23. (II) At $t = 0$, a 755-g mass at rest on the end of a horizontal spring ($k = 124\ \text{N/m}$) is struck by a hammer, which gives the mass an initial speed of 2.96 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.

24. (II) A vertical spring with spring stiffness constant 305 N/m vibrates with an amplitude of 28.0 cm when 0.260 kg hangs from it. The mass passes through the equilibrium point ($y = 0$) with positive velocity at $t = 0$. (*a*) What equation describes this motion as a function of time? (*b*) At what times will the spring have its maximum and minimum extensions?

25. (II) A mass m is connected to two springs, with spring stiffness constants k_1 and k_2, as shown in Fig. 11–51. Ignore friction. Show that the period is given by

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

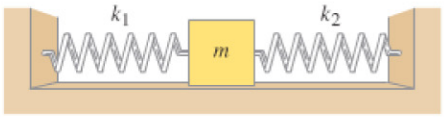

FIGURE 11–51 Problem 25.

26. (III) A 25.0-g bullet strikes a 0.600-kg block attached to a fixed horizontal spring whose spring stiffness constant is 7.70×10^3 N/m. The block is set into vibration with an amplitude of 21.5 cm. What was the speed of the bullet before impact if the bullet and block move together after impact?

27. (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 38.0 s. He finally comes to rest 25.0 m below the level of the bridge. Calculate the spring stiffness constant and the unstretched length of the bungee cord.

11–4 Simple Pendulum

28. (I) A pendulum makes 36 vibrations in exactly 60 s. What is its (*a*) period, and (*b*) frequency?

29. (I) How long must a simple pendulum be if it is to make exactly one swing per second? (That is, one complete vibration takes exactly 2.0 s.)

30. (I) A pendulum has a period of 0.80 s on Earth. What is its period on Mars, where the acceleration of gravity is about 0.37 that on Earth?

31. (II) What is the period of a simple pendulum 80 cm long (*a*) on the Earth, and (*b*) when it is in a freely falling elevator?

32. (II) The length of a simple pendulum is 0.760 m, the pendulum bob has a mass of 365 grams, and it is released at an angle of 12.0° 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?

33. (II) Your grandfather clock's pendulum has a length of 0.9930 m. If the clock loses half a minute per day, how should you adjust the length of the pendulum?

34. (II) Derive a formula for the maximum speed v_{max} of a simple pendulum bob in terms of g, the length L, and the angle of swing θ_0.

35. (III) A clock pendulum oscillates at a frequency of 2.5 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.]

11–7 and 11–8 Waves

36. (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 6.5 m. How fast are the waves traveling?

37. (I) A sound wave in air has a frequency of 262 Hz and travels with a speed of 343 m/s. How far apart are the wave crests (compressions)?

38. (I) (*a*) AM radio signals have frequencies between 550 kHz and 1600 kHz (kilohertz) and travel with a speed of 3.00×10^8 m/s. What are the wavelengths of these signals? (*b*) On FM, the frequencies range from 88.0 MHz to 108 MHz (megahertz) and travel at the same speed; what are their wavelengths?

* 39. (I) Calculate the speed of longitudinal waves in (*a*) water, (*b*) granite, and (*c*) steel.

* 40. (II) Two solid rods have the same elastic modulus, but one is twice as dense as the other. In which rod will the speed of longitudinal waves be greater, and by what factor?

41. (II) A cord of mass 0.65 kg is stretched between two supports 28 m apart. If the tension in the cord is 150 N, how long will it take a pulse to travel from one support to the other?

42. (II) A ski gondola is connected to the top of a hill by a steel cable of length 620 m and diameter 1.5 cm. As the gondola comes to the end of its run, it bumps into the terminal and sends a wave pulse along the cable. It is observed that it took 16 s for the pulse to return. (*a*) What is the speed of the pulse? (*b*) What is the tension in the cable?

* 43. (II) A sailor strikes the side of his ship just below the surface of the sea. He hears the echo of the wave reflected from the ocean floor directly below 3.0 s later. How deep is the ocean at this point?

44. (II) P and S waves from an earthquake travel at different speeds, and this difference helps in locating the earthquake "epicenter" (where the disturbance took place). (*a*) Assuming typical speeds of 8.5 km/s and 5.5 km/s for P and S waves, respectively, how far away did the earthquake occur if a particular seismic station detects the arrival of these two types of waves 2.0 min apart? (*b*) Is one seismic station sufficient to determine the position of the epicenter? Explain.

45. (III) An earthquake-produced surface wave can be approximated by a sinusoidal transverse wave. Assuming a frequency of 0.50 Hz (typical of earthquakes, which actually include a mixture of frequencies), what amplitude is needed so that objects begin to leave contact with the ground? [*Hint*: Set the acceleration $a > g$.]