•2 Figure 9-35 shows a three-particle system, with masses $m_1 = 3.0$ kg, $m_2 = 4.0$ kg, and $m_3 = 8.0$ kg. The scales on the axes are set by $x_s = 2.0$ m and $y_s = 2.0$ m. What are (a) the $x$ coordinate and (b) the $y$ coordinate of the system's center of mass? (c) If $m_3$ is gradually increased, does the center of mass of the system shift toward or away from that particle, or does it remain stationary?

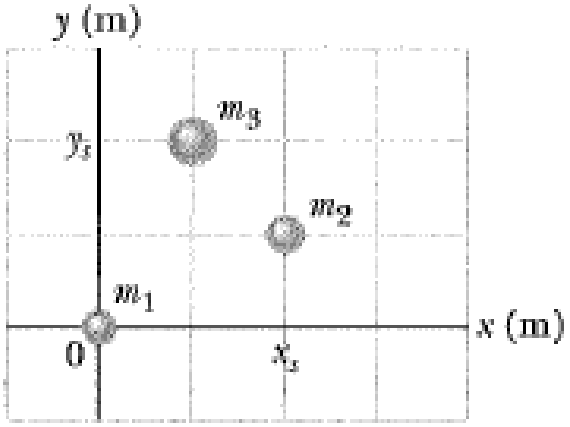



**Fig. 9-35** Problem 2.

••4 In Fig. 9-37, three uniform thin rods, each of length $L = 22$ cm, form an inverted U. The vertical rods each have a mass of 14 g; the horizontal rod has a mass of 42 g. What are (a) the $x$ coordinate and (b) the $y$ coordinate of the system's center of mass?

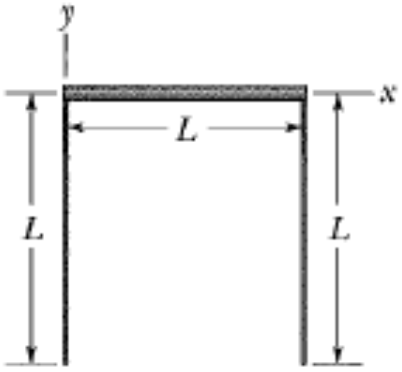



**Fig. 9-37** Problem 4.

••5 What are (a) the $x$ coordinate and (b) the $y$ coordinate of the center of mass for the uniform plate shown in Fig. 9-38 if $L = 5.0$ cm?

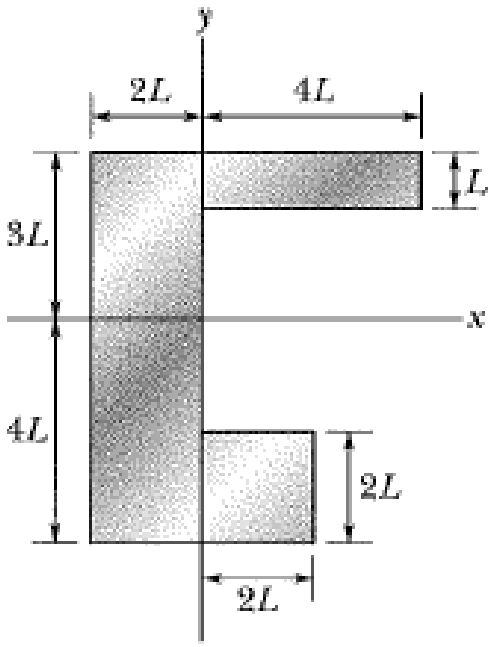



**Fig. 9-38** Problem 5.

••6 Figure 9-39 shows a cubical box that has been constructed from uniform metal plate of negligible thickness. The box is open at the top and has edge length $L = 40$ cm. Find (a) the $x$ coordinate, (b) the $y$ coordinate, and (c) the $z$ coordinate of the center of mass of the box.

