41 •• The momentum of an object is the product of its velocity and mass. Show that momentum has the dimensions of force multiplied by time. SSM

42 •• What combination of force and one other physical quantity has the dimensions of power?

43 •• When an object falls through air, there is a drag force that depends on the product of the cross sectional area of the object and the square of its velocity, that is, $F_{air} = CAv^2$, where C is a constant. Determine the dimensions of C. SSM

44 •• Kepler's third law relates the period of a planet to its orbital radius r, the constant G in Newton's law of gravitation ($F = Gm_1m_2/r^2$), and the mass of the Sun M_s. What combination of these factors gives the correct dimensions for the period of a planet?

SCIENTIFIC NOTATION AND SIGNIFICANT FIGURES

45 • Express as a decimal number without using powers of 10 notation: (*a*) 3×10^4, (*b*) 6.2×10^{-3}, (*c*) 4×10^{-6}, (*d*) 2.17×10^5. SSM

46 • Write the following in scientific notation: (*a*) 1345100 m = ______ km, (*b*) 12340. kW = ______ MW, (*c*) 54.32 ps = ______ s, (*d*) 3.0 m = ______ mm.

47 • Calculate the following, round off to the correct number of significant figures, and express your result in scientific notation: (*a*) $(1.14)(9.99 \times 10^4)$, (*b*) $(2.78 \times 10^{-8}) - (5.31 \times 10^{-9})$, (*c*) $12\pi/(4.56 \times 10^{-3})$, (*d*) $27.6 + (5.99 \times 10^2)$. SSM

48 • Calculate the following, round off to the correct number of significant figures, and express your result in scientific notation: (*a*) $(200.9)(569.3)$, (*b*) $(0.000000513)(62.3 \times 10^7)$, (*c*) $28401 + (5.78 \times 10^4)$, (*d*) $63.25/(4.17 \times 10^{-3})$.

49 • **BIOLOGICAL APPLICATION** A cell membrane has a thickness of 7.0 nm. How many cell membranes would it take to make a stack 1.0 in. high? SSM

50 •• **ENGINEERING APPLICATION** A circular hole of radius 8.470×10^{-1} cm must be cut into the front panel of a display unit. The *tolerance* is 1.0×10^{-3} cm, which means the actual hole cannot differ by more than this quantity from the desired radius. If the actual hole is larger than the desired radius by the allowed tolerance, what is the difference between the actual area and the desired area of the hole?

51 •• **ENGINEERING APPLICATION** A square peg must be made to fit through a square hole. If you have a square peg that has an edge length of 42.9 mm, and the square hole has an edge length of 43.2 mm, (*a*) what is the area of the space available when the peg is in the hole? (*b*) If the peg is made rectangular by removing 0.10 mm of material from one side, what is the area available now? SSM

VECTORS AND THEIR PROPERTIES

52 • **MULTISTEP** A vector that is 7.0 units long and a vector that is 5.5 units long are added. Their sum is a vector 10.0 units long. (*a*) Show graphically at least one way that the vectors can be added. (*b*) Using your sketch in Part (*a*), determine the angle between the original two vectors.

53 • Determine the x and y components of the following three vectors in the xy plane. (*a*) A 10-m displacement vector that makes an angle of 30° clockwise from the $+y$ direction. (*b*) A 25-m/s velocity vector that makes an angle of 40° counterclockwise from the $-x$ direction. (*c*) A 40-lb force vector that makes an angle of 120° counterclockwise from the $-y$ direction. SSM

54 • Rewrite the following vectors in terms of their magnitude and angle (counterclockwise from the $+x$ direction). (*a*) A displacement vector with an x component of $+8.5$ m and a y component of -5.5 m (*b*) A velocity vector with an x component of -75 m/s and a y component of $+35$ m/s (*c*) A force vector with a magnitude of 50 lb that is in the third quadrant with an x component whose magnitude is 40 lb.

