AYETI GBOLAHAN S.
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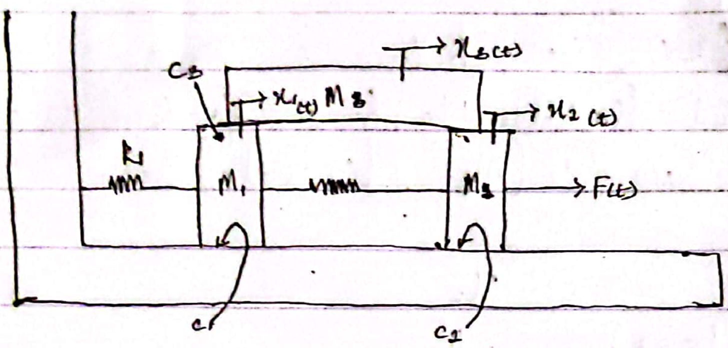
MEC 403 (ASSIGNMENT)
400lv

Mechanical engineering.

1) Give a mechanical System, resolve the form of the block diagram & calculate the transfer function.



Write the equation of motion that relates them together.

→ Mass M_1

$$\begin{bmatrix}\text{Sum of Impedances} \\ \text{Connected to motion} \\ \text{of } M_1\end{bmatrix} x_{1(s)} - \begin{bmatrix}\text{Sum of Impedances} \\ \text{between } M_1 \text{ and } M_2\end{bmatrix} x_{2(s)} -$$

$$\begin{bmatrix}\text{Sum of Impedances} \\ \text{between } M_1 \text{ and } M_3\end{bmatrix} x_{3(s)} = \begin{bmatrix}\text{Sum of applied} \\ \text{Forces at } M_1\end{bmatrix}$$

$$\left[M_1 s^2 + (C_1+C_3)s + (K_1+K_2)\right]X_{1(s)} - K_2 X_{2(s)} - C_3 s X_{3(s)} = 0 \quad \ldots\ldots (1)$$

→ MASS M_2

$$\begin{bmatrix}\text{Sum of Impedances} \\ \text{Connected to the} \\ \text{motion } M_2\end{bmatrix} X_{2(s)} - \begin{bmatrix}\text{Sum of Impedances} \\ \text{between } M_1 \text{ and} \\ M_2\end{bmatrix} - \begin{bmatrix}\text{Sum of Impedances} \\ \text{between } M_2 \text{ and } M_3\end{bmatrix} X_3$$

$$= \begin{bmatrix}\text{Sum of applied} \\ \text{Forces at } M_2\end{bmatrix}$$

$$\left[M_2 S^2 + (C_2+C_4)s + K_2\right]X_{2(s)} - K_2 X_{1(s)} - C_4 s X_{3(s)} = F(s) \quad \ldots\ (2)$$

→ Mass M_3

$$\begin{bmatrix}\text{Sum of Impedances}\\ \text{Connected to the}\\ \text{Motion of } M_3\end{bmatrix} X_{3(s)} - \begin{bmatrix}\text{Sum of Impedances}\\ \text{between } m_1 \text{ \& }\\ M_2\end{bmatrix} X_{1(s)} - \begin{bmatrix}\text{Sum of Impedances}\\ \text{between } m_2 \text{ \& } m_3\end{bmatrix} X_{3(s)}$$

$$= \begin{bmatrix}\text{Sum of applied forces}\\ \text{at } M_3\end{bmatrix}.$$

$$\left[M_3 S^2 + (C_3+C_4)_s\right] X_{3(s)} - C_{3s} X_{1(s)} - C_{4s} X_{2(s)} = 0 \quad \dots \quad ③$$

Resolving The EOM

$$\left[M_1 S^2 + (C_3+C_4)s + (k_1+k_2)\right] X_{1(s)} - k_2 X_{2(s)} - C_{3s} X_{3(s)} = 0$$

$$-k_2 X_{1(s)} + \left[M_2 S^2 + [C_2+C_4]_s + k_2\right] X_{2(s)} - C_{4s} X_{3(s)} = F_{(s)}$$

$$-C_{3s} X_{1(s)} - C_{4s} X_{2(s)} + \left[M_3 S^2 + [C_3+C_4]s\right] X_{3(s)} = 0$$

$$\begin{array}{ccc} X_1 & x_2 & x_3 \end{array}$$
$$\begin{vmatrix} M_1 S^2 + (C_3+C_4)_s + (k_1+k_2) & -k_2 & -C_{3s} \\ -k_2 & M_2 S^2 + [C_2+C_4]s + k_2 & -C_{4s} \\ -C_{3s} & -C_{4s} & [M_3 S^2 + (C_3+C_4)]s \end{vmatrix}$$

Using Crammers rule to solve for $x_{1(s)}$.

$$X_{1(s)} = \frac{\begin{vmatrix} 0 & -k_2 & -C_{3s} \\ F_{(s)} & M_2 S^2 + [C_2+C_4)s + k_2 & -C_{4s} \\ 0 & -C_{4s} & M_3 S^2 + [C_3+C_4]s \end{vmatrix}}{\Delta}$$

$$0 \begin{vmatrix} M_2 S^2 + [C_2+C_4]s + k_2 & -C_{4s} \\ -C_{4s} & M_3 S^2 + [C_3+C_4]s \end{vmatrix}$$

$$-[-k_2] \begin{vmatrix} F_{(s)} & -C_{4s} \\ 0 & M_3 s^2 + (C_3+C_4)s \end{vmatrix}$$

$$+[-C_{3s}] \begin{vmatrix} F_{(s)} & M_2 S^2 + (C_2+C_4)s + k_2 \\ 0 & -C_{4(s)} \end{vmatrix}$$

$$= 0 + k_2 \left[F_{(s)} \cdot [M_3 S^2 + (C_3+C_4)s]\right] + C_{3s}\left[F_{(s)} \cdot C_{4(s)}\right]$$

$$= F_{(s)} \left[k_2 \left[M_3 S^2 + (C_3+C_4)s\right] + [C_{3s} \cdot C_{4s}]\right]$$

$$X_{1(s)} = \frac{F_{(s)}\left[k_2\left(M_3 s^2 + (C_3+C_4)s\right] + \left[C_{3s} \cdot C_{4s}\right]\right.}{\Delta}$$

$$\frac{X_{1(s)}}{F_{(s)}} = \frac{k_2\left[M_3 s^2 + [C_3 + C_4)s\right] + (C_{3s} \cdot C_{4s})}{\Delta}$$

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