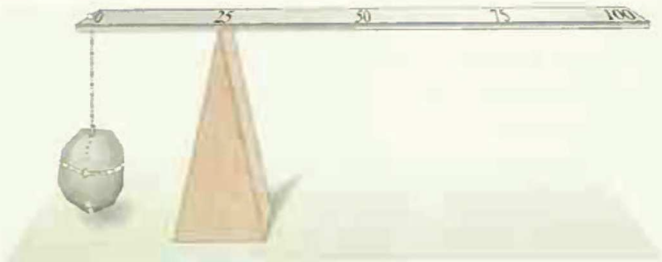


FIGURE 9–44 Question 10.

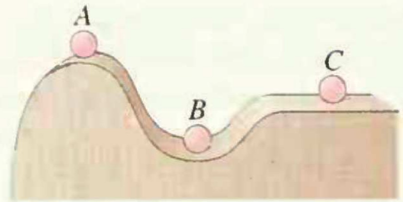
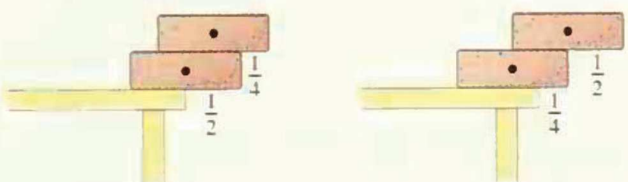


FIGURE 9–46 Question 12.

10. A uniform meter stick supported at the 25-cm mark is in equilibrium when a 1-kg rock is suspended at the 0-cm end (as shown in Fig. 9–44). Is the mass of the meter stick greater than, equal to, or less than the mass of the rock? Explain your reasoning.
11. Which of the configurations of brick, (a) or (b) of Fig. 9–45, is the more likely to be stable? Why?



(a) (b)

FIGURE 9–45 The dots indicate the CG of each brick. The fractions $\frac{1}{4}$ and $\frac{1}{2}$ indicate what portion of each brick is hanging beyond its support. Question 11.

12. Name the type of equilibrium for each position of the ball in Fig. 9–46.
13. Why do you tend to lean backward when carrying a heavy load in your arms?
14. Place yourself facing the edge of an open door. Position your feet astride the door with your nose and abdomen touching the door's edge. Try to rise on your tiptoes. Why can't this be done?
15. Why is it not possible to sit upright in a chair and rise to one's feet without first leaning forward?
16. Why is it more difficult to do sit-ups when your knees are bent than when your legs are stretched out?
17. Examine how a pair of scissors or shears cuts through a piece of cardboard. Is the name "shears" justified?
18. Materials such as ordinary concrete and stone are very weak under tension or shear. Would it be wise to use such a material for either of the supports of the cantilever shown in Fig. 9–11? If so, which one(s)?

PROBLEMS

SECTIONS 9–1 TO 9–3

1. (I) Three forces are applied to a tree sapling, as shown in Fig. 9–47, to stabilize it. If $\mathbf{F}_1 = 282$ N and $\mathbf{F}_2 = 355$ N, find $\mathbf{F}_3$ in magnitude and direction.

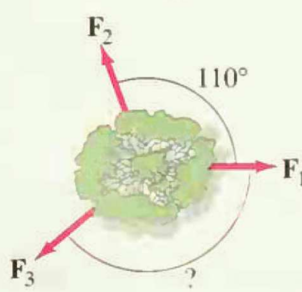


FIGURE 9–47 Problem 1.

2. (I) What should be the tension in the wire if the net force exerted on the tooth in Fig. 9–3 is to be 0.75 N? Assume that the angle between the two forces is 155° rather than the 140° in the figure.
3. (I) Calculate the torque about the front support of a diving board, on the right in Fig. 9–48, exerted by a 60-kg person 3.0 m from that support.

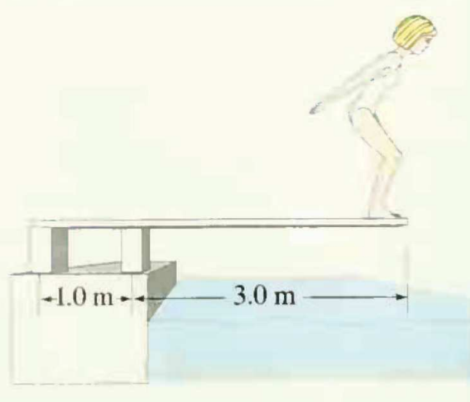


FIGURE 9–48 Problems 3, 4, 19, and 20.

