Chapter Assessment

8. The distance between Earth and the sun is often expressed as 1 astronomical unit (AU). Using this unit, find the distance between the sun and Mars, which has a period of approximately 686 Earth days.

\[
\left(\frac{T_M}{T_E}\right)^3 = \left(\frac{r_M}{r_E}\right)^3, \quad r_M = r_E \left(\frac{T_E}{T_M}\right)^{\frac{1}{3}}
\]

\[
r_M = 1 \text{ AU} \left(\frac{365 \text{ d}}{27.3 \text{ d}}\right)^{\frac{1}{3}} = 1.52 \text{ AU}
\]

9. The mean distance between the center of Earth and the center of the moon is 3.84 x 10^8 m, and the moon has an orbital period of 27.3 days. Find the distance from Earth of an artificial satellite that has an orbital period of 9.1 days.

\[
\left(\frac{T_s}{T_E}\right)^3 = \left(\frac{r_s}{r_E}\right)^3, \quad r_s = r_E \left(\frac{T_E}{T_s}\right)^{\frac{1}{3}}
\]

\[
r_s = 3.84 \times 10^8 \text{ m} \left(\frac{27.3 \text{ d}}{9.1 \text{ d}}\right)^{\frac{1}{3}} = 1.84 \times 10^8 \text{ m}
\]

10. The gravitational force between two spheres is 2.50 x 10^-8 N. Their centers are 105 cm apart. The smaller sphere has a mass of 8.2 kg. Find the mass of the larger sphere.

\[
F = G \frac{m_1 m_2}{d^2}
\]

\[
m_2 = \frac{F d^2}{G m_1} = \frac{(2.50 \times 10^{-8} \text{ N})(0.105 \text{ m})^2}{(6.67 \times 10^{-11} \text{ N} \text{ m}^2/\text{kg}^2)(8.2 \text{ kg})} = 50 \text{ kg}
\]

11. A body orbits the sun at a distance ten times the mean distance of Earth's orbit from the sun. The sun's mass is 1.99 x 10^30 kg, and its distance from Earth is 1.50 x 10^11 m.

a. Find the period of the body in years.

\[
\left(\frac{T_s}{T_E}\right)^3 = \left(\frac{r_s}{r_E}\right)^3, \quad T_s = T_E \sqrt{\left(\frac{r_s}{r_E}\right)^3} = \sqrt{\frac{T_E (10r_E)^3}{r_s}}
\]

\[
T_s = (1 \text{ year}) \sqrt{\frac{(1.50 \times 10^{11} \text{ m})^3}{(10 \times 1.50 \times 10^{11} \text{ m})}} = 32 \text{ years}
\]

b. Determine the speed of the body.

\[
v = \sqrt{\frac{G m_s}{r}} = \sqrt{\frac{(6.67 \times 10^{-11} \text{ N} \text{ m}^2/\text{kg}^2)(1.99 \times 10^{30} \text{ kg})}{(1.50 \times 10^{11} \text{ m})}} = 9.41 \times 10^3 \text{ m/s}
\]
9 Chapter Assessment

Understanding Concepts Part B

Answer the following questions, showing your calculations.

1. What is the momentum of a 145-g baseball traveling at +40.0 m/s?
   \[ p = mv \]
   \[ = (0.145 \text{ kg})(40.0 \text{ m/s}) \]
   \[ = 5.80 \text{ kg-m/s} \]

2. What impulse is needed to stop a 45-g mass traveling at a velocity of −42 m/s?
   \[ F \Delta t = m \Delta v \]
   \[ = (0.045 \text{ kg})(42 \text{ m/s}) \]
   \[ = 1.9 \text{ N-s} \]

3. A force with a magnitude of 540 N is used to stop an object with a mass of 65 kg moving at a velocity of +175 m/s. How long will it take to bring the object to a full stop?
   \[ F \Delta t = m \Delta v \]
   \[ \Delta t = \frac{m \Delta v}{F} \]
   \[ = \frac{(65 \text{ kg})(0 \text{ m/s} - 175 \text{ m/s})}{540 \text{ kg-m/s}^2} \]
   \[ = 21 \text{ s} \]

4. In hitting a stationary hockey puck having a mass of 180 g, a hockey player gives the puck an impulse of 6.0 N-s. At what speed will the puck move toward the goal?
   \[ F \Delta t = m \Delta v \]
   \[ \Delta v = \frac{F \Delta t}{m} \]
   \[ v_2 - 0 = \Delta v = \frac{6.0 \text{ N-s}}{6.0 \text{ kg-m/s}} \]
   \[ v_2 = 33 \text{ m/s} \]

5. A metal sphere with a mass of 80.0 g rolls along a frictionless surface at 20.0 m/s and strikes a stationary sphere having a mass of 200.0 g. The first sphere stops completely. At what speed does the second sphere move away from the point of impact?
   \[ p_{A1} + p_{B1} = p_{A2} + p_{B2} \]
   \[ p_{A1} + 0 = 0 + p_{B2} \]
   \[ p_{A1} = p_{B2} \]
   \[ m_A v_{A1} = m_B v_{B2} \]
   \[ v_{B2} = \frac{m_A v_{A1}}{m_B} \]
   \[ = \frac{(0.0800 \text{ kg})(20.0 \text{ m/s})}{0.2000 \text{ kg}} \]
   \[ = 8.00 \text{ m/s} \]

