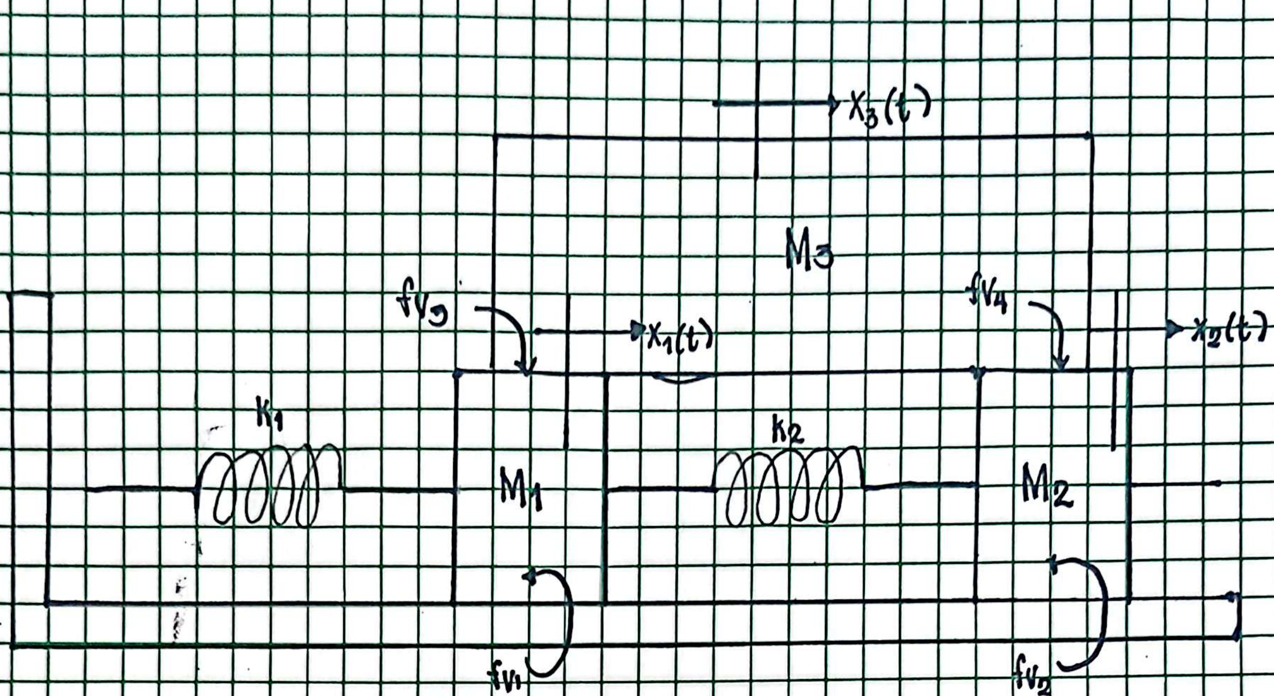
PROBLEM 1



FOR M_1

$$0 = M_1 X_1 + B_1\dot{X}_1 + B_3\dot{X}_1 + K_1X_1 + K_2X_1 - B_3\dot{X}_3 - K_2X_2$$

$$f(t) = M_2\dot{X}_2 + B_2\dot{X}_2 + B_1\dot{X}_2 + K_2X_2 - B_1\dot{X}_3 - K_2X_1$$

$$0 = M_3\ddot{X}_3 + B_3\dot{X}_3 + B_4\dot{X}_3 - B_1\dot{X}_1 - B_2\dot{X}_2$$

$X_1 = X_1(t)$	$X_3 = X_2(t)$	$X_5 = X_3(t)$
$X_2 = \dot{X}_1(t)$	$X_4 = \dot{X}_2(t)$	$X_6 = \dot{X}_3(t)$
$\dot{X}_1 = \dot{x}_1(t) = X_2$	$\dot{X}_3 = \dot{x}_2(t) = X_4$	$\dot{X}_5 = \dot{X}_3(t) = X_6$
$\dot{X}_2 = \ddot{x}_2(t)$	$\dot{X}_4 = \ddot{x}_2(t)$	$\dot{X}_6 = \ddot{X}_3$

$$\dot{X} = 0X_1 + X_2 + 0X_3 + 0X_4 + 0X_5 + 0X_6 + 0U_1$$

$$\dot{x}_2 = -\left(\frac{K_1 + K_2}{M_1}\right)x_1 - \left(\frac{B_1 + B_3}{M_1}\right)x_2 + \left(\frac{K_2}{M_1}\right)x_3 + 0X_4 + 0X_5 + \left(\frac{B_3}{M_1}\right)x_6 + 0U_1$$

$$\dot{x}_3 = 0X_1 + 0X_2 + 0X_3 + X_4 + 0X_5 + 0X_6 + 0U_1$$

$$\dot{x}_4 = \left(\frac{K_2}{M_2}\right)x_1 + 0X_2 - \left(\frac{K_2}{M_2}\right)x_3 - \left(\frac{B_2 + B_4}{M_2}\right)x_4 - 0X_5 + \left(\frac{B_4}{M_2}\right)x_6 + 0U_1$$

$$\dot{x}_5 = 0X_1 + 0X_2 + 0X_3 + 0X_4 + 0X_5 + X_6 + 0U_1$$

$$\dot{x}_6 = 0X_1 + \left(\frac{B_1}{M_3}\right)x_2 - 0X_3 + \left(\frac{B_2}{M_3}\right)x_4 + 0X_5 - \left(\frac{B_3 + B_4}{M_3}\right)x_6 + 0U_1$$

