Due at 1700, Fri. Feb. 20 in homework box under stairs, first floor Cory .
Note: up to 2 students may turn in a single writeup. Reading Nise 5,6,7.

1. (10 pts) Block Diagram Equivalence (Nise 5.2)
Find and draw the unity feedback system that is equivalent to the system in Fig. 1. below.

2. (20 pts) Routh Array (Section 6.4)
In the control system in Fig. 2, $D(s) = 0$, $G_1(s) = k$, $H(s) = 1$, and

$$G_2(s) = \frac{s-2}{(s+1)(s^2+6s+25)}.$$

a. Determine the closed loop transfer function $\frac{C(s)}{R(s)}$.
b. Using the Routh-Hurwitz table, find the range of k for the system to have all closed loop poles in the LHP.

3. (20 pts) Routh Array (Section 6.4)
In the control system in Fig. 2, $D(s) = 0$, $G_1(s)G_2(s) = \frac{k}{s}$, and

$$H(s) = \frac{s-1}{s^2+2s+1)}.$$

a. Determine the closed loop transfer function $\frac{C(s)}{R(s)}$.
b. Using the Routh-Hurwitz table, find the range of k for the system to have all closed loop poles in the LHP.

4. (10 pts) Stability in state space (Nise 6.5)
For the following system, use the Routh array to determine how many eigenvalues are in the RHP, on imaginary axis, and in LHP. Check with Matlab.

$$\dot{\mathbf{x}} = A\mathbf{x} + Bu = \begin{bmatrix} \dot{x_1} \\ \dot{x_2} \\ \dot{x_3} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 3 \\ 2 & 2 & -4 \\ 1 & -4 & 3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} u(t) \text{ , and } \ y = [1 \quad 1 \quad 0]\mathbf{x}$$

5. (20 pts) Steady state error (Nise 7.5)
For the system in Fig. 2, let $G_1(s) = \frac{k_1(s+2)}{s+3}$, $G_2(s) = \frac{k_2}{s(s+4)}$ and $H(s) = 1$. Let $e(t) = r(t) - c(t)$. Find the values of k_1, k_2 such that:
a) The steady state error $e(t)$ due to a unit step disturbance $d(t)$ is -10^{-4};
b) The steady state error $e(t)$ due to a unit ramp input $r(t)$ is 10^{-4};

6. (20 pts) Steady state error (Nise 7.8)
a) Find steady state error for a unit step input, using input substitution.
b) Find steady state error for a unit ramp input, using input substitution.
Given system:

$$\dot{\mathbf{x}} = A\mathbf{x} + Bu = \begin{bmatrix} 0 & 1 & 0 \\ -5 & -9 & 7 \\ -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} r \text{ , and } \ y = [1 \quad 0 \quad 0]\mathbf{x}$$

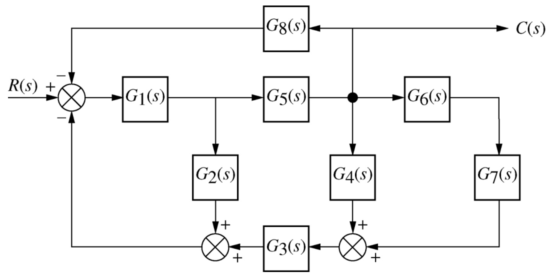

Fig. 1. Block Diagram.

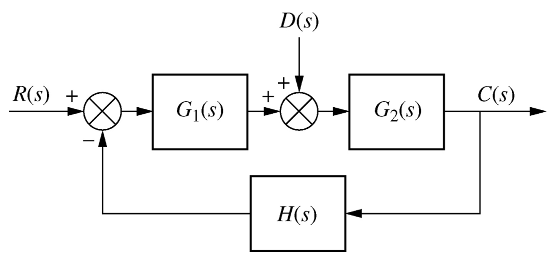

Fig. 2. Control System