Chapter 3 Review Answer Key

Vocabulary Answers

Section 3.1

1. law of conservation of momentum
2. impulse
3. Newton's third law
4. momentum

Section 3.2

5. law of conservation of energy
6. joule
7. potential energy
8. kinetic energy
9. energy
10. work

Section 3.3

11. collision
12. inelastic collision
13. elastic collision

Reviewing Concepts

Section 3.1

1. Newton's third law states that for every action force there is an equal and opposite reaction force.
2. same; opposite
3. Answers are:
   a. The forces are exactly the same but in opposite directions.
   b. Because you have more mass than your friend, your acceleration is less than your friend's.
4. The table pushes up on the book with an equal and opposite force.
5. Examples will vary. If I am on roller blades, I can push against a wall, and the wall pushes back on me and I start rolling. When you walk, your foot pushes down on the ground and the ground pushes back on you with an equal and opposite force, thus propelling you forward.
6. mass and velocity
7. Answers are:
   a. The airplane has the greater mass.
   b. The person walking through the airport has the greater velocity. The airplane's velocity is zero because it is at rest.
   c. The person walking through the airport has the greater momentum. Since the airplane is not moving, it does not have any momentum.
8. Impulse is the change in momentum created by a force exerted over time. Impulse can be calculated by multiplying force over the time the force is applied (ft) or it can be calculated by finding the change in momentum (mv_2-mv_1).
9. Since impulse is a measure of the change in momentum of a system, it has units of momentum.
   Impulse = force × time
   Units of impulse = newtons × sec = (Kg-m/sec^2)(sec) = kg-m/sec
   Momentum = mass × velocity
   Units of momentum = kg × m/sec = kg-m/sec
10. If interacting objects in a system are not acted on by outside forces, the total amount of momentum in the system cannot change.
11. Answers are:
    a. Your cousin moves faster because he has less mass. In order for momentum to be conserved, $m_1v_1 = m_2v_2$. If the mass of your cousin is less, then his velocity must be higher.
    b. Your impulse and your cousin's impulse are the same, because you both have the same change in momentum.
12. Earth's mass is so large that you don't notice the motion of its momentum.

Section 3.2

13. Anything with energy is able to change or to cause change.

14. newton × meter.
15. energy
16. Increase its height.
17. A bicycle at rest at the top of a hill has potential energy. The bike is capable of becoming active because of the force of gravity and its position at the top of the hill.
18. An object's mass and speed determine its kinetic energy.
19. Kinetic energy is proportional to the square of the velocity. If the speed doubles, kinetic energy is four times greater. If the speed triples, kinetic energy is nine times greater.
20. As the ball moves up: its kinetic energy decreases as it slows down and its potential energy increases as its height increases. As the ball moves down: its kinetic energy increases as it speeds up and its potential energy decreases as its height decreases.
21. As a ball falls toward the ground, its total energy is conserved. As the ball falls, its speed increases and its height decreases. Its potential energy is transformed to kinetic energy as it approaches the ground, but its total amount of energy stays the same.
22. The total amount of energy on Earth remains constant, it will never run out. Certain forms of energy, such as oil or gas, may run out, but that's because they've been transformed into a different type of energy. The energy is not gone, just transformed into a different type.

Section 3.3

23. In an elastic collision, objects bounce off each other with no loss of kinetic energy in the system. The kinetic energy before the collision and the kinetic energy after the collision are the same. In an inelastic collision, objects collide and stick together or change shape. In an inelastic collision, some the kinetic energy of the system is transformed into other energy forms.
24. Answers are:
    a. inelastic
    b. elastic
    c. elastic
    d. inelastic
25. Momentum is conserved during both elastic and inelastic collisions.
26. [illegible] uses a greater force than stopping during a [illegible] ge in momentum is greater. If the object stops, its velocity goes to zero in the collision. If the object bounces, its velocity changes direction, resulting in a larger momentum change. The force of the collision depends on the momentum change.
27. The car body is designed to absorb the momentum of a crash by crumpling as slowly as possible to reduce the force of the impact by spreading out the change in momentum over a longer period of time.
28. The secret to catching a water balloon without breaking it is to move your hands along with the water balloon to slow its impact and spread out the momentum change over a longer period of time by "riding with the catch."

