3.11 A spring-mass system, resting on an inclined plane, is subjected to a harmonic force as shown in Fig. 3.38. Find the response of the system by assuming zero initial conditions.

3.12 The natural frequency of vibration of a person is found to be 5.2 Hz while standing on a horizontal floor. Assuming damping to be negligible, determine the following:

a. If the weight of the person is 70 kg_f, determine the equivalent stiffness of his body in the vertical direction.

b. If the floor is subjected to a vertical harmonic vibration of frequency of 5.3 Hz and amplitude of 0.1 m due to an unbalanced rotating machine operating on the floor, determine the vertical displacement of the person.

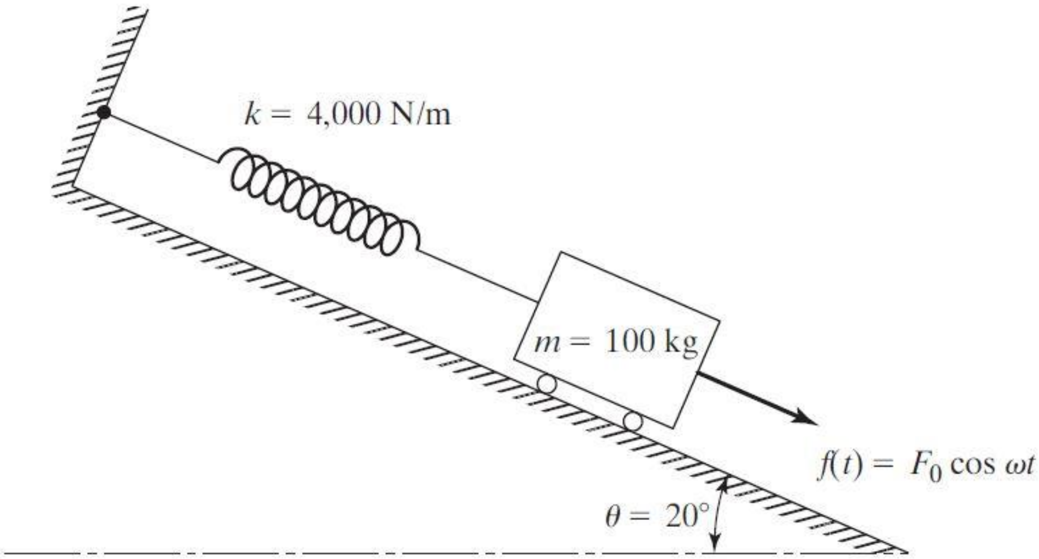
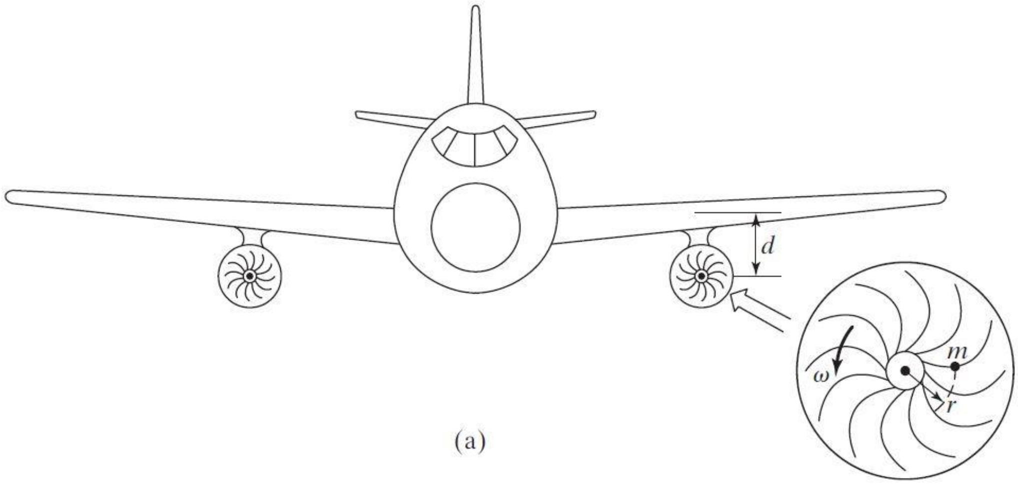


FIGURE 3.38

3.14 A spring-mass system is set to vibrate from zero initial conditions under a harmonic force. The response is found to exhibit the phenomenon of beats with the period of beating equal to 0.5 s and the period of oscillation equal to 0.05 s. Find the natural frequency of the system and the frequency of the harmonic force.

