Professor Fearing EECS128/Problem Set 2 v 1.02 Fall 2019

Due at 17:00, Fri. Sep. 13 in Gradescope .

Note: up to 2 students may turn in a single writeup. Reading Nise 2, 3

1. (15 pts) Equivalent Circuit (Nise 2.9)

Draw the equivalent mechanical circuit for the system shown in in Fig. 1. (Note 2 inputs v_1 and v_2).

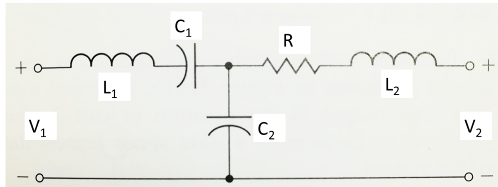

Fig.1

2. (20 pts) Equivalent Circuit (Nise 2.9)

Draw the equivalent electrical circuit for the system in Fig. 2.

3. (25 pts) State Space for Mechanical System (Nise 2.6, 2.7, 3.4, 3.5)

Consider the system in Fig. 2, with input force $f(t)$ and output $y(t) = x_3(t)$.

[10pts] a. Find the transfer function for the system shown in Fig. 2, $\frac{Y(s)}{F(s)}$.

[10pts] b. Write the state space equations for this system in phase-variable form and find A, B, C, D.

[5pts] c. Draw the equivalent block diagram of the system in phase variable form using integrator, scale, and summing blocks.

4. (20 pts) Linearization (Nise 2.11)

A capacitive actuator has force given by $F_A = \frac{\epsilon_o A}{x} V^2$ where x is the capacitor plate gap, A is plate area, ϵ_o is the vacuum dielectric constant, and V is applied voltage (input). The capacitive actuator has mass m_A and has a return spring with stiffness $k = k_s + k_A$, with damping b_s and can be modelled as shown in Fig. 3.

[5pts] a) Write the dynamic equations in state space form $\dot{\mathbf{x}} = f(\mathbf{x}, u)$, with x and $\dot{x}$ as the states.

[15pts] b) Write the dynamic equations in state space form $\dot{\mathbf{x}} = A\mathbf{x} + Bu$ for the system linearized about a non-zero operating point $V_o = x_o \sqrt{\frac{k}{\epsilon_o A}}$, $x_1 = x_o$, and $x_2 = \dot{x}_1 = 0$.

5. (20 pts) State Space (Nise 3.4, 3.5, Lec 3. Phase Variable Form handout)

Given $\frac{Y(s)}{U(s)} = \frac{s^3+s^2}{s^3+12s^2+45s+50}$,

[8pts] a. Write the state space equations for this system in phase-variable form and find A, B, C, D.

[4pts] b. Write the differential equation relating $y(t)$ to $u(t)$.

[6pts] c. Draw the block diagram (in phase variable form using integrators) corresponding to this differential equation.

[2pts] d. Explain how $\cancel{\frac{d^3y(t)}{dt^3}}$ $\frac{d^3x(t)}{dt^3}$ could be found from signals in the block diagram.

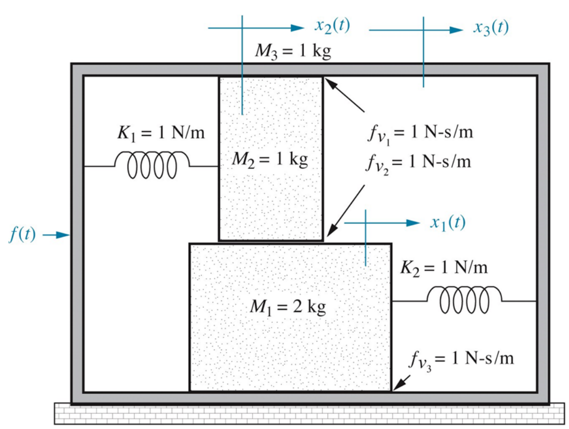

Fig. 2.

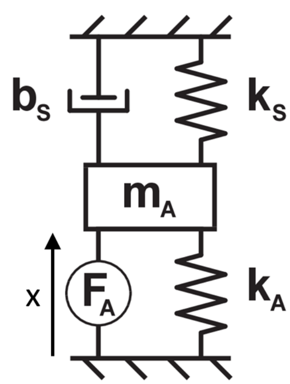

Fig 3.