

**Department of Electrical and Computer Engineering**  
University of Massachusetts Lowell  
EECE 4130 Problem Set 3

1. Consider the a uncontrolled system where the open-loop transfer function is given by

$$G(s) = \frac{(s + 6)}{s(s + 3)(s + 10)}$$

and the input is  $X(s)$  and the output is  $Y(s)$ .

- a. Given the feedback gain is  $H(s)$  determine the transfer function  $Y(s)/X(s)$  for the negative feedback system.
- b. If the error is defined as  $E = X - YH$  determine  $E/X$ .
- c. For  $x(t) = tu(t)$  find  $H(s)$  such that

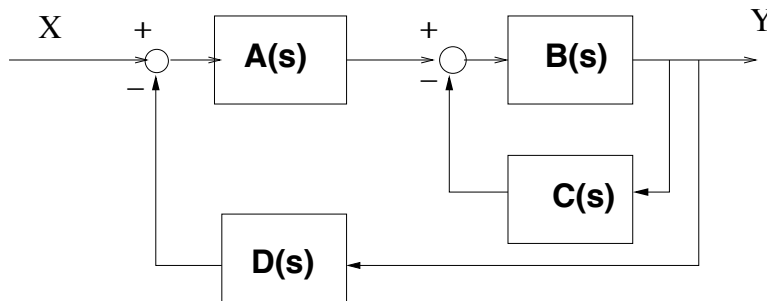
$$\lim_{t \rightarrow \infty} \frac{de}{dt} = \frac{1}{10}$$

2. The error in a unity feedback system is the error  $e(t) = x - y$  where  $x$  is the input and  $y$  is the output. The open loop-transfer function is

$$G(s) = \frac{5000}{s(s + 75)}$$

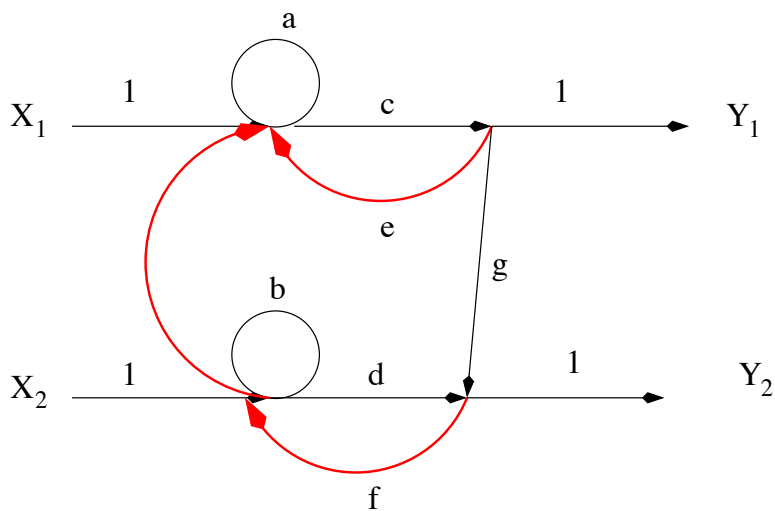
- a. Determine the steady state error for  $x = 5u(t)$
- b. Determine the steady state error for  $x = 5t^2u(t)$ .

3. Given the block diagram shown below



- a. Determine its signal flow graph realization.
- b. Using Mason's gain formula determine  $Y(s)/X(s)$ .

4. Given the signal flow graph below determine the transfer matrix  $A$  where  $A_{ij} = Y_i/X_j$ .



$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$$

Note that  $A_{ij} = Y_i/X_j$  given that all other inputs are equal to zero.

5. Given the system equations

$$\begin{aligned} \frac{dx_1}{dt} &= x_1 + 5x_2 \\ \frac{dx_2}{dt} &= 2x_1 + u \end{aligned}$$

- a. Using only amplifiers and integrators draw a signal-flow graph representation of the system where  $U(s)$  is the input and  $X_1(s)$  is the output. You may assume zero initial conditions.
- b. Find the transfer function  $X_1(s)/U(s)$  using Mason's Gain formula. Check your result using an algebraic approach.