

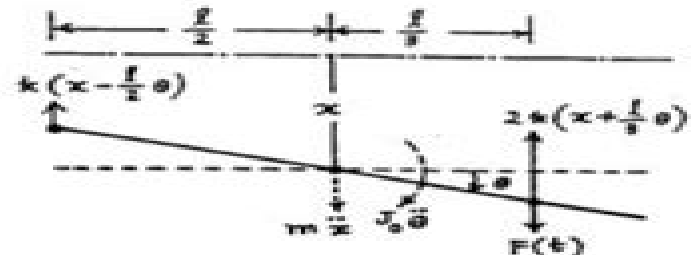
or

$$\begin{bmatrix} m & 0 \\ 0 & J_0 \end{bmatrix} \begin{Bmatrix} \ddot{x} \\ \ddot{\theta} \end{Bmatrix} + \begin{bmatrix} 3k & k\ell/6 \\ k\ell/6 & 17k\ell^2/36 \end{bmatrix} \begin{Bmatrix} x \\ \theta \end{Bmatrix} = \begin{Bmatrix} F(t) \\ \ell F(t)/3 \end{Bmatrix}$$

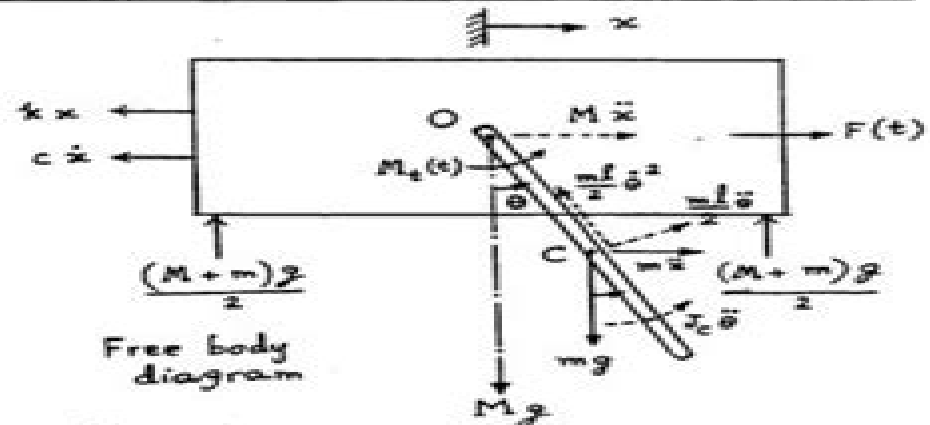
where $J_0 = \frac{m\ell^2}{12}$ and $F(t) = F_0 \sin \omega t$.

(b)

Elastic or static coupling.



5.42



Equations of motion with coordinates $x(t)$ and $\theta(t)$:

For motion along x :

$$M\ddot{x} = -kx - c\dot{x} - (m\ell/2)\ddot{\theta}\cos\theta - m\ddot{x} + (m\ell/2)\ddot{\theta}^2\sin\theta + F(t) \quad (1)$$

For rotation about O:

$$J_c\ddot{\theta} + (m\ell/2)\ddot{\theta}(\ell/2) + m\ddot{x}(\ell\cos\theta/2) = -mg(\ell/2)\sin\theta + M_1(t) \quad (2)$$

Using $J_c = \frac{1}{12}m\ell^2$, $\cos\theta \approx 1$ and $\sin\theta \approx \theta$ and neglecting the nonlinear term involving $\ddot{\theta}^2$ in Eq. (1), Eqs. (1) and (2) can be rewritten in matrix form as:

$$\begin{bmatrix} (M+m) & m\ell/2 \\ m\ell/2 & (J_c + m\ell^2/4) \end{bmatrix} \begin{Bmatrix} \ddot{x} \\ \ddot{\theta} \end{Bmatrix} + \begin{bmatrix} c & 0 \\ 0 & 0 \end{bmatrix} \begin{Bmatrix} \dot{x} \\ \dot{\theta} \end{Bmatrix} + \begin{bmatrix} k & 0 \\ 0 & mg\ell/2 \end{bmatrix} \begin{Bmatrix} x \\ \theta \end{Bmatrix} = \begin{Bmatrix} F(t) \\ M_1(t) \end{Bmatrix}$$

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