3.16 An aircraft engine has a rotating unbalanced mass m at radius r. If the wing can be modeled as a cantilever beam of uniform cross section $a \times b$, as shown in Fig. 3.39(b), determine the maximum deflection of the engine at a speed of N rpm. Assume damping and effect of the wing between the engine and the free end to be negligible.



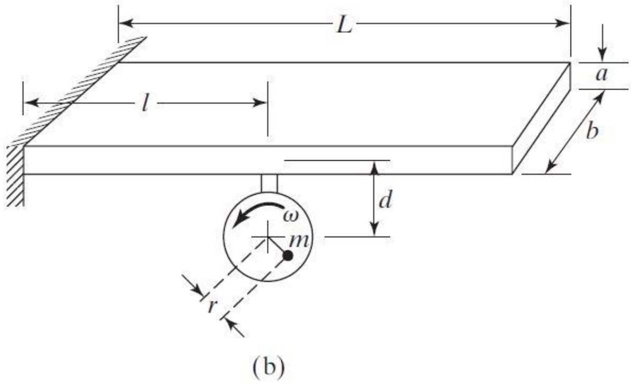


FIGURE 3.39

3.30 A four-cylinder automobile engine is to be supported on three shock mounts, as indicated in Fig. 3.46. The engine-block assembly weighs 500 lb. If the unbalanced force generated by the engine is given by 200 sin 100 πt lb, design the three shock mounts (each of stiffness k and viscous-damping constant c) such that the amplitude of vibration is less than 0.1 in.