55 • **CONCEPTUAL** You walk 100 m in a straight line on a horizontal plane. If this walk took you 50 m east, what are your possible north or south movements? What are the possible angles that your walk made with respect to due east?

56 • **ESTIMATION** The final destination of your journey is 300 m due east of your starting point. The first leg of this journey is the walk described in Problem 55, and the second leg in also a walk along a single straight-line path. Estimate graphically the length and heading for the second leg of your journey.

57 •• Given the following vectors: $\vec{A} = 3.4\hat{i} + 4.7\hat{j}$, $\vec{B} = (-7.7)\hat{i} + 3.2\hat{j}$, and $\vec{C} = 5.4\hat{i} + (-9.1)\hat{j}$. (*a*) Find the vector $\vec{D}$, in unit vector notation, such that $\vec{D} + 2\vec{A} - 3\vec{C} + 4\vec{B} = 0$. (*b*) Express your answer in Part (*a*) in terms of magnitude and angle with the $+x$ direction.

58 •• Given the following force vectors: $\vec{A}$ is 25 lb at an angle of 30° clockwise from the $+x$ axis, and $\vec{B}$ is 42 lb at an angle of 50° clockwise from the $+y$ axis. (*a*) Make a sketch and visually estimate the magnitude and angle of the vector $\vec{C}$ such that $2\vec{A} + \vec{C} - \vec{B}$ results in a vector with a magnitude of 35 lb pointing in the $+x$ direction. (*b*) Repeat the calculation in Part (*a*) using the method of components and compare your result to the estimate in (*a*).

59 •• Calculate the unit vector (in terms of $\hat{i}$, and $\hat{j}$) in the direction opposite to the direction of each of vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$ in Problem 57. SSM

60 •• Unit vectors $\hat{i}$ and $\hat{j}$ are directed east and north, respectively. Calculate the unit vector (in terms of $\hat{i}$ and $\hat{j}$) in the following directions. (*a*) northeast, (*b*) 70° clockwise from the $-y$ axis, (*c*) southwest.

GENERAL PROBLEMS

61 • The Apollo trips to the moon in the 1960s and 1970s typically took 3 days to travel the Earth–moon distance once they left Earth orbit. Estimate the spacecraft's average speed in kilometers per hour, miles per hour, and meters per second. SSM

62 • On many of the roads in Canada the speed limit is 100 km/h. What is this speed limit in miles per hour?

63 • If you could count \$1.00 per second, how many years would it take to count 1.00 billion dollars?

64 • (*a*) The speed of light in vacuum is 186000 mi/s = 3.00×10^8 m/s. Use this fact to find the number of kilometers in a mile. (*b*) The weight of 1.00 ft³ of water is 62.4 lb, and 1.00 ft = 30.5 cm. Use this information and the fact that 1.00 cm³ of water has a mass of 1.00 g to find the weight in pounds of a 1.00-kg mass.

65 • The mass of one uranium atom is 4.0×10^{-26} kg. How many uranium atoms are there in 8.0 g of pure uranium?

66 •• During a thunderstorm, a total of 1.4 in. of rain falls. How much water falls on one acre of land? (1 mi² = 640 acres.) Express your answer in (*a*) cubic inches, (*b*) cubic feet, (*c*) cubic meters, and (*d*) kilograms. Note that the density of water is 1000 kg/m³.

is at rest at the origin at time $t = 0$. (*a*) What is the object's acceleration? (*b*) What is its velocity at time $t = 3.0$ s? (*c*) Where is the object at time $t = 3.0$ s?

MASS AND WEIGHT

42 • On the moon, the acceleration due to the effect of gravity is only about 1/6 of that on Earth. An astronaut whose weight on Earth is 600 N travels to the lunar surface. His mass, as measured on the moon, will be (*a*) 600 kg, (*b*) 100 kg, (*c*) 61.2 kg, (*d*) 9.81 kg, (*e*) 360 kg.

43 • Find the weight of a 54-kg student in (*a*) newtons, and (*b*) pounds.

44 • Find the mass of a 165-lb engineer in kilograms.