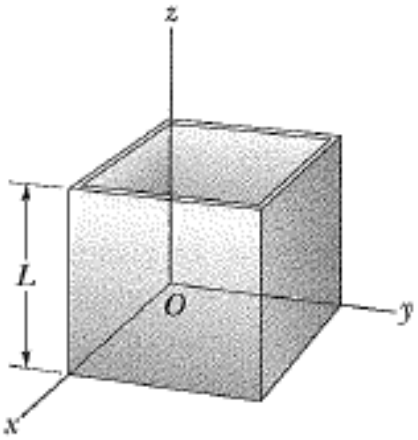



**Fig. 9-39** Problem 6.

•10 A 1000 kg automobile is at rest at a traffic signal. At the instant the light turns green, the automobile starts to move with a constant acceleration of 4.0 m/s². At the same instant a 2000 kg truck, traveling at a constant speed of 8.0 m/s, overtakes and passes the automobile. (a) How far is the com of the automobile–truck system from the traffic light at $t = 3.0$ s? (b) What is the speed of the com then?

••13 SSM A shell is shot with an initial velocity $\vec{v}_0$ of 20 m/s, at an angle of $\theta_0 = 60°$ with the horizontal. At the top of the trajectory, the shell explodes into two fragments of equal mass (Fig. 9-42). One fragment, whose speed immediately after the explosion is zero, falls vertically. How far from the gun does the other fragment land, assuming that the terrain is level and that air drag is negligible?

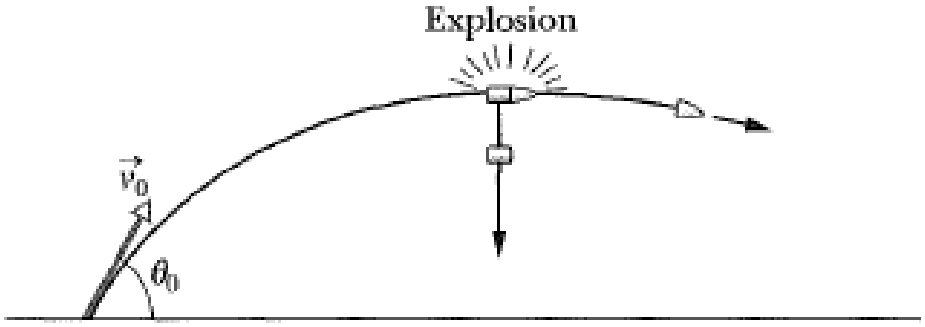



**Fig. 9-42** Problem 13.

••22 Figure 9-47 gives an overhead view of the path taken by a 0.165 kg cue ball as it bounces from a rail of a pool table. The ball's initial speed is 2.00 m/s, and the angle $\theta_1$ is 30.0°. The bounce reverses the $y$ component of the ball's velocity but does not alter the $x$ component. What are (a) angle $\theta_2$ and (b) the change in the ball's linear momentum in unit-vector notation? (The fact that the ball rolls is irrelevant to the problem.)

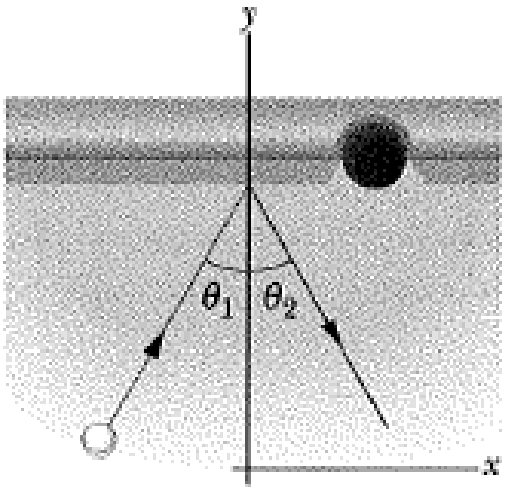
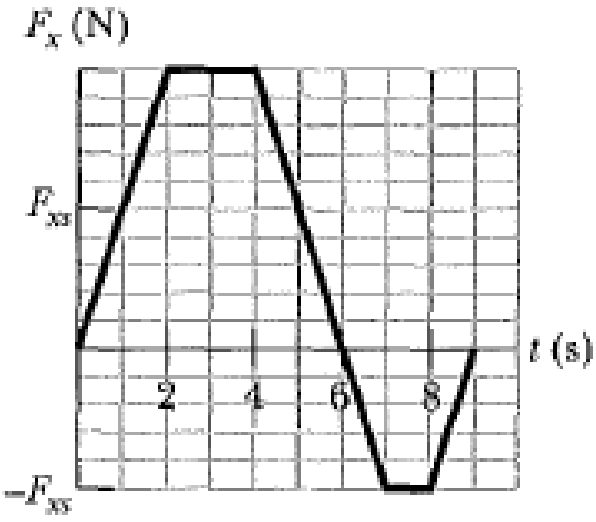


