

## 2.1 Solution

(a) Determine the equation of motion of the mass  $m$  in Fig. 1.



Figure 1

To determine the stiffness of the columns, we can use the unit dummy load method.



Figure 2

$$u = \int_0^L \frac{(-Fx)(-x)}{EI} dx + \int_0^L \frac{M(-x)}{EI} dx$$

$$= \frac{FL^3}{3EI} - \frac{ML^2}{2EI}$$

$$\theta = \int_0^L \frac{(-Fx)(1)}{EI} dx + \int_0^L \frac{M(1)}{EI} dx$$

$$= -\frac{FL^2}{2EI} + \frac{ML}{EI}$$

Since  $\theta = 0$ ,

$$M = \frac{FL}{2} \quad \text{and} \quad F = \frac{12EI}{L^3}u = ku$$



Figure 3

$$\sum F_x = m\ddot{u}$$

From the free-body diagram in Fig. 3,

$$-F_B - F_C = -\frac{12EI}{L^3}u - \frac{12EI}{L^3}u = m\ddot{u}$$

$$m\ddot{u} + \frac{24EI}{L^3}u = 0$$

Ans. (a)

(b) How would the equation of motion differ if the left-hand column had a stiffness  $2EI$ , with no other changes to the structure?

$$-F_B - F_C = -\frac{12(2EI)}{L^3}u - \frac{12EI}{L^3}u = m\ddot{u}$$

$$m\ddot{u} + \frac{36EI}{L^3}u = 0$$

Ans. (b)

# Fundamentals Of Structural Dynamics

**Levon Gregory Petrosian**



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