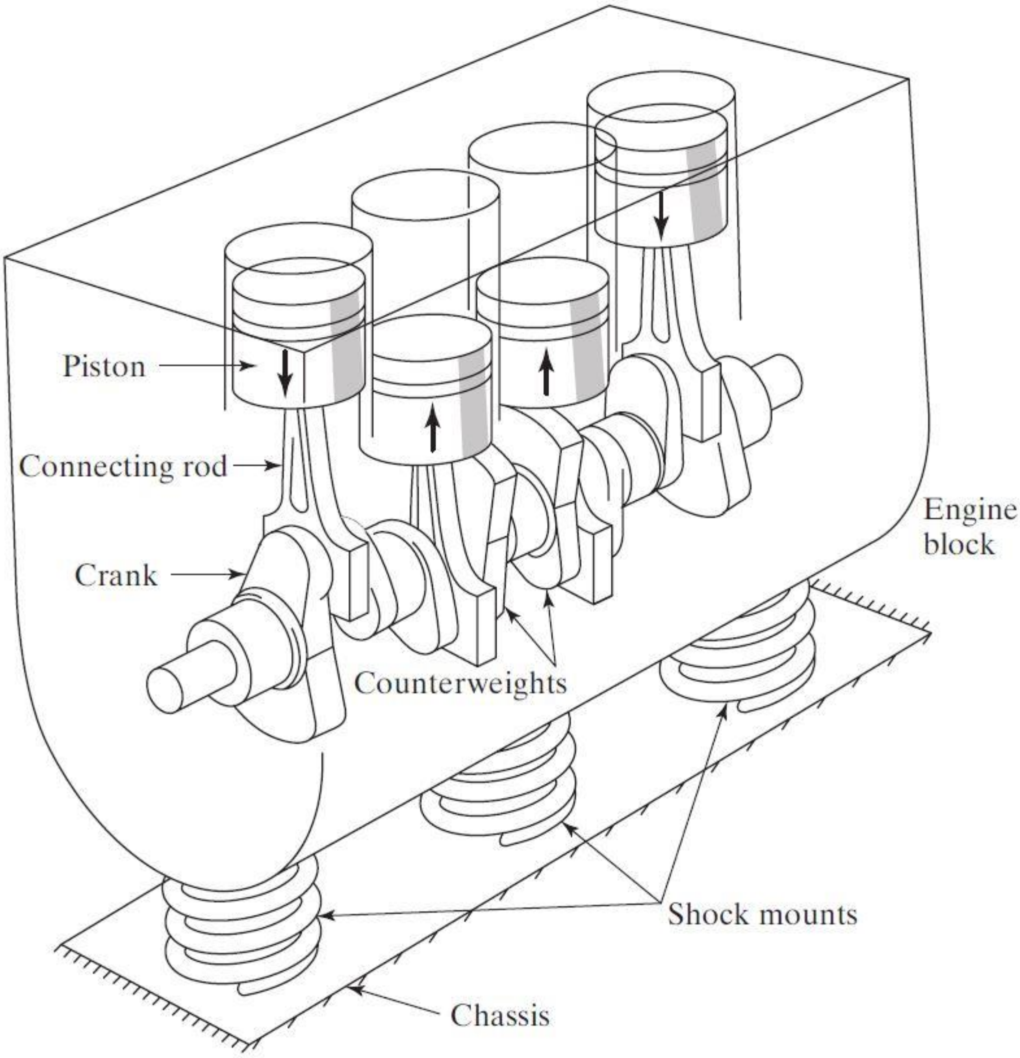


FIGURE 3.46 Four-cylinder automobile engine.

3.31 The propeller of a ship, of weight 10^5 N and polar mass moment of inertia 10,000 kg-m^2, is connected to the engine through a hollow stepped steel propeller shaft, as shown in Fig. 3.47. Assuming that water provides a viscous damping ratio of 0.1, determine the torsional vibratory response of the propeller when the engine induces a harmonic angular displacement of $0.05 \sin 314.16t$ rad at the base (point A) of the propeller shaft.