4. (I) How far out on the diving board (Fig. 9–48) would a 60-kg diver have to be to exert a torque of 1000 m·N on the board, relative to the left support post?
5. (I) Two cords support a chandelier in the manner shown in Fig. 9–6 except that the upper wire makes an angle of 45° with the ceiling. If the cords can sustain a force of 1300 N without breaking, what is the maximum chandelier weight that can be supported?

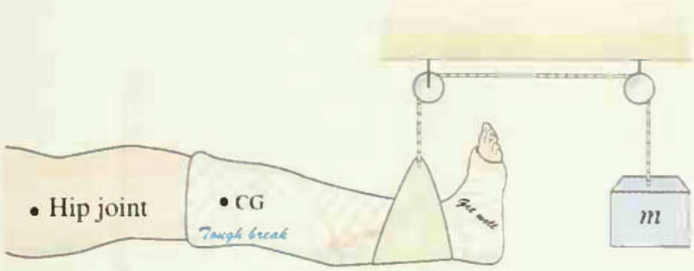


FIGURE 9–49 Problems 6 and 21.

6. (I) Calculate the mass m needed in order to suspend the leg shown in Fig. 9–49. Assume the leg (with cast) has a mass of 15.0 kg, and its CG is 35.0 cm from the hip joint; the sling is 80.5 cm from the hip joint.
7. (II) A 160-kg horizontal beam is supported at each end. A 300-kg piano rests a quarter of the way from one end. What is the vertical force on each of the supports?
8. (II) A uniform steel beam has a mass of 1000 kg. On it is resting half of an identical beam, as shown in Fig. 9–50. What is the vertical support force at each end?

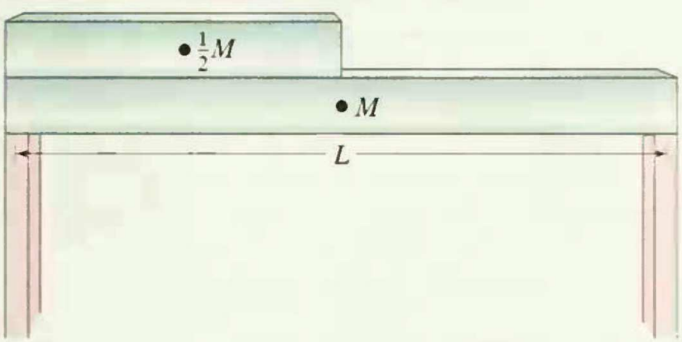


FIGURE 9–50 Problem 8.

9. (II) Suppose that the net force as calculated in Example 9–1 is 10° to the left of where it should point if the tooth is to move correctly. If the tension to the left is 2.0 N, what should the tension to the right be to make the net force act in the correct direction?
10. (II) A 70-kg adult sits at one end of a 10-m board, on the other end of which sits his 30-kg child. Where should the pivot be placed so the board (ignore its mass) is balanced?
11. (II) Repeat Problem 10 taking into account the board's 15-kg mass.
12. (II) Find the tension in the two cords shown in Fig. 9–51. Neglect the mass of the cords, and assume that the angle θ is 30° and the mass m is 200 kg.

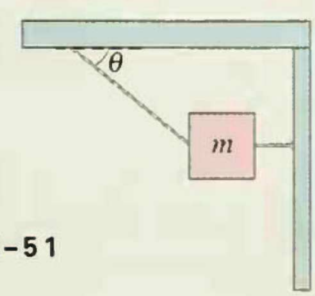


FIGURE 9–51
Problem 12.

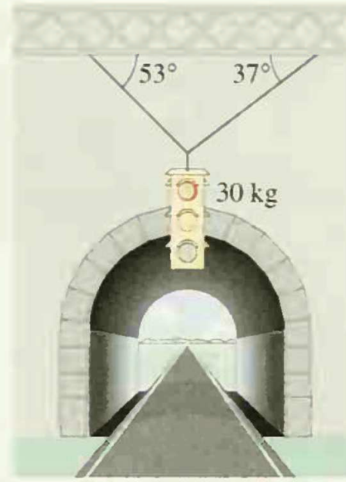


FIGURE 9–52
Problems 13 and 48.

