Key

Conservation of Momentum Text book Problems

Conceptual: pg 233 17,19,20,22,23

Problems: pg 233-234: 24, 25, 31, 37 (identify collision type first)

Conceptual Questions:

17. Two skaters initially at rest push against each other so that they move in opposite directions. What is the total momentum of the two skaters when they begin moving? Explain.

$P_{before} = P_{after}$ — at rest, $p = 0$ — $P_{after} = 0$ — total momentum constant, was 0 before (at rest) (ball moves one way, earth the other)

19. Explain how momentum is conserved when a ball bounces against a floor.

Momentum is conserved for the ball and the earth combined, however if only the ball is considered, momentum is not conserved because the earth exerts a force on the ball to change its momentum

20. As a ball falls toward Earth, the momentum of the ball increases. How would you reconcile this observation with the law of conservation of momentum?

A force is causing a change in momentum. The earth also has a change in momentum but this change does not significantly affect the earth (large mass)

22. An astronaut carrying a camera in space finds herself drifting away from a space shuttle after her tether becomes unfastened. If she has no propulsion device, what should she do to move back to the shuttle?

She should throw the camera away from the shuttle so she would move toward the shuttle to conserve momentum

23. When a bullet is fired from a gun, what happens to the gun? Explain your answer using the principles of momentum.

The gun recoils in the opposite direction of the bullet.

← gun momentum → bullet momentum

Practice Problems

Equations:

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ — Elastic

$(m_1+m_2)*v_i = m_1v_{1f} + m_2v_{2f}$ — Separation

$m_1v_{1i} + m_2v_{2i} = (m_1+m_2)*v_f$ — Inelastic

24. A 65.0 kg ice skater moving to the right with a velocity of 2.50 m/s throws a 0.150 kg snowball to the right with a velocity of 32.0 m/s.
   a. What type of "collision" is this? (Elastic, Inelastic or Separation)
   b. What is the velocity of the ice skater after throwing the snowball? Ignore friction between the skates and the ice.

   $(65 + 0.150)\,2.50 = 65 \cdot v_{1f} + 0.15 \cdot 32$

   $v_{1f} = 2.43$ m/s right

   c. A second skater initially at rest with a mass of 60.0 kg catches the snowball. What is the velocity of the second skater after catching the snowball in a perfectly inelastic collision?

   $0.15 \cdot 32 + 60 \cdot 0 = (0.15 + 60) \cdot v_f$

   $v_f = 0.0798$ m/s right

25. A tennis player places a 55 kg ball machine on a frictionless surface. The machine fires a 0.057 kg tennis ball horizontally with a velocity of 36 m/s North.

a. What type of "collision" is this? (Elastic, Inelastic or Separation)

b. What is the final velocity of the machine?

$$(55 + 0.057) \cdot 0 = 55 \cdot V_{1f} + 0.057 \cdot 36$$

$$V_{1f} = 0.037 \text{ m/s South}$$

31. Two carts with masses of 4.0 kg and 3.0 kg move toward each other on a frictionless track. The 4.0 kg cart has a speed of 5.0 m/s and the 3.0 kg cart has a speed of 4.0 m/s. The cars stick together after colliding head-on.

a. What type of "collision" is this? (Elastic, Inelastic or Separation)

b. Find the final speed of the combined carts.

$$4.0 \cdot {}^{+}5.0 + 3.0 \cdot {}^{-}4.0 = (4.0 + 3.0) V_f$$

$$V_f = {}^{+}1.1 \text{ m/s}$$

37. A billiard ball traveling at 4.0 m/s has an elastic head-on collision with a billiard ball of equal mass that is initially at rest. The first ball is at rest after the collision.

a. What type of "collision" is this? (Elastic, Inelastic or Separation)

b. What is the speed of the second ball after the collision?

$m_1 = m_2$

$$m_1 \cdot 4.0 + m_2 \cdot 0 = m_1 \cdot 0 + m_2 \cdot V_f$$

$$V_f = 4.0 \text{ m/s}$$

Additional Practice problems:

1. A 63.0 kg astronaut with a 10.0 kg oxygen tank is at rest when his tether line to the shuttle breaks. To propel himself back to the shuttle, the astronaut throws the 10.0 kg oxygen tank with a velocity of 12.0 m/s away from the shuttle.

a. What type of "collision" is this? (Elastic, Inelastic or Separation)

b. What is the astronaut's final velocity when the tank is thrown?

$$(63.0 + 10.0) \cdot 0 = 63 \cdot V_{1f} + 10.0 \cdot 12.0$$

$$V_{1f} = 1.9 \text{ m/s toward the shuttle}$$

2. An 85.0 kg fisherman jumps from a dock onto a 135.0 kg rowboat at rest. If the velocity of the fisherman is 4.30 m/s West,

a. What type of "collision" is this? (Elastic, Inelastic or Separation)

b. What is the final velocity of the fisherman and the boat?

$$85 \cdot \bar{4}.3 + 135 \cdot 0 = (85 + 135) V_f$$

$$V_f = 1.66 \text{ m/s West}$$