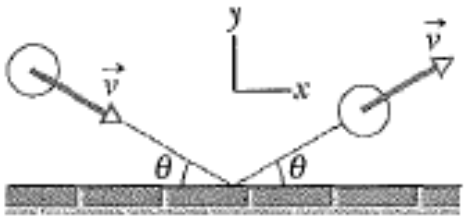

**Fig. 9-47** Problem 22.

•25 A 1.2 kg ball drops vertically onto a floor, hitting with a speed of 25 m/s. It rebounds with an initial speed of 10 m/s. (a) What impulse acts on the ball during the contact? (b) If the ball is in contact with the floor for 0.020 s, what is the magnitude of the average force on the floor from the ball?

••32 A 5.0 kg toy car can move along an $x$ axis; Fig. 9-50 gives $F_x$ of the force acting on the car, which begins at rest at time $t = 0$. The scale on the $F_x$ axis is set by $F_{xs} = 5.0$ N. In unit-vector notation, what is $\vec{p}$ at (a) $t = 4.0$ s and (b) $t = 7.0$ s, and (c) what is $\vec{v}$ at $t = 9.0$ s?

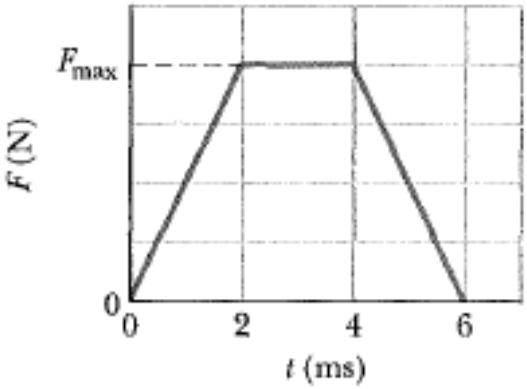


••38 In the overhead view of Fig. 9-54, a 300 g ball with a speed $v$ of 6.0 m/s strikes a wall at an angle $\theta$ of 30° and then rebounds with the




same speed and angle. It is in contact with the wall for 10 ms. In unit-vector notation, what are (a) the impulse on the ball from the wall and (b) the average force on the wall from the ball?

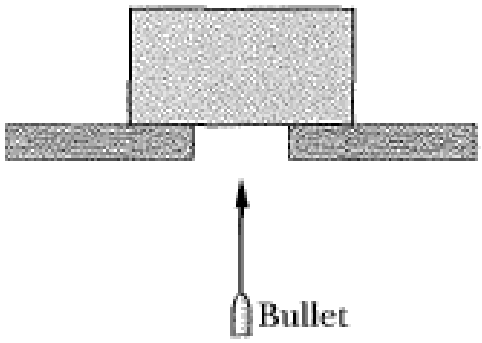
••35 GO Figure 9-53 shows an approximate plot of force magnitude $F$ versus time $t$ during the collision of a 58 g Superball with a wall. The initial velocity of the ball is 34 m/s perpendicular to the wall; the ball rebounds directly back with approximately the same speed, also perpendicular to the wall. What is $F_{max}$, the maximum magnitude of the force on the ball from the wall during the collision?