45 •• **ENGINEERING APPLICATION** To train astronauts to work on the moon, where the free-fall acceleration is only about 1/6 of that on Earth, NASA submerges them in a tank of water. If an astronaut who is carrying a backpack, air conditioning unit, oxygen supply, and other equipment, has a total mass of 250 kg, determine the following quantities. (*a*) her weight including backpack, etc. on Earth, (*b*) her weight on the moon, (*c*) the required upward buoyancy force of the water during her training for the moon's environment on Earth SSM

46 •• It is the year 2075 and space travel is common. A physics professor brings his favorite teaching demonstration with him to the moon. The apparatus consists of a very smooth (frictionless) horizontal table and an object to slide on it. On Earth, when the professor attaches a spring (force constant 50 N/m) to the object and pulls horizontally so the spring stretches 2.0 cm, the object accelerates at 1.5 m/s². (*a*) Draw the free-body diagram of the object and use it and Newton's laws to determine the object's mass. (*b*) What would the object's acceleration be under identical conditions on the moon?

FREE-BODY DIAGRAMS: STATIC EQUILIBRIUM

47 • **ENGINEERING APPLICATION, MULTISTEP** A 35.0-kg traffic light is supported by two wires as in Figure 4-36. (*a*) Draw the light's free-body diagram and use it to answer the following question qualitatively: Is the tension in wire 2 greater than or less than the tension in wire 1? (*b*) Verify your answer by applying Newton's laws and solving for the two tensions.

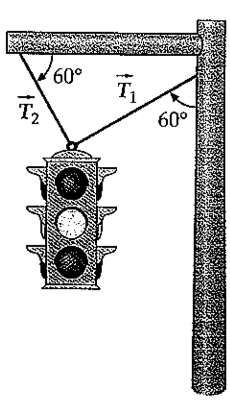

FIGURE 4-36 Problem 47

48 • A 42.6-kg lamp is hanging from wires as show Figure 4-37. The ring has negligible mass. The tension T_1 in the tical wire is (*a*) 209 N, (*b*) 418 N, (*c*) 570 N, (*d*) 360 N, (*e*) 730 N.

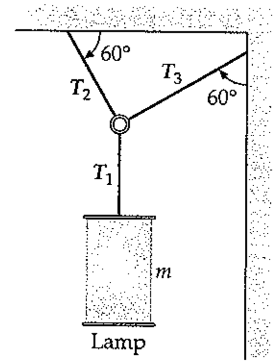

FIGURE 4-37 Problem 48

49 •• In Figure 4-38*a*, a 0.500-kg block is suspended at the point of a 1.25-m-long string. The ends of the string are attache the ceiling at points separated by 1.00 m. (*a*) What angle doe string make with the ceiling? (*b*) What is the tension in the str (*c*) The 0.500-kg block is removed and two 0.250-kg blocks ar tached to the string such that the lengths of the three string ments are equal (Figure 4-38*b*). What is the tension in each segr of the string? SSM

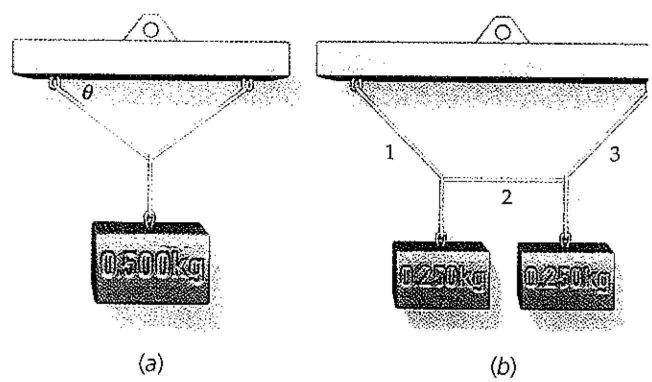

FIGURE 4-38 Problem 49

50 •• A ball weighing 100-N is shown suspended fro system of cords (Figure 4-39). What are the tensions in the hori tal and angled cords?

