

Translational Mechanical Systems Transfer Functions - Q.26

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1 Given Question

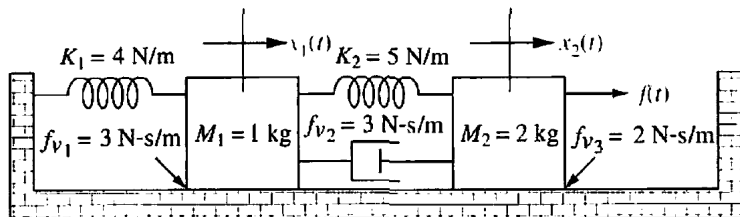
2 Solution

Given Question

Problem 26

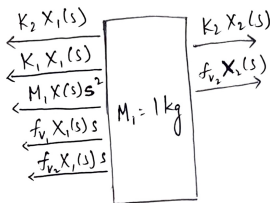
Q.26) For the system in the Figure below, find the transfer function

$$G(s) = X_1(s)/F(s) .$$

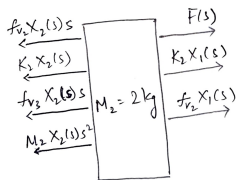


Solution

Free Body Diagrams



Forces acting on first block



Forces acting on second block

Solution

Equations

From the Free Body Diagrams, we get the equations as below,

Equation of the first body,

$$\implies 0 = (K_1 + K_2)X_1(s) + (f_{v_1} + f_{v_2})sX_1(s) + M_1s^2X_1(s) - K_2X_2(s) - f_{v_2}sX_2(s)$$

Equation of the second body,

$$\implies F(s) = K_2X_2(s) + (f_{v_2} + f_{v_3})sX_2(s) + M_2s^2X_2(s) - K_2X_1(s) - f_{v_2}sX_1(s)$$

Solution

Given Values

Substituting these values in the equations above,

$$K_1 = 4N/m$$

$$K_2 = 5N/m$$

$$M_1 = 1Kg$$

$$M_2 = 2Kg$$

$$f_{v_1} = 3Ns/m$$

$$f_{v_2} = 3Ns/m$$

$$f_{v_3} = 2Ns/m$$

Solution

Simplified Equations

$$\implies (s^2 + 6s + 9)X_1(s) - (3s + 5)X_2(s) = 0$$

$$\implies (2s^2 + 5s + 5)X_1(s) - (3s + 5)X_1(s) = F(s)$$

Solving for $X_1(s)$,

$$\implies X_1(s) = \frac{\begin{vmatrix} 0 & -(3s + 5) \\ F(s) & (2s^2 + 5s + 5) \end{vmatrix}}{\begin{vmatrix} (s^2 + 6s + 9) & -(3s + 5) \\ -(3s + 5) & (2s^2 + 5s + 5) \end{vmatrix}}$$

$$\implies X_1(s) = \frac{(3s+5)F(s)}{2s^4+17s^3+44s^2+45s+20}$$

Solution

Final Answer

∴ The Transfer Function is,

$$\Rightarrow G(s) = X_1(s)/F(s) = \frac{(3s+5)}{2s^4+17s^3+44s^2+45s+20}$$