1. (a) Find the closed-loop transfer function \( T(s) = \frac{Y(s)}{U(s)} \). (5%) 
(b) Determine the undamped natural frequency \( \omega_n \) and the damping ratio \( \zeta \) of the closed-loop system. Solve for the value of \( K \) for which \( \omega_n = 5 \text{ rad/s} \), and find the corresponding value of \( \zeta \). (10%) 
(c) Find the steady-state value of the response when the input is a step function of height 5 and when \( K \) has the value determined in part (b). (5%) 

2. The system input is the force, \( f(t) \), and the output is the displacement \( x_2 \) of the massless junction \( A \) as shown. 
(a) Find the state equation and output equation. (10%) 
(b) Repeat the problem when the dashpot \( B_2 \) is removed. (10%) 

3. Consider the system defined by

\[
\begin{bmatrix}
  x_1 \\
  x_2
\end{bmatrix} =
\begin{bmatrix}
  -1 & 1 \\
  0 & 2
\end{bmatrix}
\begin{bmatrix}
  x_1 \\
  x_2
\end{bmatrix}
+ 
\begin{bmatrix}
  1 \\
  0
\end{bmatrix} u
\]

Show that the system cannot be stabilized by the state feedback control scheme

\[ u = -K \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \] whatever matrix \( K \) is chosen. (10%)
4. Consider the system shown in Fig. (a), where \( G(s) = \frac{K}{(s+3)(s+6)} \)

(A) Sketch the root locus for the system (5%)
(B) Find the value of \( K \) to let damping ratio \( \zeta = 0.707 \) (5%)
(C) Determine the %OSS, Ts, KP for an step input. (10%)
(D) Design an idea controller to drive the step response error to zero (5%)

![Figure (a)](image)

5. Given the unity feedback system of Fig. (a), where \( G(s) = \frac{K}{s(s+5)(s+7)} \)

(A) Draw the Bode plots of the system (10%)
(B) Use Bode plots to determine the range of \( K \) within which the system is stable (5%)
(C) Use frequency response methods to determine the value of gain, \( K \), to yield a step response with a 20% overshoot. (10%)