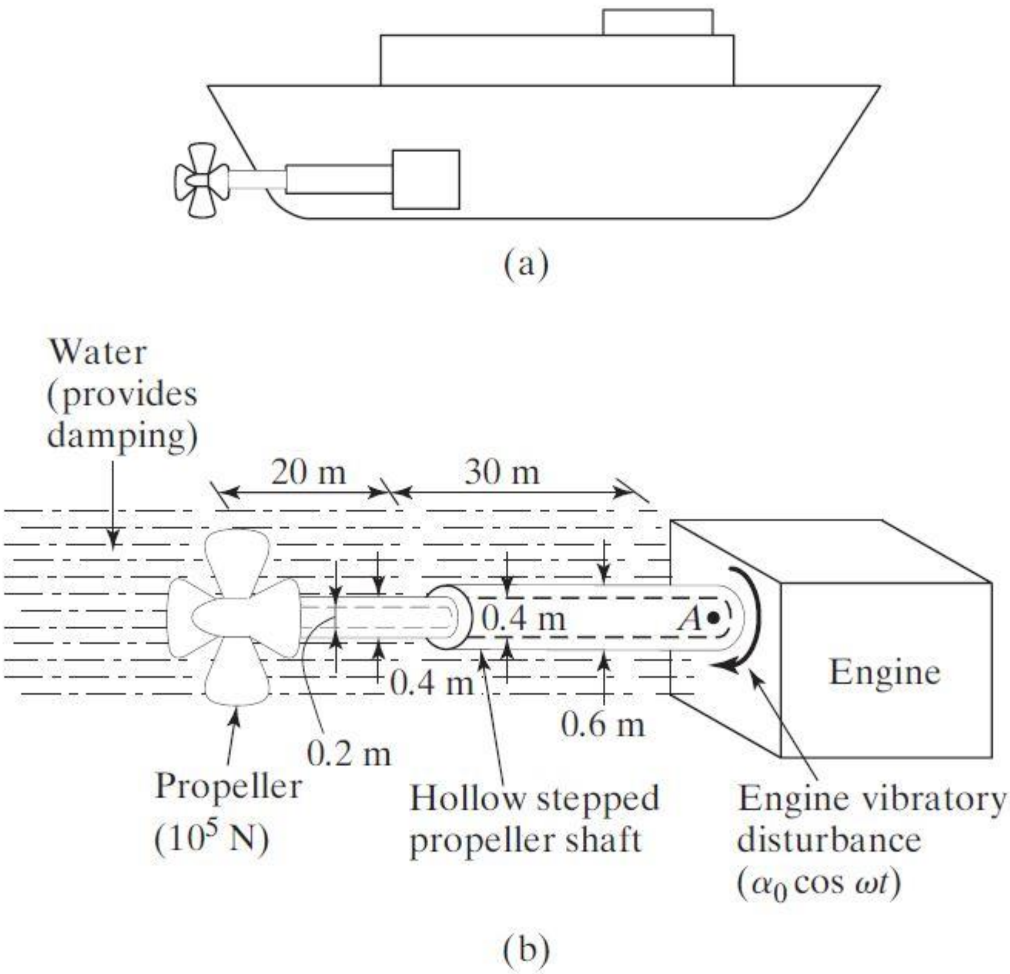


FIGURE 3.47 Propeller of a ship.

3.44 The landing gear of an airplane can be idealized as the spring-mass-damper system shown in Fig. 3.52. If the runway surface is described $y(t) = y_0 \cos \omega t$, determine the values of k and c that limit the amplitude of vibration of the airplane (x) to 0.1 m. Assume $m = 2000$ kg, $y_0 = 0.2$ m, and $\omega = 157.08$ rad/s.