6. A snowball with a mass of 85 g hits a snowman’s top hat and sticks to it. The hat and the snowball, with a combined mass of 220 g, fall off together at 8.0 m/s. How fast was the snowball moving at the moment of impact?
   \[ p_{A1} + p_{B1} = p_{A2} + p_{B2} \]
   \[ p_{A1} + 0 = p_{A2} + p_{B2} \]
   \[ m_A v_{A1} = (m_A + m_B)v_{A2 + B2} \]
   \[ v_{A1} = \frac{(m_A + m_B)v_{A2 + B2}}{m_A} \]
   \[ = \frac{(0.22 \text{ kg})(8.0 \text{ m/s})}{0.085 \text{ kg}} \]
   \[ = 21 \text{ m/s} \]
**Chapter Assessment**

### Applying Concepts

**Answer the following questions, using complete sentences.**

1. Explain how a motorcycle can have the same linear momentum as an automobile.
   
   *Because linear momentum is the product of an object's mass and velocity, the less massive motorcycle must have proportionately greater velocity to have the same linear momentum as an automobile.*

2. To bunt a baseball effectively, at the instant the ball strikes the bat, the batter moves the bat in the same direction as the moving baseball. What effect does this action have? Why?
   
   *It reduces the velocity at which the ball rebounds from the bat. When the bat moves in the same direction as the moving ball, the two are in contact for less time than when the bat moves toward the ball. Because the two are in contact for less time, the impulse on the ball is reduced, and its change in momentum, and therefore its change in velocity, is reduced. The smaller change in velocity indicates that the ball rebounds from a bunt at less velocity than from a normal swing.*

3. In the sport of curling, players slide 19-kg masses called stones along the surface of the ice toward a target. If a stone traveling 3 m/s strikes a stationary stone directly, the first stone will stop moving. Using the concept of conservation of momentum, describe what happens to the second stone. Assume there is no friction.
   
   *Because the two stones are an isolated, closed system, momentum is conserved. Therefore, the second stone will move in the same direction and at the same speed as the first.*

4. Why does a fire hose recoil when the water is turned on?
   
   *Before the water is turned on, the momentum of the hose-and-water system is zero. After the water is turned on, the water gains momentum as it is pushed forward from the hose. Because the hose and water form an isolated, closed system, momentum is conserved. For the momentum of the system to remain zero, the hose gains an equal magnitude of momentum in the opposite direction. The backward momentum of the hose gives it a backward velocity, or recoil.*

5. Suppose you were an astronaut drifting in space several meters from your spacecraft. The only thing you have with you is a sack filled with moon rocks. How could you return to your ship? While holding the rocks, you and the rocks form an isolated, closed system, with an initial momentum of zero. Because the momentum of such a system is conserved, at a later time the momentum of the system has to be zero. If you give the rocks momentum by throwing them away from the ship, you will gain momentum in the opposite direction, which means you will move toward the ship.

### Problem Solving

**Answer the following questions, showing your calculations.**

6. A ball with a mass of 12 g moving at +15.0 m/s collides with a second ball with a mass of 36 g moving at +5.0 m/s. After the collision, the 12-g ball moves at +6.0 m/s. What is the change in momentum of the 36-g ball?
   
   \[
   \Delta p = m_B v_B - m_B v_{B1} 
   \]
   
   \[
   \Delta p = (0.036 \text{ kg})(5.0 \text{ m/s}) - (0.012 \text{ kg})(15.0 \text{ m/s}) = 0.11 \text{ kg m/s} 
   \]

7. A 24.0-kg dog running at a speed of 3.0 m/s jumps onto a stationary skateboard that has a mass of 3.6 kg. How long will it take an average force with a magnitude 9.0 N to stop the skateboard and dog?
   
   \[
   \Delta p = m_B v - m_B v_{B1}
   \]
   
   \[
   \Delta p = (0.036 \text{ kg})(8.0 \text{ m/s}) - (27.6 \text{ kg})(0 \text{ m/s} - 2.6 \text{ m/s}) = -8.0 \text{ kg m/s}^2
   \]
   
   \[
   \Delta p = F \Delta t
   \]
   
   \[
   \Delta t = \frac{m_B (v_B - v_{B1})}{F} = \frac{2.6 \text{ m/s}}{9.0 \text{ kg m/s}^2} = 0.29 \text{ s}
   \]
Chapter Assessment

Energy, Work, and Simple Machines

Understanding Concepts Part A

Write the letter of the choice that best completes the statement or answers the question.

1. Any object that has energy has the ability to
a. burn  b. produce a change  c. fall

2. If the environment does work on a system,
   a. the environment warms  b. the energy of the system increases  c. the energy of the system decreases  d. the quantity of work done on the system has a negative value

3. When a force is exerted on an object, work is done only if the object
   a. is heavy  b. remains stationary  c. moves  d. has no momentum

4. In which of the following situations is no work done on a football?
   a. picking up the football  b. carrying the football down the field  c. dropping the football

5. In which of the following situations is work done on the football by a person?
   a. picking up the football  b. carrying the football down the field  c. dropping the football

6. In which of the following situations is work done on the football by gravity?
   a. picking up the football  b. carrying the football down the field  c. dropping the football

Write the term that correctly completes each statement.

7. One definition of ________ power ________ is "work done per unit time."

8. A machine with a mechanical advantage greater than 1 increases ________ effort force ________.

9. For an ideal machine, efficiency is always ________ 100 ________ percent.

10. If the mechanical advantage of a machine is less than 1, effort force is ________ greater ________ than resistance force.

11. A wedge used to split wood is a ________ simple ________ machine.

12. A pair of gears make up a ________ compound ________ machine.