Due at 1700, Fri. Sep. 6 on BCourses.

Note: up to 2 students may turn in a single writeup. Reading Nise 1,2.

1. (20 pts) Case study (Nise 1.4)

In an aircraft, the roll rate can be controlled by ailerons as shown in Fig. 1. A gyroscope is used to measure actual roll angle rate. Assume a reference input r (from pilot) is used to specify desired roll angle rate.

a) Draw a functional block diagram for a roll angle rate control system. Show all blocks and signals, identify input and output transducers, controller and plant.

b) Suppose the gyro fails (e.g. stuck at maximum full range). Draw a block diagram for a controller which could allow pilot to reasonably handle this case.

2. (20 pts) Static Nonlinearity in Feedback

A nonlinear amplifier has voltage response $g(\varepsilon) = 1000 \log(\varepsilon + 1)$. Let $\delta(t) = 0$. The nonlinear amplifier is used in a negative feedback system as shown in Fig. 2, with $k = \frac{1}{3}$.

a) Assume $|x(t)| << 1$. Using Taylor series approximation, show that $y(t) \approx 3x(t)$.

b) Consider constant output $y_1 = 3$. Without approximations, find the value of input x corresponding to this output.

c) Consider constant output $y_2 = 6$. Without approximations, find the value of input x corresponding to this output.

d) What is the per cent error for b) and c) compared to an ideal gain of 3?

Aside: For stable systems with slow dynamics, with sufficient gain, a learned control law can have wide variation with little effect on reward.

3. (20 pts) Laplace transform review (Nise 2.2)

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

i) $H_1(s) = \frac{1}{s^2+14s+48}$ ii) $H_2(s) = \frac{s}{s^2+14s+48}$ iii) $H_3(s) = \frac{s+10}{s^2+14s+48}$

iv) $H_4(s) = \frac{1}{s^2+6s+18}$ v) $H_5(s) = \frac{1}{s^3+14s^2+48s}$

4. (20 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) $Y_1(s) = \frac{s}{s+5}$ ii) $Y_2(s) = \frac{s-3}{s+5}$ iii) $Y_3(s) = \frac{(s+3)}{s(s+5)}$

iv) $Y_4(s) = \frac{1}{s(s+5)}$ v) $Y_5(s) = \frac{(s+3)^2}{(s+5)^2}$

5. (20 pts) Electrical circuit example (Nise 2.4)

For the circuit in Fig. 3. below, using ideal op-amp assumptions (p. 58 in 6th edition), determine $H(s) = \frac{v_{out}(s)}{v_{in}(s)}$.

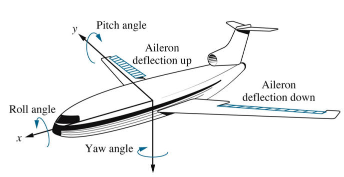

Fig.1.

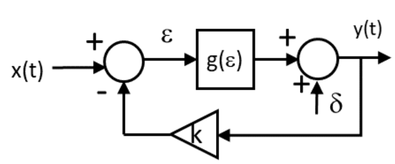

Fig. 2.

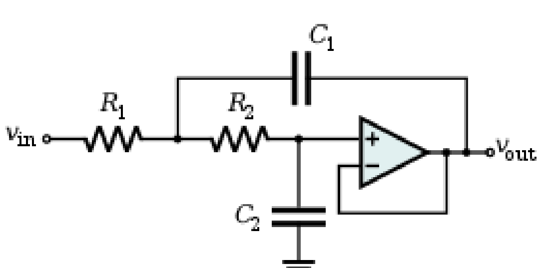

Fig. 3