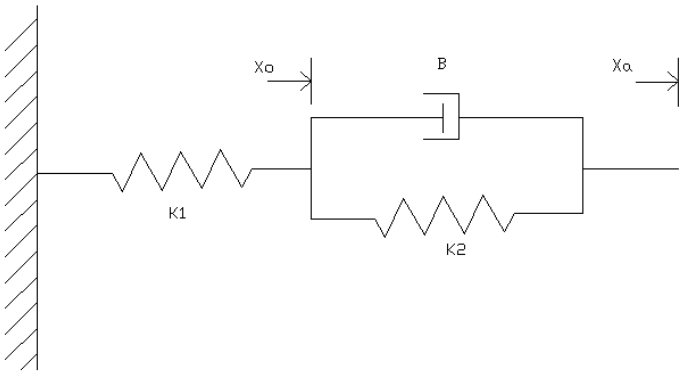
1. For the combined translational and rotational system shown, the input is the applied force, and the output is the displacement x_2. Assume that θ is small. The lever has a mass M.
Hint: $J_G = (1/12)ML^2$ for a lever where G is the centre of mass.



Derive a set of state variables and write the system in state-variable (matrix) form. Let a=b=L/2

2. For the system shown the input is the displacement $x_a(t)$ and the output is $x_o(t)$.

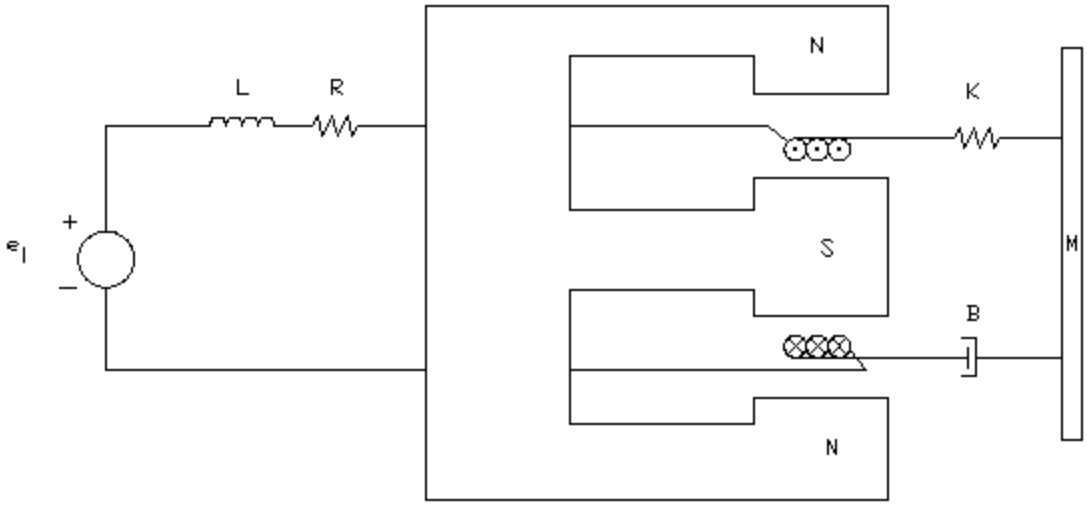


a. What is the order of the system? What is the time constant?
b. Given $K_1 = 1$, $K_2 = 2$, and $B = 1$ find $x_o(t)$ for $t>0$ if there is now initial energy stored for $t<0$ and the input is $x_a(t) = 1 - e^{-2t}$ for $t>0$.

3. Given the transfer function $H(s) = \frac{s+3}{s^3+7s^2+10s}$

a. Find the unit step response $y_U(t)$.
b. Find the unit impulse response h(t).
c. Find the response for u(t) = 6cos2t.

4. For the loudspeaker shown below, the input to the system is the voltage $e_i(t)$. The output is the displacement of the mass M to the right. The coil is made up of N turns and is of radius a.



a. Determine a set of state variables and write the state-variable model (in matrix form).
Hint: Let α = 2πNaβ where β is the magnetic flux.
b. Find the transfer function for this system.

5. a. For the given transfer function, determine the number of inputs and outputs.

$$H(s) = \begin{bmatrix} H_{11} & H_{12} & H_{13} \\ H_{21} & H_{22} & H_{23} \end{bmatrix}$$

b. A fellow engineer brings you a work package containing calculations for several subsystems. For the following subsystems, determine which of them are obviously wrong and give a brief description for your reasoning.

A. $H(s) = \frac{\tau}{\tau s+1}$

B. $H(s) = \frac{M}{Js^2+Bs+K}$

C. $H(s) = \frac{1}{s+\frac{J}{B}}$