Due at 1700, Fri. Jan. 27 in homework box under stairs, first floor Cory .

Note: up to 2 students may turn in a single writeup.

Reading Nise 1,2.

1. (10 pts) Case study (Nise 1.4)

The human eye has a control system that regulates average light intensity on the retina. Based on light intensity, the brain commands internal eye muscles. Draw a functional block diagram for the light-pupil system. Show all blocks and signals.

2. (10 pts) Static Nonlinearity in Feedback

A nonlinear amplifier has voltage response $g(\epsilon) = e^{100\frac{\epsilon}{V_o}}$, where $V_o = 1$ volt. The nonlinear element is used in a negative feedback system as shown in Fig. 1, with $k1 = 0.1$. Let $x(t) = \cos \omega_o t$. Let $k2 = 100$. Show that $y(t) \approx 10x(t)$. (Hint: assume ϵ is small and check that the assumption holds.) How close is the closed loop amplifier to a gain of 10?

3. (15 pts) Laplace transform review (Nise 2.2)

For each transfer function below determine $h(t)$.

i) $H_1(s) = \frac{1}{s^2+2s+101}$ ii) $H_2(s) = \frac{s}{s^2+2s+101}$ iii) $H_3(s) = \frac{s+3}{s^2+2s+101}$

iv) $H_4(s) = \frac{s^2}{s^2+2s+101}$ v) $H_5(s) = \frac{1}{(s+3)^2(s+2)}$

4. (15 pts) Initial value, final value (Nise 2.2)

For each of the following Laplace transforms $Y_i(s)$ determine $y_i(t = 0^+)$ and if the limit exists, $\lim_{t\to\infty} y_i(t)$:

i) $Y_1(s) = \frac{s-1}{s+3}$ ii) $Y_2(s) = \frac{(s+1)}{s+3}$ iii) $Y_3(s) = \frac{(s-1)}{(s+3)^2}$

iv) $Y_4(s) = \frac{s+2}{s(s+1)}$ v) $Y_5(s) = \frac{(s+3)^2}{s^2}$

5. (15 pts) Electrical circuit example (Nise 2.4)

For the circuit in Fig. 2. below, using ideal op-amp assumptions, determine $H(s) = \frac{V_o(s)}{V_i(s)}$.

6. (15 pts) Equivalent models (Nise 2.5)

For the translational mechanical system in Fig. 3, write the transfer function relating input force $f(t)$ to output velocity $\dot{x}_1(t)$.

7. (20 pts) Equivalent electrical circuit (Nise 2.9)

Draw the equivalent electrical circuit for the system in Fig. 3, (with voltage corresponding to force, and current corresponding to velocity), and re-derive the transfer function from voltage input to current output for the circuit to verify that it is equivalent to the transfer function found in problem 6 above.

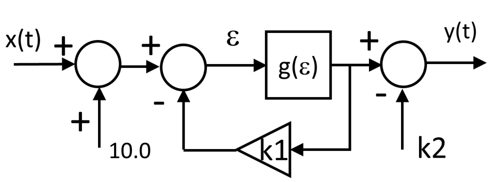

Fig. 1

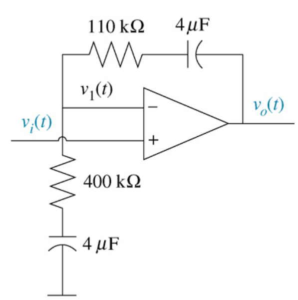

Fig. 2

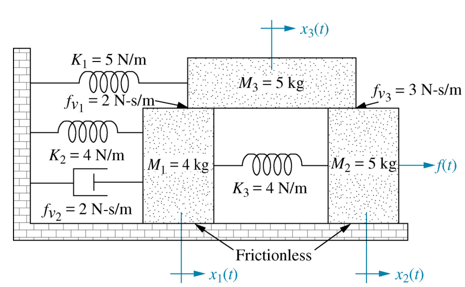

Fig. 3