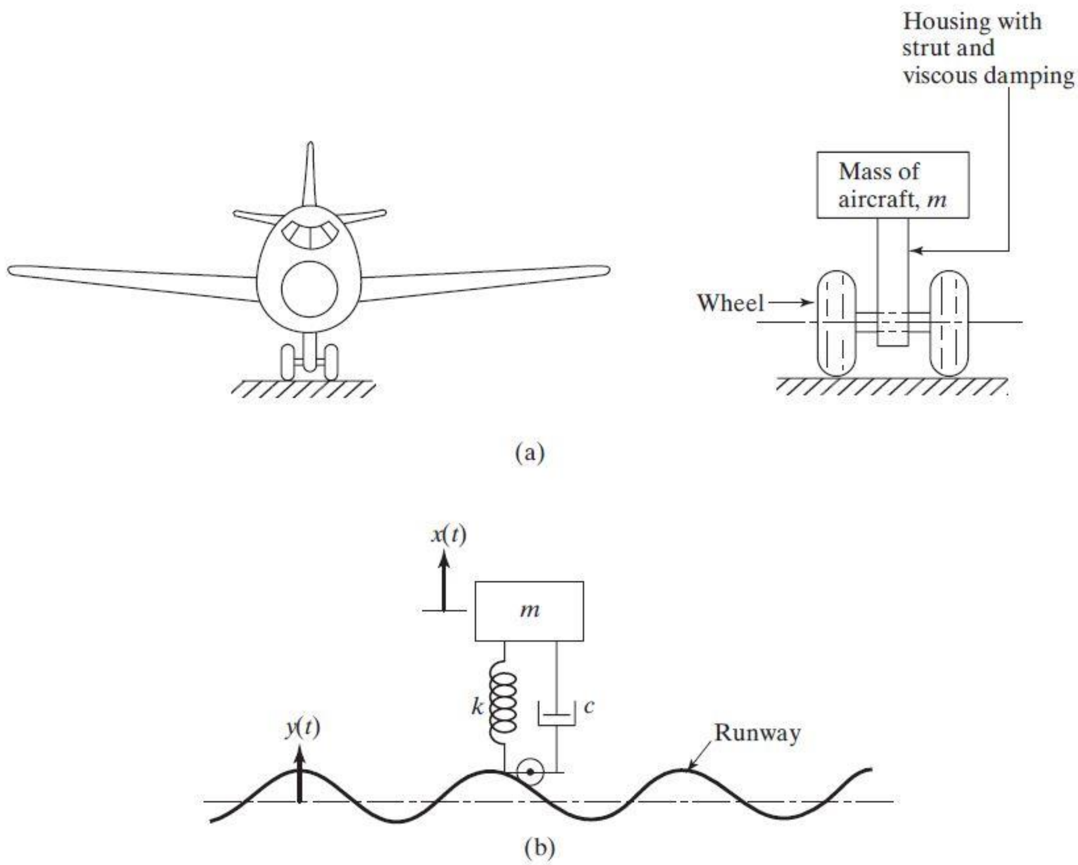


FIGURE 3.52 Modeling of landing gear.

5.1 Derive the equations of motion of the system shown in Fig. 5.20.

5.2 Derive the equations of motion of the system shown in Fig. 5.21.

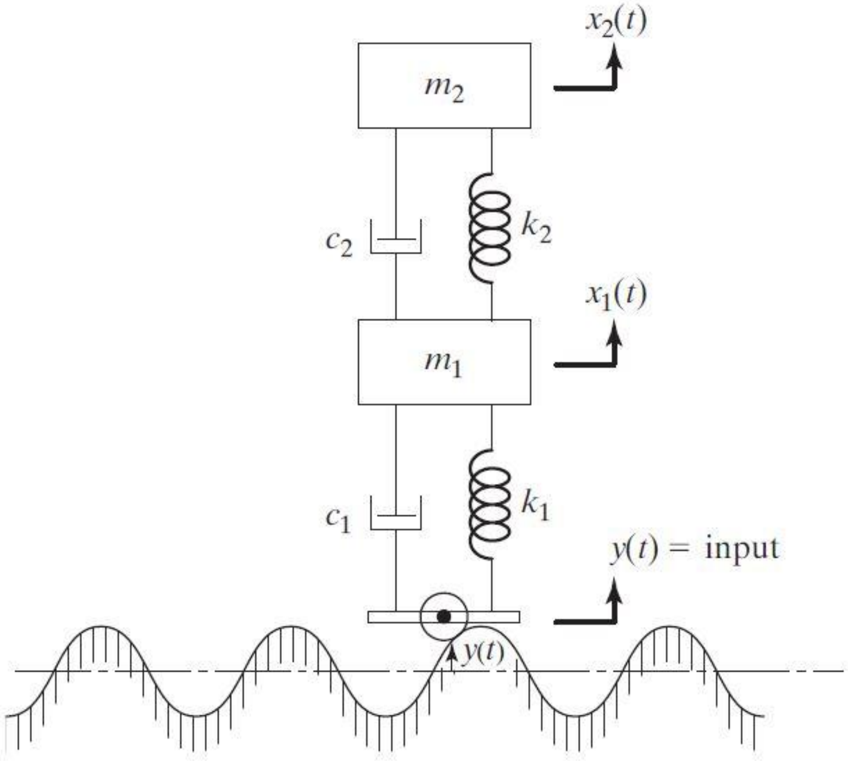


FIGURE 5.20

5.5 Find the natural frequencies of the system shown in Fig. 5.24, with $m_1 = m$, $m_2 = 2m$, $k_1 = k$, and $k_2 = 2k$. Determine the response of the system when $k = 1000$ N/m, $m = 20$ kg, and the initial values of the displacements of the masses m_1 and m_2 are 1 and -1, respectively.

