Due at 1700, Fri. Sep 21 on bcourses. .
Note: up to 2 students may turn in a single writeup. Reading Nise 5-5.6, 6

1. (20 pts) Pole-Zero cancellation (Nise 4.8)
For the following transfer functions determine if pole-zero cancellation can be approximated by examining terms of the partial fraction expansion. Using MATLAB, plot the step response for the original system and the system assuming pole-zero cancellation. (Normalize amplitude so that final value is -1 for approximated systems). Briefly discuss if the step response for the approximation is reasonably close to the orignal system.

a. $C(s) = 120\frac{(s+2)(s-2)}{(s+4)(s+10)(s+12)}$

b. $C(s) = \frac{240}{7}\frac{(s+3.5)(s-2)}{(s+4)(s+10)(s+12)}$

2. (25 pts) Time Domain Solution - Convolution (Nise 4.11)
a. Find $\mathbf{x}(t)$ and $y(t)$ using convolution (4.109) for the system below with unit step input $u(t)$:
b. Show that the $\mathbf{x}(t)$ found above is a solution to $\dot{\mathbf{x}} = A\mathbf{x} + Bu$ (by direct substitution).

$$\dot{\mathbf{x}} = A\mathbf{x} + Bu = \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -10 & -7 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}u(t) , \quad \mathbf{x}(0) = \begin{bmatrix} 2 \\ 1 \end{bmatrix} \text{ and } y = \begin{bmatrix} 1 & 3 \end{bmatrix}\mathbf{x}$$

3. (15 pts) Block Diagram Equivalence (Nise 5.2)
Find and draw the unity feedback system that is equivalent to the system in Fig. 1. below.

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

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

[2pts] a. Determine the closed loop transfer function $\frac{C(s)}{R(s)}$.
[14pts] 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.

5. (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

$$G_2(s) = \frac{(s + 3)(s + 5)}{(s - 2)(s - 4)}.$$

[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.
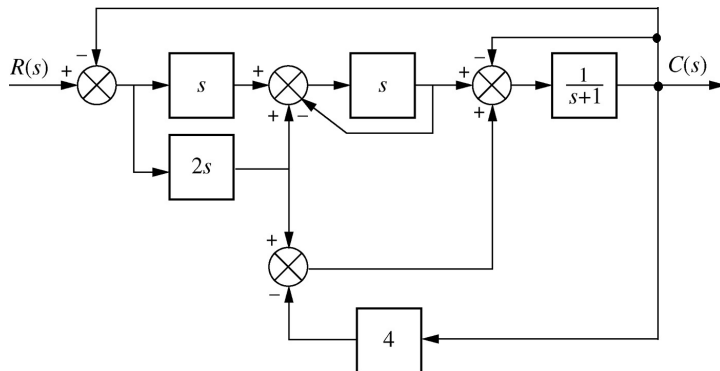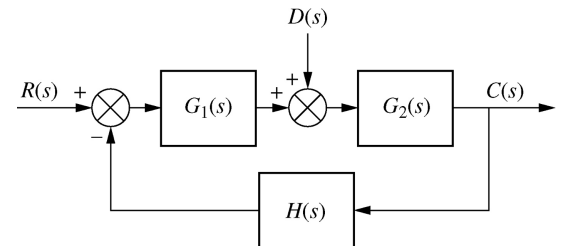

Fig. 1. Block Diagram.   Fig. 2. Control System