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 \( g(\epsilon) = e^{100\epsilon} \), where \( V_o = 1 \) volt. The nonlinear element is used in a negative feedback system as shown in Fig. 1, with \( k_1 = 0.1 \). Let \( x(t) = \cos \omega t \). Let \( k_2 = 100 \). Show that \( y(t) \approx 10x(t) \). (Hint: assume \( \epsilon \) 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 \( h(t) \).

\[
\begin{align*}
\text{i) } & H_1(s) = \frac{1}{s^2 + 2s + 101} \\
\text{ii) } & H_2(s) = \frac{s}{s^2 + 2s + 101} \\
\text{iii) } & H_3(s) = \frac{s + 3}{s^2 + 2s + 101} \\
\text{iv) } & H_4(s) = \frac{2}{s^2 + 2s + 101} \\
\text{v) } & H_5(s) = \frac{1}{(s+3)^2(s+2)}
\end{align*}
\]

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, \( \lim_{t \to \infty} y_i(t) \):

\[
\begin{align*}
\text{i) } & Y_1(s) = \frac{s-1}{s+3} \\
\text{ii) } & Y_2(s) = \frac{(s+1)}{(s+3)^2} \\
\text{iii) } & Y_3(s) = \frac{(s-1)}{(s+3)^2} \\
\text{iv) } & Y_4(s) = \frac{s+2}{s(s+1)} \\
\text{v) } & Y_5(s) = \frac{(s+3)^2}{s^2}
\end{align*}
\]

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.