1. Consider the 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

\[ \lim_{t \to \infty} \frac{de}{dt} = \frac{1}{10} \]

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

\[ \begin{array}{c}
\text{X} \\
\text{A(s)} \\
\text{B(s)} \\
\text{C(s)} \\
\text{D(s)} \\
\text{Y}
\end{array} \]

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

\[
\begin{align*}
\frac{dx_1}{dt} &= x_1 + 5x_2 \\
\frac{dx_2}{dt} &= 2x_1 + u
\end{align*}
\]

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.