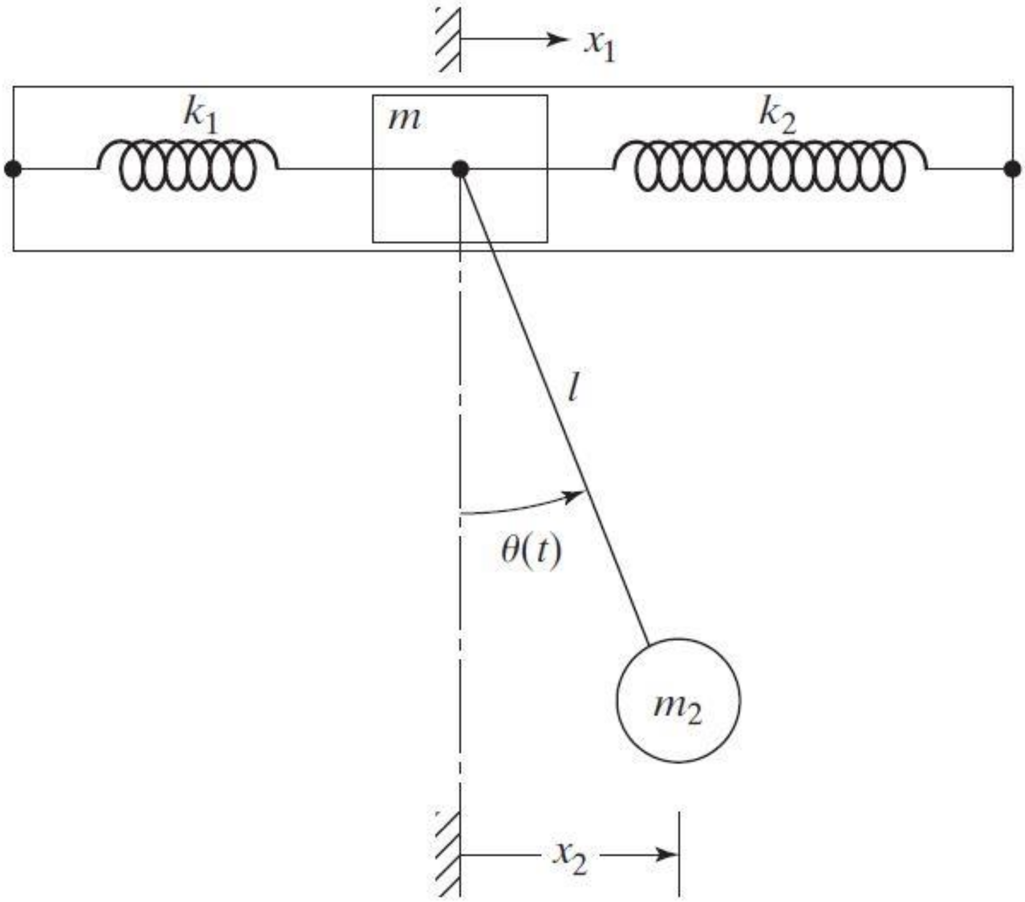


FIGURE 5.23

5.6 Set up the differential equations of motion for the double pendulum shown in Fig. 5.25, using the coordinates x_1 and x_2 and assuming small amplitudes. Find the natural frequencies, the ratios of amplitudes, and the locations of nodes for the two modes of vibration when $m_1 = m_2 = m$ and $l_1 = l_2 = l$.