13. (II) Find the tension in the two wires supporting the traffic light shown in Fig. 9–52.
14. (II) Determine the force F_N that the pivot exerts on the seesaw board in Fig. 9–9.
15. (II) Calculate F_1 and F_2 for the uniform cantilever shown in Fig. 9–11 whose mass is 1200 kg.
16. (II) A 0.60 kg sheet hangs from a massless clothesline as shown in Fig. 9–53. The line on either side of the sheet makes an angle of 3.5° with the horizontal. Calculate the tension in the clothesline on either side of the sheet. Why is the tension so much greater than the weight of the sheet?

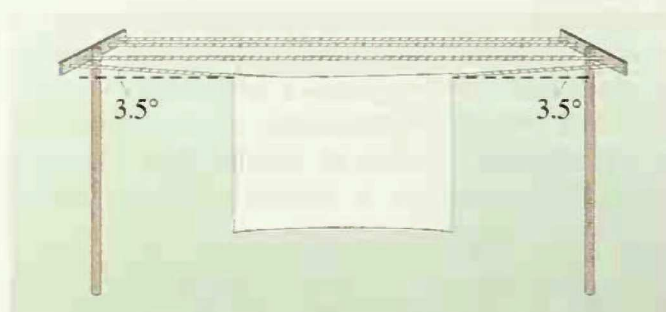
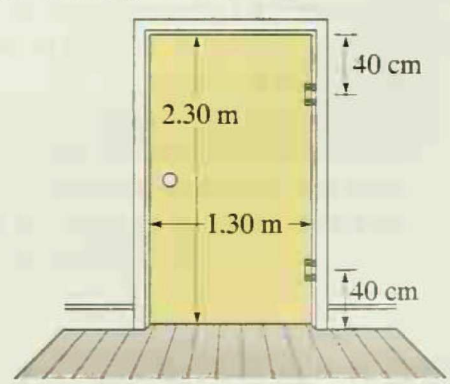


FIGURE 9–53 Problem 16.

17. (II) A door, 2.30 m high and 1.30 m wide, has a mass of 13.0 kg. A hinge 0.40 m from the top and another hinge 0.40 m from the bottom each support half the door's weight (Fig. 9–54). Assume that the center of gravity is at the geometrical center of the door, and determine the horizontal and vertical force components exerted by each hinge on the door.

FIGURE 9–54
Problem 17.



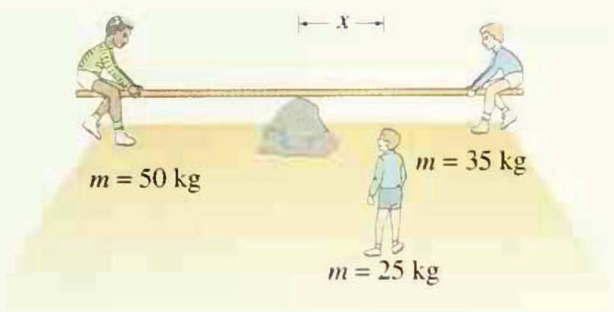


FIGURE 9–55 Problem 18.

18. (II) Three boys are trying to balance on a seesaw, which consists of a fulcrum rock, acting as a pivot at the center, and a very light board 3.6 m long (Fig. 9–55). Two boys are already on either end. One has a mass of 50 kg, and the other a mass of 35 kg. Where should the third boy, whose mass is 25 kg, place himself so as to balance the seesaw?

19. (II) Calculate the forces F_1 and F_2 that the supports exert on the diving board of Fig. 9–48 when a 60-kg person stands at its tip. Ignore the weight of the board.

20. (II) Repeat the last problem, taking into account the board's mass of 35 kg. Assume the board's CG is at its center.

21. (II) Calculate the mass m required in Fig. 9–49 to support the leg (without cast), using the result of Example 7–12 and the values given in Table 7–1, assuming a 60.0-kg person 160 cm tall. The leg pivots about the hip joint and the support acts at the ankle joint.

22. (II) Calculate F_1 and F_2 for the beam shown in Fig. 9–56. Assume it is uniform and has a mass of 250 kg.

