

2.3 Solution

(a) Determine the equation of motion of the beam in Fig. 1 in terms of tip displacement v .

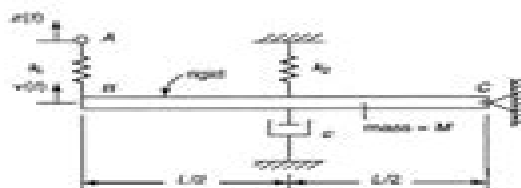


Figure 1



Figure 2

$$\sum M_C = I_C \ddot{\theta}$$

where

$$I_C = \frac{1}{3} M L^2$$

From the free-body diagram (Fig. 2 top),

$$f_{11} L - (f_{22} + f_{12}) \frac{L}{2} = I_C \ddot{\theta}$$

The constitutive relationships of the linear springs and the linear dashpot are:

$$f_{11} = k_1 [z(t) - v], \quad f_{22} = k_2 \frac{v}{2}, \quad f_{12} = c \frac{\dot{v}}{2}$$

From the deformation diagram (Fig. 2 bottom) and kinematics, for small θ ,

$$v = L\theta, \quad \text{or} \quad \theta = \frac{v}{L}$$

Combining the above equations, we get

$$k_1 [z(t) - v] L - \left(k_2 \frac{v}{2} + c \frac{\dot{v}}{2} \right) \frac{L}{2} = \frac{1}{3} M L^2 \left(\frac{\ddot{v}}{L} \right)$$

Finally, the equation of motion of the beam in terms of displacement v is

$$4M\ddot{v} + 3c\dot{v} + (12k_1 + 3k_2)v = 12k_1 z(t) \quad \text{Ans. (a)}$$

(b) Determine the equation of motion of the beam in terms of the spring force f_{11} .

In the above answer to Part (a), substitute the force-deformation of spring 1 in the form

$$v = z(t) - \frac{f_{11}}{k_1}$$

Then, the equation of motion for f_{11} is

$$4M\ddot{f}_{11} + 3c\dot{f}_{11} + (12k_1 + 3k_2)f_{11} = k_1(4M\ddot{z} + 3c\dot{z} + 3k_2 z) \quad \text{Ans. (b)}$$

Although the left-hand sides of these two equations of motion have exactly the same form, the right-hand side of Ans. (b) is more complicated.

Fundamentals Of Structural Dynamics

Robert N. Coppelino



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Special Topics in Structural Dynamics, Volume 6 Randall Allemang, James De Clerck, Christopher Niezrecki, Alfred Wicks, 2025-08-07 Special Topics in Structural Dynamics Volume 6 Proceedings of the 31st IMAC A Conference and Exposition on Structural Dynamics 2013 the sixth volume of seven from the Conference brings together contributions to this important area of research and engineering The collection presents early findings and case studies on fundamental and applied aspects of Structural Dynamics including papers on Teaching Experimental Analytical Structural Dynamics Sensors Instrumentation Aircraft Aerospace Bio Dynamics Sports Equipment Dynamics Advanced ODS Stress Estimation Shock Vibration Full Field Optical Measurements Image Analysis Structural Health Monitoring Operational Modal Analysis Wind Turbine Dynamics Rotating Machinery Finite Element Methods Energy Harvesting

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