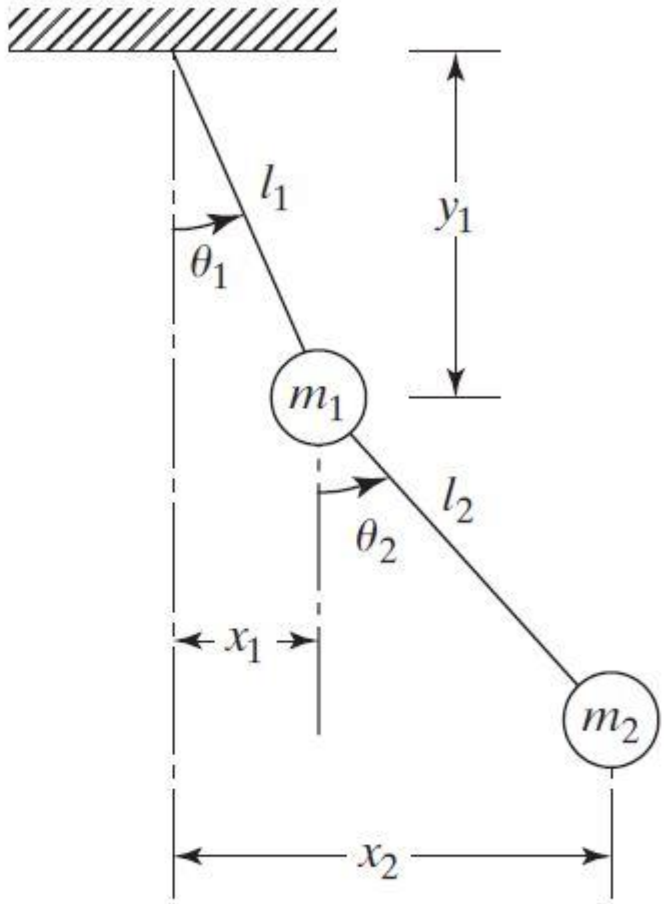


FIGURE 5.25

5.14 Find the natural frequencies and mode shapes of the system shown in Fig. 5.24 for $m_1 = m_2 = m$ and $k_1 = k_2 = k$.

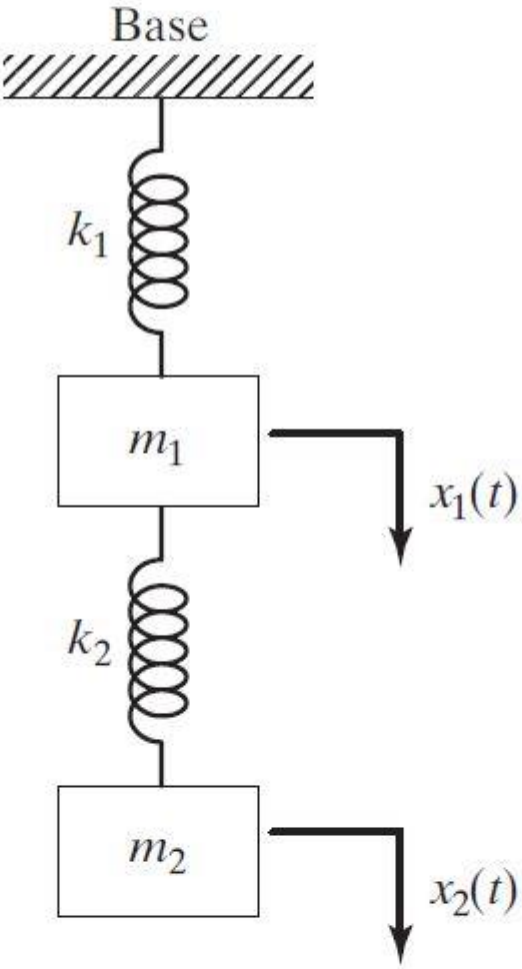


FIGURE 5.24

5.26 The system shown in Fig. 5.24 is initially disturbed by holding the mass m_1 stationary and giving the mass m_2 a downward displacement of 0.1 m. Discuss the nature of the resulting motion of the system.

5.33 An airplane standing on a runway is shown in Fig. 5.37. The airplane has a mass $m = 20{,}000$ kg and a mass moment of inertia $J_0 = 50 \times 10^6$ kg-m^2. If the values of stiffness and damping constant are $k_1 = 10$ kN/m and $c_1 = 2$ kN-s/m for the main landing gear and $k_2 = 5$ kN/m and $c_2 = 5$kN-s/m for the nose landing gear, (a) derive the equations of motion of the airplane, and (b) find the undamped natural frequencies of the system.

