CHAPTER IX
CENTER OF MASS & LINEAR MOMENTUM

PROBLEM SET

1) A 145-g baseball, moving along the *x* axis with speed 30.0 m/s, strikes a fence at a 45° angle and rebounds along the *y* axis with unchanged speed. Give its change in momentum using unit vector notation. **[Answer: $4.35\ \mathbf{kg}\cdot\frac{\mathbf{m}}{\mathbf{s}}(\hat{\mathbf{j}}-\hat{\mathbf{i}})$]**

2) An object at rest is suddenly broken apart into two fragments by an explosion. One fragment acquires twice the kinetic energy of the other. What is the ratio of their masses?

[Answer: $\frac{m_A}{m_B}=\frac{1}{2}$]

3) A mass $m_A = 2.0$ kg, moving with velocity $\overrightarrow{v_A}$ =$(4.0\hat{\mathbf{i}}+5.0\hat{\mathbf{j}}-2.0\hat{\mathbf{k}})\ m/s$ collides with mass $m_B = 3.0$ kg, which is initially at rest. Immediately after the collision, mass m_A is observed traveling at velocity $\overrightarrow{v'_A}=\left(-2.0\hat{\mathbf{i}}+3.0\hat{\mathbf{k}}\right)m/s$ Find the velocity of mass m_B after the collision. Assume no outside force acts on the two masses during the collision.

[Answer: $4.0\hat{\mathbf{i}}+3.3\hat{\mathbf{j}}-3.3\hat{\mathbf{k}}$ m/s]

4) *** A 224-kg projectile, fired with a speed of 116 m/s at a 60.0° angle, breaks into three pieces of equal mass at the highest point of its arc (where its velocity is horizontal). Two of the fragments move with the same speed right after the explosion as the entire projectile had just before the explosion; one of these moves vertically downward and the other horizontally. Determine (*a*) the velocity of the third fragment immediately after the explosion and (*b*) the energy released in the explosion.

[Answer: a) $(116\hat{\mathbf{i}}+58.0\hat{\mathbf{j}})$ m/s, b) 5.02×10^5 J]

5) A 0.145-kg baseball pitched at 35.0 m/s is hit on a horizontal line drive straight back at the pitcher at 56.0 m/s. If the contact time between bat and ball is $5.00\times10^{-3}\ s$ calculate the force (assumed to be constant) between the ball and bat.**[Answer: 2640 N, towards to pitcher]**

6) A golf ball of mass 0.045 kg is hit off the tee at a speed of 45 m/s. The golf club was in contact with the ball for 3.5×10^{-3} **s.** Find (*a*) the impulse imparted to the golf ball, and (*b*) the average force exerted on the ball by the golf club.

[Answer: a) $2.0\ \mathbf{kg}\cdot\mathbf{m/s}$, forward direction, b) 580 N, forward direction]

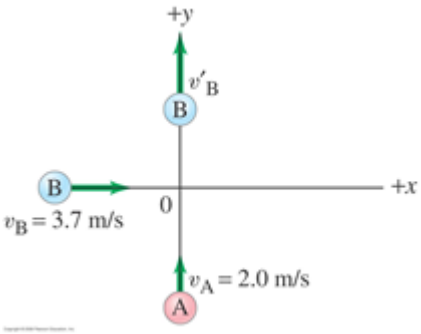
7) A ball of mass 0.220 kg that is moving with a speed of 7.5 m/s collides head-on and elastically with another ball initially at rest. Immediately after the collision, the incoming ball bounces backward with a speed of 3.8 m/s. Calculate (*a*) the velocity of the target ball after the collision, and (*b*) the mass of the target ball.**[Answer: a) 3.7 m/s, b) 0,67 kg]**

8) *** A 144-g baseball moving 28.0 m/s strikes a stationary 5.25-kg brick resting on small rollers so it moves without significant friction. After hitting the brick, the baseball bounces straight back, and the brick moves forward at 1.10 m/s. (*a*) What is the baseball's speed after the collision? (*b*) Find the total kinetic energy before and after the collision.

[Answer: a) 12.1 m/s, b) before collision, 56.4 J; after collision, 13.7 J]

9) *** Two billiard balls of equal mass move at right angles and meet at the origin of an *xy* coordinate system. Initially ball A is moving upward along the *y* axis at + 2.0 m/s, and ball B is moving to the right along the *x* axis with speed + 3.7 m/s. After the collision (assumed elastic), the second ball is moving along the positive *y* axis (Fig. 9–43). What is the final direction of ball A, and what are the speeds of the two balls?

[Answer: final direction of A = x direction; velocity of A= 3.7 m/s, velocity of B= 2.0 m/s]



10) A uniform circular plate of radius 2*R* has a circular hole of radius *R* cut out of it. The center C' of the smaller circle is a distance 0.80*R* from the center C of the larger circle, Fig. 9–45. What is the position of the center of mass of the plate? [*Hint*: Try subtraction.]

[Answer: $-0.27R$, to the left of the center of the circle of radius 2*R*.]