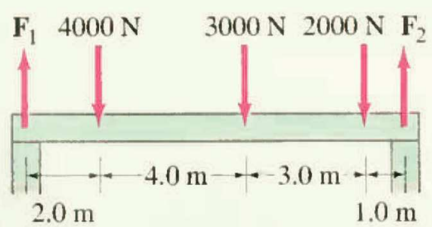


FIGURE 9–56 Problem 22.

23. (II) Calculate the tension F_T in the wire that supports the 30-kg beam shown in Fig. 9–57, and the force $\mathbf{F}_W$ exerted by the wall on the beam (give magnitude and direction).

24. (II) The two trees in Fig. 9–41 are 7.6 m apart. Calculate the magnitude of the force **F** a backpacker must exert to hold a 16-kg backpack so that the rope sags at its midpoint by (*a*) 1.5 m, (*b*) 0.15 m.

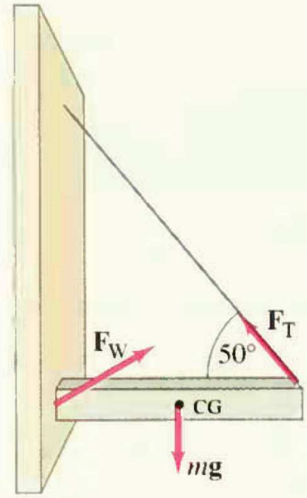


FIGURE 9–57 Problem 23.

25. (II) A 170-cm-tall person lies on a light (massless) board which is supported by two scales, one under the feet and one beneath the top of the head (Fig. 9–58). The two scales read, respectively, 31.6 and 35.1 kg. Where is the center of gravity of this person?

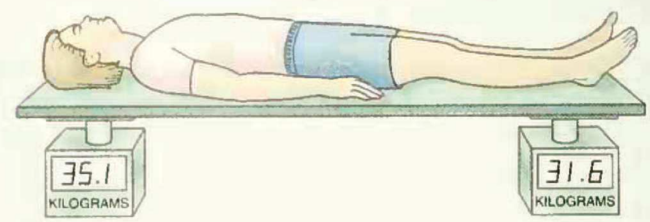


FIGURE 9–58 Problem 25.

26. (II) A shop sign weighing 215 N is supported by a uniform 135-N beam as shown in Fig. 9–59. Find the tension in the guy wire and the horizontal and vertical forces exerted by the hinge on the beam.

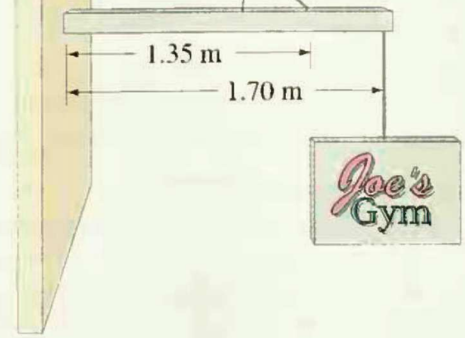


FIGURE 9–59 Problem 26.

PROBLEMS

SECTIONS 11–1 TO 11–3

1. (I) When a 65-kg person climbs into a 1000-kg car, the car's springs compress vertically by 2.8 cm. What will be the frequency of vibration when the car hits a bump? Ignore damping.

2. (I) An elastic cord is 65 cm long when a weight of 55 N hangs from it and is 85 cm long when a weight of 80 N hangs from it. What is the "spring" constant of this elastic cord?

3. (I) If a particle undergoes SHM with amplitude 0.25 m, what is the total distance it travels in one period?

4. (I) A fisherman's scale stretches 3.9 cm when a 2.7-kg fish hangs from it. (*a*) What is the spring constant and (*b*) what will be the amplitude and frequency of vibration if the fish is pulled down 2.5 cm more and released so that it vibrates up and down?

5. (II) Construct a table indicating the position of the mass in Fig. 11–2 at the times $t = 0, \frac{1}{4}T, \frac{1}{2}T, \frac{3}{4}T, T$, and $\frac{5}{4}T$, where T is the period of oscillation. On a graph of x versus t, plot these six points. Now connect these points with a smooth curve. Does your curve, based on these simple considerations, resemble that of a cosine or sine wave (Fig. 11–9 or 11–11)?