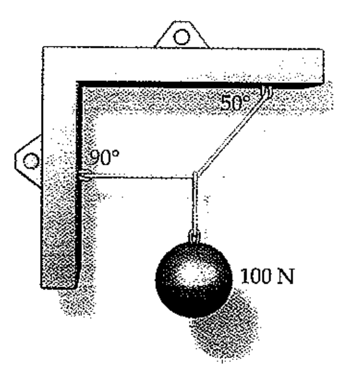

FIGURE 4-39 Problem 50

51 •• A 10-kg object on a frictionless table is subjected to two horizontal forces, $\vec{F}_1$ and $\vec{F}_2$, with magnitudes $F_1 = 20$ N and $F_2 = 30$ N, as shown in Figure 4-40. Find the third horizontal force $\vec{F}_3$ that must be applied so that the object is in static equilibrium. SSM

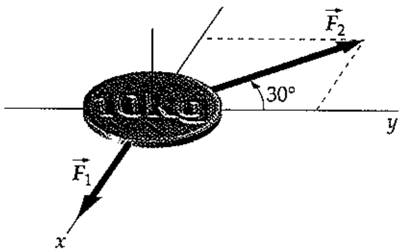

FIGURE 4-40
Problem 51

52 •• For the systems to be in equilibrium in Figure 4-41*a*, Figure 4-41*b*, and Figure 4-41*c*, find the unknown tensions and masses.

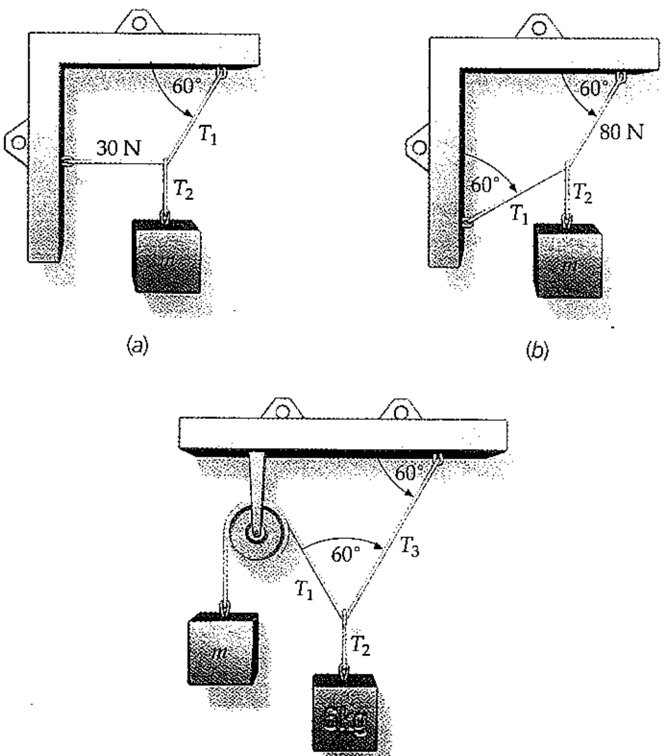

FIGURE 4-41
Problem 52

53 •• **ENGINEERING APPLICATION** Your car is stuck in a mud hole. You are alone, but you have a long, strong rope. Having studied physics, you tie the rope tautly to a telephone pole and pull on it sideways, as shown in Figure 4-42. (*a*) Find the force exerted by the rope on the car when the angle θ is 3.00° and you are pulling with a force of 400 N, but the car does not move. (*b*) How strong must the rope be if it takes a force of 600 N to move the car when θ is 4.00°?

