Control systems

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Electrical Engneering
Assignment-1

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Problem Statement

23. Find the transfer function, G(s)= $\frac{X_1(S)}{F(S)}$, for the traslation mechanical system shown in Figure P2.9.

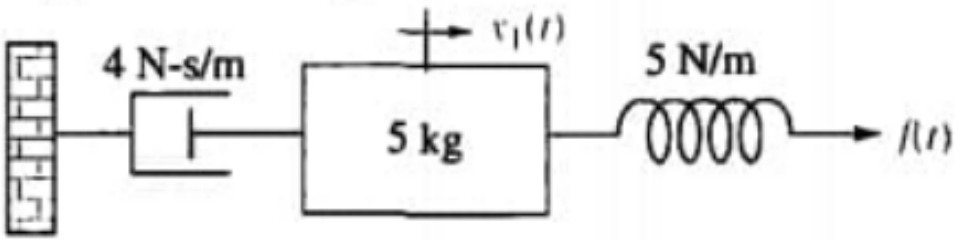

FIGURE P2.9

Solution

X2(t) is the displacement of the right member of the spring as the force is applied to the spring.
Writing the equation of motion
forces act on the block are left direction due to viscous damper, left due to block, left due to displacement
$X_1(t)$ *on spring and right due to displacement* $X_2(t)$ *on spring*.
so the eqation of motion of the block is

$$M\frac{d^2X_1(t)}{dt^2}+f_v\frac{dX_1(t)}{dt} + KX_1(t) = KX_2(t) \quad (3.1)$$

substuting the values we get following equation

$$5\frac{d^2X_1(t)}{dt^2} + 4\frac{dX_1(t)}{dt} + 5X_1(t) = 5X_2(t) \quad (3.2)$$

The laplace transform of the equation of motion is

$$5S^2X_1(S) + 4SX_1(S) + 5X_1(S) - 5X_2(S) = 0 \quad (3.3)$$

$$X_1(S)(5S^2 + 4S + 5) - 5X_2(S) = 0 \quad (3.4)$$

Forces act on the spring are right direction due to displacement X1(t) on spring and left due to displacement X2(t) on spring and force acting right on the spring
the equation of motion of spring

$$KX_2(t) = F(t) + kX_1(t) \tag{3.5}$$

substuting the values we get

$$5X_2(t) = F(t) + 5X_1(t) \tag{3.6}$$

The laplace transform of the equation of motion is

$$5X_2(S) = F(S) + 5X_1(S) \tag{3.7}$$

adding equation (3.4) and (3.7) we get

$$X_1(S)(5S^2 + 4S + 5) = F(S) + 5X_1(S) \tag{3.8}$$

solving the equation (3.8) we get

$$X_1(S)(5S^2 + 4S + 5) - 5X_1(S) = F(S) \tag{3.9}$$

$$X_1(S)(5S^2 + 4S + 5 - 5) = F(S) \tag{3.10}$$

$$X_1(S)(5S^2 + 4S) = F(S) \tag{3.11}$$

Transfer Function

T.F = $\frac{X_1(S)}{F(S)}$

from equation (3.11) we get

$$\frac{X_1(S)}{F(S)} = \frac{1}{S(5S+4)}$$

$$\frac{X_1(S)}{F(S)} = \frac{\frac{1}{5}}{S(S+\frac{4}{5})}$$

$$\text{therefore, T.F} = \frac{\frac{1}{5}}{S(S+\frac{4}{5})}$$