Solving Problems

Section 3.1

1. The two equal forces are acting on different objects. The basketball accelerates from the force you apply to it. You accelerate from the force the basketball applies to you.
2. $P = mv = 2 \text{ kg} \times 4 \text{ m/sec} = 8 \text{ kg-m/sec}$
3. $v = P \div m = (50{,}000 \text{ kg-m/sec}) \div (1{,}000 \text{ kg}) = 50 \text{ m/sec}$
4. $m = P \div v = (110 \text{ kg-m/sec}) \div (2 \text{ m/sec}) = 55 \text{ kg}$
5. Truck: $P = mv = 5000 \text{ kg} \times 10 \text{ m/sec} = 50{,}000 \text{ kg-m/sec}$
   Sports car: $P = mv = 1200 \text{ kg} \times 50 \text{ m/sec} = 60{,}000 \text{ kg-m/sec}$
   The sports car has more momentum.
6. Answers are:
   a. $P_{80} = mv = 80 \text{ kg} \times 3 \text{ m/sec} = 240 \text{ kg-m/sec}$
   b. by conservation of momentum, $P_{60} = P_{80} = 240 \text{ kg-m/sec}$
   c. $v_{60} = P \div m = (240 \text{ kg-m/sec}) \div (60 \text{ kg}) = 4 \text{ m/sec}$
7. by conservation of momentum, $P_{\text{astronaut}} - P_{\text{rock}} = 0$
   $P_{\text{astronaut}} = P_{\text{rock}}$
   $m_a v_a = m_r v_r$
   $(75 \text{ kg}) v_a = (5 \text{ kg})(5 \text{ m/sec})$
   $v_a = 0.33 \text{ m/sec}$
8. Answers are:
   a. change in momentum $= m(v_2 - v_1) = (2 \text{ kg})(8 \text{ m/sec} - 0)$
      $= 16 \text{ kg-m/sec}$
   b. impulse = change in momentum = 16 kg-m/sec

c. $Ft = m(v_2 - v_1)$ = 16 kg-m/sec; F = 32 N
t = 0.5 sec

9. Answers are:
   a. Impulse = Ft = (10,000 N)(2 sec) = 20,000 kg-m/sec
   b. Change in momentum = impulse = 20,000 kg-m/sec
   c. $Ft = m(v_2 - v_1)$
   20,000 kg-m/sec = (1000 kg)(0 - v_1)
   v_1 = -20 m/sec

Section 3.2

10. $F = mg$ = (5 kg) × (9.8 m/sec^2) = 49 N
$W = Fd$ = (49 N) × (2 m) = 98 joules
$E_p = mgh$ = (5 kg) × (9.8 m/sec^2) × (2 m) = 98 joules

11. $W = Fd$ = (10,000 N) × (20 m) = 200,000 joules

12. Earth: $E_p = mgh$ = (5 kg) × (9.8 m/sec^2) × (2 m) = 98 joules
Moon: $E_p = mgh$ = (5 kg) × (1.6 m/sec^2) × (2 m) = 16 joules
The rock has more potential energy on Earth because the acceleration due to gravity on the moon is lower.

13. $E_p = mgh$ = (60 kg) × (9.8 m/sec^2) × (500 m) = 294,000 joules

14. Answers are:
   a. $E_k = ½mv^2$ = ½(50 kg)(5 m/sec)^2 = 625 joules
   b. $E_k = ½mv^2$ = ½(50 kg)(10 m/sec)^2 = 2,500 joules
   c. $E_k = ½mv^2$ = ½(50 kg + 50 kg)(5 m/sec)^2 = 1,250 joules
   d. Doubling the speed increases the kinetic energy by 4 times, while doubling the mass only increases the kinetic energy by 2 times.