6. (II) A small fly of mass 0.15 g is caught in a spider's web. The web vibrates predominately with a frequency of 4.0 Hz. (*a*) What is the value of the effective spring constant k for the web? (*b*) At what frequency would you expect the web to vibrate if an insect of mass 0.50 g were trapped?

7. (II) A balsa wood block of mass 50 g floats on a lake, bobbing up and down at a frequency of 2.5 Hz. (*a*) What is the value of the effective spring constant of the water? (*b*) A partially filled water bottle of mass 0.25 kg and almost the same size and shape of the balsa block is tossed into the water. At what frequency would you expect the bottle to bob up and down? Assume SHM.

8. (II) An elastic cord vibrates with a frequency of 3.0 Hz when a mass of 0.60 kg is hung from it. What will its frequency be if only 0.38 kg hangs from it?

9. (II) A 0.50-kg mass at the end of a spring vibrates 3.0 times per second with an amplitude of 0.15 m. Determine (*a*) the velocity when it passes the equilibrium point, (*b*) the velocity when it is 0.10 m from equilibrium, (*c*) the total energy of the system, and (*d*) the equation describing the motion of the mass, assuming that at $t = 0$, x was a maximum.

10. (II) A mass m at the end of a spring vibrates with a frequency of 0.88 Hz. When an additional 600-g mass is added to m, the frequency is 0.60 Hz. What is the value of m?

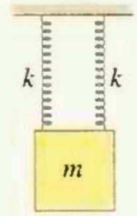


FIGURE 11–45 Problem 11.

11. (II) A block of mass m is supported by two identical parallel vertical springs, each with spring constant k (Fig. 11–45). What will be the frequency of vibration?

12. (II) A mass of 1.62 kg stretches a vertical spring 0.315 m. If the spring is stretched an additional 0.130 m and released, how long does it take to reach the (new) equilibrium position again?

13. (II) It takes a force of 80.0 N to compress the spring of a toy popgun 0.200 m to "load" a 0.150-kg ball. With what speed will the ball leave the gun?

14. (II) At $t = 0$, a 750-g mass at rest on the end of a horizontal spring ($k = 124$ N/m) is struck by a hammer, which gives it an initial speed of 2.76 m/s. Determine (*a*) the period and frequency of the motion, (*b*) the amplitude, (*c*) the maximum acceleration, (*d*) the position as a function of time, and (*e*) the total energy.

15. (II) A mass sitting on a horizontal, frictionless surface is attached to one end of a spring; the other end is fixed to a wall. 3.0 J of work is required to compress the spring by 0.12 m. If the mass is released from rest with the spring compressed, it experiences a maximum acceleration of 15 m/s^2. Find the value of (*a*) the spring constant and (*b*) the mass.

16. (II) A mass attached to the end of a spring is stretched a distance x_0 from equilibrium and released. At what distance from equilibrium will it have (*a*) velocity equal to half its maximum velocity and (*b*) acceleration equal to half its maximum acceleration?

17. (II) A 0.50-kg mass vibrates according to the equation $x = 0.45 \cos 8.40t$, where x is in meters, and t in seconds. Determine (*a*) the amplitude, (*b*) the frequency, (*c*) the total energy, and (*d*) the kinetic energy and potential energy when $x = 0.30$ m.

18. (II) A 400-g mass vibrates according to the equation $x = 0.35 \sin(5.50t)$ where x is in meters and t is in seconds. Determine (*a*) the amplitude, (*b*) the frequency, (*c*) the period, (*d*) the total energy, and (*e*) the KE and PE when x is 10 cm. (*f*) Draw a careful graph of x vs. t showing correct amplitude and period.

19. (II) A spring of force constant 210 N/m vibrates with an amplitude of 28.0 cm when 0.250 kg hangs from it. (*a*) What is the equation describing this motion as a function of time? Assume that the mass passes through the equilibrium point with positive velocity at $t = 0$. (*b*) At what times will the spring have its maximum and minimum extensions?

20. (II) A 2.00-kg pumpkin oscillates from a vertically hanging light spring once every 0.55 s. (*a*) Write down the equation giving the pumpkin's position y (+ upward) as a function of time t, assuming it started by being compressed 10 cm from the equilibrium position (where $y = 0$), and released. (*b*) How long will it take to get to the equilibrium position for the first time? (*c*) What will be its maximum speed? (*d*) What will be its maximum acceleration, and where will it first be attained?