$Y_1 = X_1 + 0U_1$
$Y_2 = X_3 + 0U_1$
$Y_3 = X_5 + 0U_1$

STATE SPACE EQUATION

$$
\begin{array}{c} \\ \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \\ \dot{x}_5 \\ \dot{x}_6 \end{array}
\begin{array}{c}
\begin{array}{cccccc} x_1 & x_2 & x_3 & x_4 & x_5 & x_6 \end{array} \\
\begin{bmatrix}
0 & 1 & 0 & 0 & 0 & 0 \\
-\left(\frac{K_1+K_2}{M_1}\right) & -\left(\frac{B_1+B_3}{M_1}\right) & \frac{K_2}{M_1} & 0 & 0 & \frac{B_3}{M_1} \\
0 & 0 & 0 & 1 & 0 & 0 \\
\frac{K_2}{M_2} & 0 & -\frac{K_2}{M_2} & -\frac{B_2+B_4}{M_2} & 0 & \frac{B_4}{M_2} \\
0 & 0 & 0 & 0 & 0 & 1 \\
0 & \frac{B_1}{M_3} & 0 & \frac{B_2}{M_3} & 0 & -\frac{B_2+B_4}{M_3}
\end{bmatrix}
\end{array}
\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix}
+
\begin{bmatrix} 0 \\ 0 \\ \frac{1}{M_2} \\ 0 \\ 0 \\ 0 \end{bmatrix} U_1
$$

$$
Y =
\begin{array}{c}
\begin{array}{cccccc} X_1 & X_2 & X_3 & X_4 & X_5 & X_6 \end{array} \\
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0
\end{bmatrix}
\end{array}
\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix}
+
\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} U_1
$$

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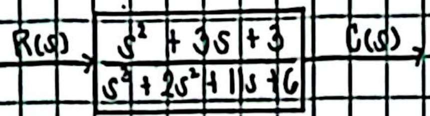
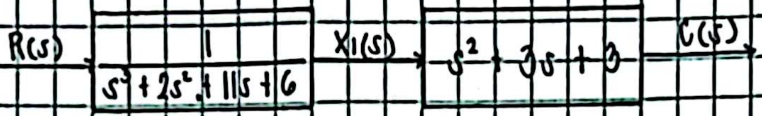
PROBLEM 3





$$\frac{X_1(s)}{R(s)} = \frac{1}{s^3+2s^2+11s+6}$$

$$X_1(s)\left[s^3+2s^2+11s+6\right] = R(s)$$

$$\mathcal{L}^{-1}\left\{s^3X_1(s)+2s^2X_1(s)+11sX_1(s)+6X_1(s) = R(s)\right\}$$

$$\underset{\dot{x}_3}{\dddot{x}_1} + 2\underset{x_3}{\ddot{x}_1} + 11\underset{x_2}{\dot{x}_1} + 6\underset{x_1}{x_1} = \underset{u_1}{r}$$

$x_1 = x_1 \qquad \dot{x}_1 = \dot{x}_1 = x_2 \qquad u = r$

$x_2 = \dot{x}_1 \qquad \dot{x}_2 = \ddot{x}_1 = x_3$

$x_3 = \ddot{x}_1 \qquad \dot{x}_3 = \dddot{x}_1$

$\dot{x}_1 = 0x_1 + x_2 + 0x_3 + 0u_1$

$\dot{x}_2 = 0x_1 + 0x_2 + x_3 + 0u_1$

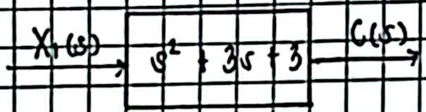
$\dot{x}_3 = -6x_1 - 11x_2 - 2x_3 + u_1$

STATE SPACE EQUATION

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix} = \begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u_1$$

$$y = \begin{array}{c} \begin{array}{ccc} x_1 & x_2 & x_3 \end{array} \\ \begin{bmatrix}3 & 3 & 1\end{bmatrix} \end{array} \begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + [0]u_1$$

FOR OUTPUT EQUATION



$$\frac{C(s)}{X_1(s)} = s^2+3s+3$$

$$\mathcal{L}^{-1}\left\{C(s) = s^2X_1(s) + 3sX_1(s) + 3X_1(s)\right\}$$

$C = \ddot{x}_1 + 3\dot{x}_1 + 3x_1$

$y = \ddot{x}_1 + 3\dot{x}_1 + 3x_1$

$y = x_3 + 3x_2 + 3x_1$