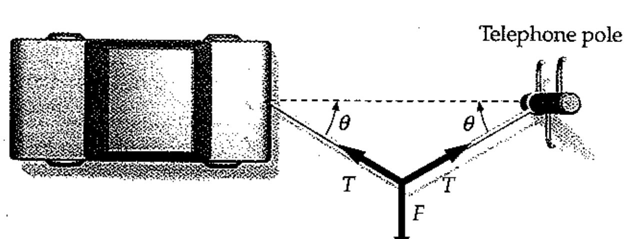

FIGURE 4-42 Problem 53

54 ••• **ENGINEERING APPLICATION, MULTISTEP** Balloon arches are often seen at festivals or celebrations; they are made by attaching helium-filled balloons to a rope that is fixed to the ground at each end. The lift from the balloons raises the structure into the arch shape. Figure 4-43*a* shows the geometry of such a structure: N balloons are attached at equally spaced intervals along a massless rope of length L, which is attached to two supports at its ends. Each balloon provides a lift force of magnitude F. The horizontal and vertical coordinates of the point on the rope where the ith balloon is attached are x_i and y_i, and T_i is the tension in the ith segment. (Note segment 0 is the segment between the point of attachment and the first balloon, and segment N is the segment between the last balloon and the other point of attachment). (*a*) Figure 4-43*b* shows a free-body diagram for the ith balloon. From this diagram, show that the horizontal component of the force T_i (call it T_H) is the same for all the string segments. (*b*) By considering the vertical component of the forces, use Newton's laws to derive the following relationship between the tension in the ith and $(i-1)$th segments: $T_{i-1}\sin\theta_{i-1} - T_i\sin\theta_i = F$. (*c*) Show that $\tan\theta_0 = -\tan\theta_{N+1} = NF/2T_H$. (*d*) From the diagram and the two expressions above, show that $\tan\theta_i = (N - 2i)F/2T_H$ and that $y_i = \frac{L}{N+1}\sum_{j=0}^{i-1}\cos\theta_j$, $y_i = \frac{L}{N+1}\sum_{j=0}^{i-1}\sin\theta_j$.

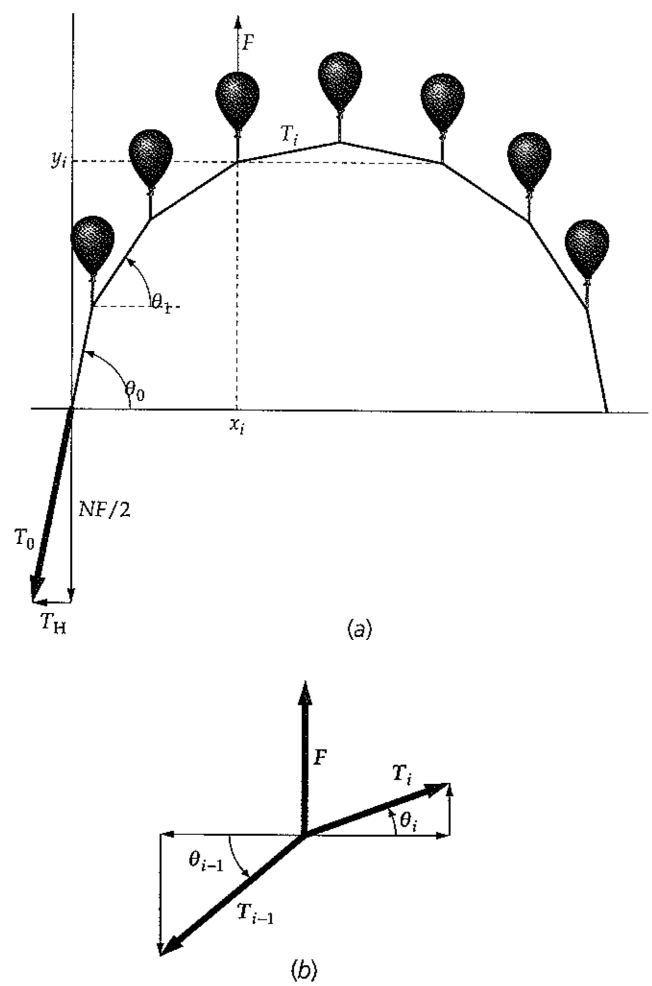

FIGURE 4-43 Problem 54