15. Sample answers:

Position	P.E. (J)	K.E. (J)
A	117.6	0
B	88.2	29.4
C	58.8	58.8
D	29.4	88.2
E	0	117.6

Section 3.3

16. Answers are:
   a. The collision is inelastic since the cars stick to each other.
   b. $P_1 = m_1v_1$ = 800 kg × 20 m/sec = 16,000 kg-m/sec
   $P_2 = m_2v_2$ = 1200 kg × 10 m/sec = 12,000 kg-m/sec
   c. The momentum of the stuck together cars is the sum of the momentums of the cars before the collision because the momentum of the system must be conserved. The total momentum before the collision equals the total momentum after the collision.
   $P_3 = P_1 + P_2$
   P_3 = (16,000 kg-m/sec) + (12,000 kg-m/sec) = 28,000 kg-m/sec
   d. The momentum after the collision equals the total mass of the two cars multiplied by the velocity.
   $P_3 = (m_1 + m_2) \times v_3$
   $v_3 = P_3 \div (m_1 + m_2)$ = 28,000 kg-m/sec ÷ (800 kg + 1200 kg)
   v_3 = 14 m/sec

17. net momentum before = net momentum after
$m_1v_1 + m_2v_2 = m_3v_3 + m_4v_4$
(5 kg)(6 m/sec) + (1 kg)(0 m/sec) = (5 kg)(v) + (1 kg)(10 m/sec)
30 + 0 = 5v + 10
v = 4 m/sec

18. Answers are:
   a. The change in momentum is the same for both cars. They both have the same mass and same change in speed.
   b. The impulse on both cars is the same. Impulse is equal to change in momentum.
   c. The force of Yanick's brakes is 5 times larger than the force on Nancy's brakes because Yanick stops 5 times faster.
   d. $Ft = m(v_2 - v_1)$
   F_y(1 sec) = (1500 kg)(20 m/sec - 0)
   F_y = 30,000 N
   F_n(5 sec) = (1500 kg)(20 m/sec - 0)
   F_n = 6000 N

19. Answers are:
    a. Impulse = Ft = (800 N)(10 sec) = 80(
    b. $Ft = m(v_2-v_1)$
       8000 N-sec = (1000 kg)(v_2 - 0)
       v_2 = 8 m/sec

Applying Your Knowledge

Section 3.1

1. Answers will vary. If Newton's third law of motion was no long longer true, every step you took on a hard floor might feel like you were walking through a snow drift because the floor would not be pushing back equally on your foot to help you move along.

2. (1) Water pushes on the hose - hose pushes on the water
   (2) Firefighter pulls on hose - hose pulls on firefighter
   (3) Firefighter pushes against Earth - Earth pushes against firefighter

3. $m_e = 5.97 \times 10^{24}$ kg
   m_s = 60 kg
   conservation of momentum:
   $m_e v_e - m_s v_s = 0$; $m_e v_e = m_s v_s$
   $(5.97 \times 10^{24}\text{ kg})v_e = (60\text{ kg})(5\text{ m/sec})$
   $v_e = 5 \times 10^{-23}$ m/sec

Section 3.2

4. The kinetic energy formula tells us that the kinetic energy of the car is proportional to the square of its speed. As the result, the car has four times as much kinetic energy when it goes twice as fast, so it requires four times as much stopping distance.

5. Answers will vary. Examples include:
   1 serving of crackers = 140 Calories = 586,180 J
   1 serving of tortilla chips = 143 Calories = 598,741 J
   1 serving of chocolate chip cookies = 1,088,620 J

Section 3.3

6. When a ball is hit using an aluminum bat rather than a wooden bat, the greater change in shape of the bat allows the bat more contact time with the ball, imparting a greater impulse, more momentum, and therefore, greater speed to the ball. MLB considers that to be an unfair advantage.

7. . In their poster, encourage students to be
   vay to display the information they find. If they use poster board, have them fill up the entire available space. Students can use the National Highway Traffic Safety Administration web site, NHTSA.dot.gov, for information on car testing.