Due at 1700, Fri. Feb. 17 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. (18 pts) Pole-Zero cancellation (Nise 4.8)

For the following transfer functions determine if pole-zero cancellation can be approximated. If it can, find percent overshoot, settling time, and peak time from the second order approximation. Using MATLAB, plot the time response for each original function and compare actual percent overshoot, settling time, and peak time to the approximation.

a. $C(s) = \frac{s+3}{s(s+2)(s^2+3s+10)}$

b. $C(s) = \frac{s+2.01}{s(s+2)(s^2+5s+20)}$

2. (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.

3. (22 pts) Routh Array (Section 6.4)

In the control system in Fig. 2, $D(s) = 0$, $G_1(s) = k$, $H(s) = 1$, and

$$G_2(s) = \frac{1}{(s+1)(s+2)(s+5)(s+6)}.$$

[2pts] a. Determine the closed loop transfer function $\frac{C(s)}{R(s)}$.

[16pts] b. Using the Routh-Hurwitz table, find the range of k for the system to have all closed loop poles in the LHP.

[4pts] c. Find the value of k for marginal stability, and determine the location of the closed loop poles for this value of k.

4. (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

ver 1.01 CHANGE OF POLE from s to s+1:

$$G_2(s) = \frac{s+2}{(s+1)(s-1)(s+3)}.$$

[2pts] a. Determine the closed loop transfer function $\frac{C(s)}{R(s)}$.

[18pts] b. Using the Routh-Hurwitz table, find the range of k for the system to have all closed loop poles in the LHP.

5. (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.

$$\dot{\mathbf{x}} = A\mathbf{x} + Bu = \begin{bmatrix} \dot{x_1} \\ \dot{x_2} \\ \dot{x_3} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & -4 \\ -1 & 1 & 8 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t) \text{ , and } \; y = [0 \quad 0 \quad 1]\mathbf{x}$$

6. (20 pts) Steady state error (Nise 7.5)

For the system in Fig. 2, let $G_1(s) = \frac{k_1}{s(s+5)}$, $G_2(s) = \frac{k_2}{s(s+4)}$ and $H(s) = \frac{s+1}{s+2}$.

[6pts] a. Find transfer functions $\frac{E(s)}{R(s)}$ and $\frac{E(s)}{D(s)}$.

Let $e(t) = r(t) - c(t)$. Find the values of k_1, k_2 such that:

[7pts] b. The steady state error $|e(t)|$ due to a unit ramp disturbance $d(t) = tu(t)$ is $< 10^{-4}$;

[7pts] c. The steady state error $e(t)$ due to a unit ramp input $r(t) = tu(t)$ is $< 10^{-4}$;

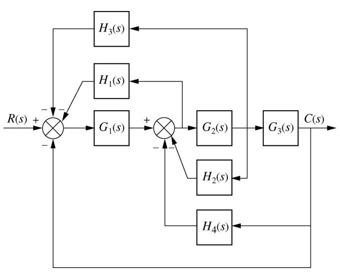

Fig. 1. Block Diagram.

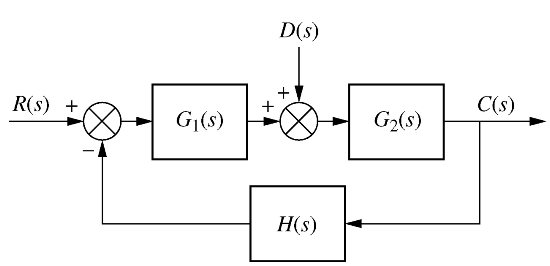

Fig. 2. Control System