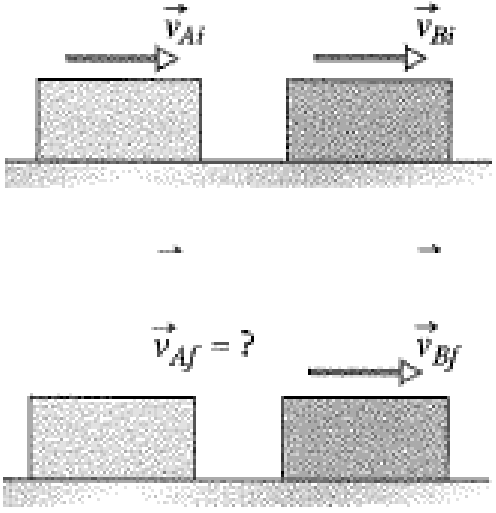

••47 A vessel at rest at the origin of an $xy$ coordinate system explodes into three pieces. Just after the explosion, one piece, of mass $m$, moves with velocity $(-30\text{ m/s})\hat{i}$ and a second piece, also of mass $m$, moves with velocity $(-30\text{ m/s})\hat{j}$. The third piece has mass $3m$. Just after the explosion, what are the (a) magnitude and (b) direction of the velocity of the third piece?

•49 A bullet of mass 10 g strikes a ballistic pendulum of mass 2.0 kg. The center of mass of the pendulum rises a vertical distance of 12 cm. Assuming that the bullet remains embedded in the pendulum, calculate the bullet's initial speed.

••52 GO In Fig. 9-59, a 10 g bullet moving directly upward at 1000 m/s strikes and passes through the center of mass of a 5.0 kg block initially at rest. The bullet emerges from the block moving directly upward at 400 m/s. To what maximum height does the block then rise above its initial position?



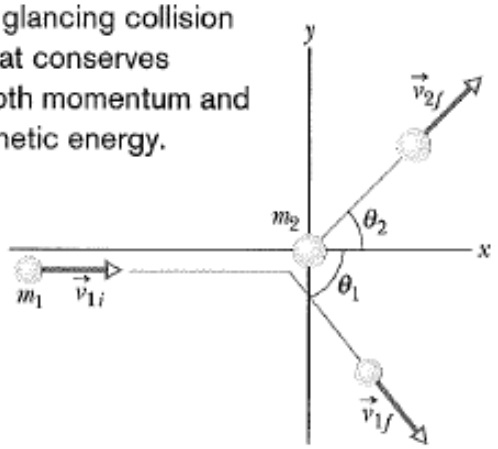

•60 In Fig. 9-64, block $A$ (mass 1.6 kg) slides into block $B$ (mass 2.4 kg), along a frictionless surface. The directions of three velocities before ($i$) and after ($f$) the collision are indicated; the corresponding speeds are $v_{Ai} = 5.5$ m/s, $v_{Bi} = 2.5$ m/s, and $v_{Bf} = 4.9$ m/s. What are the (a) speed and (b) direction (left or right) of velocity $\vec{v}_{Af}$? (c) Is the collision elastic?



••68 In Fig. 9-67, block 1 of mass $m_1$ slides from rest along a frictionless ramp from height $h = 2.50$ m and then collides with stationary block 2, which has mass $m_2 = 2.00m_1$. After the collision, block 2 slides into a region where the coefficient of kinetic friction $\mu_k$ is 0.500 and comes to a stop in distance $d$ within that region. What is the value of distance $d$ if the collision is (a) elastic and (b) completely inelastic?


••71 ILW In Fig. 9-21, projectile particle 1 is an alpha particle and target particle 2 is an oxygen nucleus. The alpha particle is scattered at angle $\theta_1 = 64.0°$ and the oxygen nucleus recoils with speed $1.20 \times 10^5$ m/s and at angle $\theta_2 = 51.0°$. In atomic mass units, the mass of the alpha particle is 4.00 u and the mass of the oxygen nucleus is 16.0 u. What are the (a) final and (b) initial speeds of the alpha particle?

A glancing collision that conserves both momentum and kinetic energy.



••74 Two 2.0 kg bodies, $A$ and $B$, collide. The velocities before the collision are $\vec{v}_A = (15\hat{i} + 30\hat{j})$ m/s and $\vec{v}_B = (-10\hat{i} + 5.0\hat{j})$ m/s. After the collision, $\vec{v}'_A = (-5.0\hat{i} + 20\hat{j})$ m/s. What are (a) the final velocity of $B$ and (b) the change in the total kinetic energy (including sign)?

114 Figure 9-82 shows a uniform square plate of edge length $6d = 6.0$ m from which a square piece of edge length $2d$ has been removed. What are (a) the $x$ coordinate and (b) the $y$ coordinate of the center of mass of the remaining piece?