

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

$$\begin{aligned}
 u &= \int_0^L \frac{(-Fx)(-x)}{EI} dx + \int_0^L \frac{M(-x)}{EI} dx \\
 &= \frac{FL^3}{3EI} - \frac{ML^2}{2EI} \\
 \theta &= \int_0^L \frac{(-Fx)(1)}{EI} dx + \int_0^L \frac{M(1)}{EI} dx \\
 &= -\frac{FL^2}{2EI} + \frac{ML}{EI}
 \end{aligned}$$

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

Michael Seilmaier



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