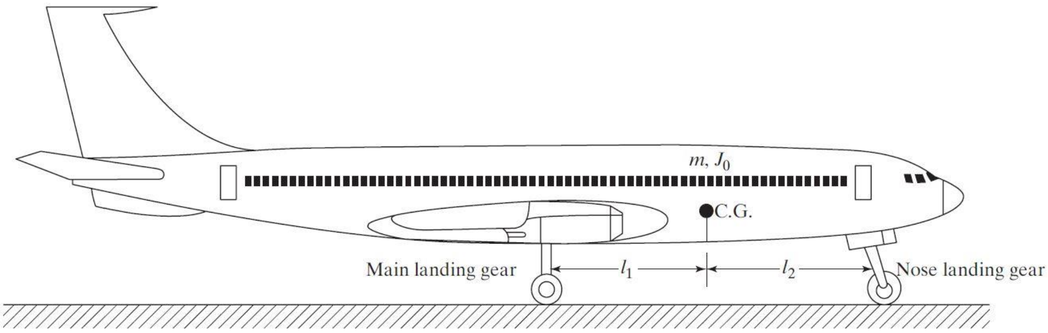


FIGURE 5.37

9.64 An electric motor, having an unbalance of 2 kg-cm, is mounted at the end of a steel cantilever beam, as shown in Fig. 9.50. The beam is observed to vibrate with large amplitudes at the operating speed of 1500 rpm of the motor. It is proposed to add a vibration absorber to reduce the vibration of the beam. Determine the ratio of the absorber mass to the mass of the motor needed in order to have the lower frequency of the resulting system equal to 75 percent of the operating speed of the motor. If the mass of the motor is 300 kg, determine the stiffness and mass of the absorber. Also find the amplitude of vibration of the absorber mass.

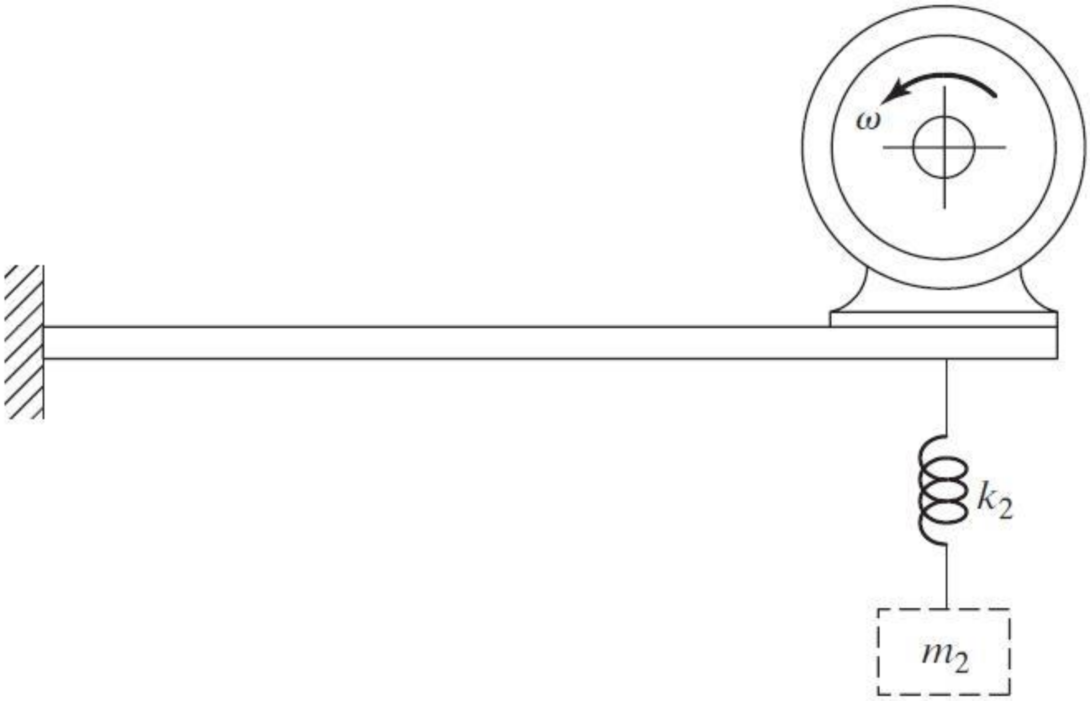


FIGURE 9.50

9.72 When an undamped vibration absorber, having a mass 30 kg and a stiffness k, is added to a spring-mass system, of mass 40 kg and stiffness 0.1 MN/m, the main mass (40 kg mass) is found to have zero amplitude during its steady-state operation under a harmonic force of amplitude 300 N. Determine the steady-state amplitude of the absorber mass.

Fonte: Rao, S.S. *Mechanical Vibrations*, 5th Ed., Prentice Hall, 2011