Professor Fearing EECS128/Problem Set 2 v 1.01 Fall 2020

Due at 17:00 Berkeley time, Fri. Sep. 11 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 circuits for the two systems shown in Fig. 1. (Note input v_{in} and output v_{out}).

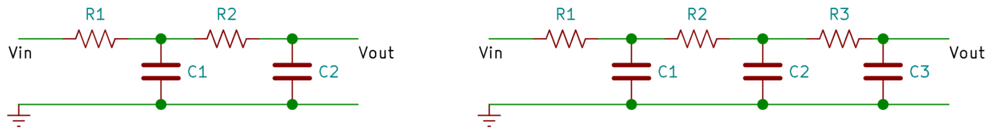

Fig.1a Fig.1b

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

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

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 $y(t) = x_2(t)$.

[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 maglev system uses an electromaget to levitate a steel sphere of mass m. The vertical displacement x of the sphere is described by the following non-linear differential equation:

$$m\frac{d^2x}{dt^2} = mg - k\frac{u^2}{x^2}$$

where g is gravity constant, k is a positive constant, input $u(t)$ is coil current, and $x(t)$ is the gap between electromagnet and sphere.

[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.

[2pts] b) Find the equilibrium point in terms of a nominal current $u_o = I_o$ and nominal position x_o.

[13pts] c) Write the dynamic equations in state space form $\dot{\mathbf{x}} = A\mathbf{x} + Bu$ for the system linearized about a non-zero equilibrium point found in part b). Use $x(t) = x_o + \delta_x(t)$ and $u(t) = u_o + \delta_u(t)$

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

Given $\frac{Y(s)}{U(s)} = \frac{s^4+s}{s^4+s^3+45s+10}$

[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 $\frac{d^4x(t)}{dt^4}$ could be found from signals in the block diagram.

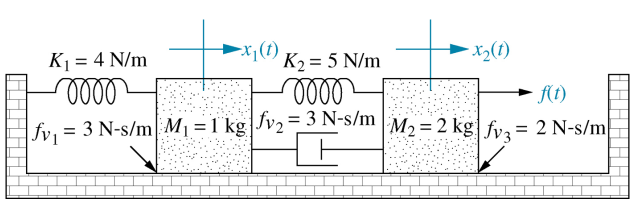

Fig. 2.