21. (II) A 25.0-g bullet strikes a 0.600-kg block attached to a fixed horizontal spring whose spring constant is 6.70×10^3 N/m and sets it into vibration with an amplitude of 21.5 cm. What was the speed of the bullet before impact if the two objects move together after impact?

22. (II) If one vibration has 10 times the energy of a second, but their frequencies and masses are the same, how do their amplitudes compare?

23. (II) (*a*) At what displacement from equilibrium is the energy of a SHO half KE and half PE? (*b*) At what displacement from equilibrium is the speed half the maximum value?

24. (II) If a mass m hangs from a vertical spring, as shown in Fig. 11–3, show that $F = -kx$ holds for extension or compression of the spring, where x is the displacement from the (vertical position) equilibrium point.

25. (III) Show that the conservation of energy (Eq. 11–3) holds also for a vertical spring (see Fig. 11–3) where x is measured from the vertical equilibrium position ($x_0 = mg/k$) for a mass m.

26. (III) A bungee jumper with mass 65.0 kg jumps from a high bridge. After reaching his lowest point, he oscillates up and down, hitting a low point eight more times in 34.7 s. He finally comes to rest 25.0 m below the level of the bridge. Calculate the spring constant and the unstretched length of the bungee cord.

27. (III) A mass m is connected to two springs, with spring constants k_1 and k_2, in two different ways, as shown in Fig. 11–46a and b. Show that the period for the configuration shown in part (a) is given by

$$T = 2\pi\sqrt{m\left(\frac{1}{k_1} + \frac{1}{k_2}\right)}$$

and for that in part (b) is given by

$$T = 2\pi\sqrt{\frac{m}{k_1 + k_2}}.$$

Ignore friction.

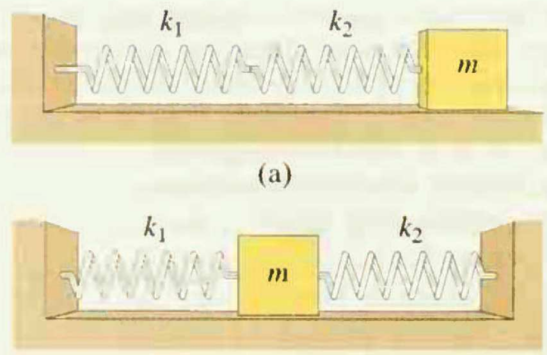


FIGURE 11–46 Problem 27.

SECTION 11–4

28. (I) A pendulum makes 36 vibrations in 50 s. What is its (*a*) period, and (*b*) frequency?

29. (I) You want to build a grandfather clock with a pendulum (a weight on the end of a light cable) that has one second between its "tick" (swinging to) and its "tock" (swinging fro). (*a*) How long do you make the cable? (*b*) Suppose the cable stretches a bit from the weight on the end. Will the clock run fast or slow?

30. (II) What is the period of a simple pendulum 50 cm long (*a*) on the Earth, and (*b*) when it is in a freely falling elevator?

31. (II) The length of a simple pendulum is 0.66 m, the pendulum bob has a mass of 310 grams, and it is released at an angle of 12° to the vertical. (*a*) With what frequency does it vibrate? Assume SHM. (*b*) What is the pendulum bob's speed when it passes through the lowest point of the swing? (*c*) What is the total energy stored in this oscillation, assuming no losses?

32. (II) Derive a formula for the maximum speed v_0 of a simple pendulum bob in terms of g, the length L, and the angle of swing θ_0.

33. (III) A clock pendulum oscillates at a frequency of 2.0 Hz. At $t = 0$, it is released from rest starting at an angle of 15° to the vertical. Ignoring friction, what will be the position (angle) of the pendulum at (*a*) $t = 0.25$ s, (*b*) $t = 1.60$ s, and (*c*) $t = 500$ s? [*Hint*: Do not confuse the angle of swing θ of the pendulum with the angle that appears as the argument of the cosine.]

SECTIONS 11–7 AND 11–8

34. (I) A fisherman notices that wave crests pass the bow of his anchored boat every 3.0 s. He measures the distance between two crests to be 8.5 m. How fast are the waves traveling?

35. (I) A sound wave in air has a frequency of 262 Hz and travels with a speed of 330 m/s. How far apart are the wave crests (compressions)?