Solve It!

Calculate:

Momentum of Player #1 = 80 kg × 2 m/s = 160 kg-m/s

Momentum of Player #2 = 40 kg × 3 m/s = 120 kg-m/s

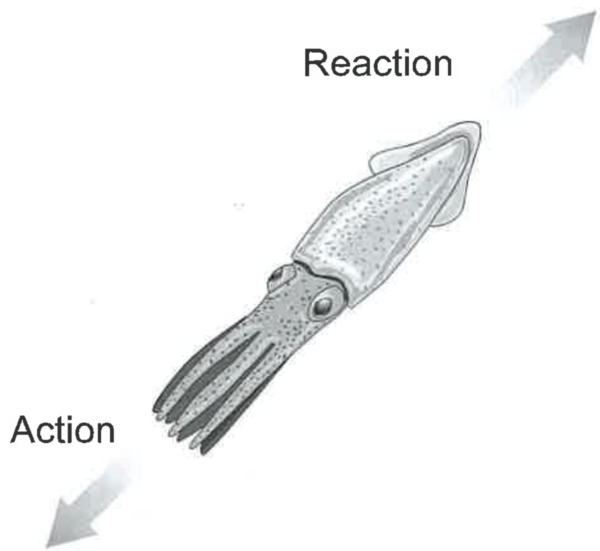
Predict:

The colliding players will move in the positive direction (in this case to the right) because Player #1 (moving to the right) has more momentum.

Science Fact

Squid Science

The water is pushed out of the squid by the squid's muscles. The water creates a pushing force back on the squid that causes it to move forward (the reaction).



Connection

1. Forensic engineers act as both detectives (gathering clues and evidence) and engineers (analyzing evidence).
2. The law of conservation of energy tells us that the vehicle's kinetic energy had to be transferred somewhere. Forensic engineers look for evidence of energy transfer. They often find it in damage to the roadway, roadside obstacles, and the vehicle(s) involved in the collision.
3. Vehicle kinematics is the study of how the vehicle moved before, during, and after the collision. Occupant kinematics looks at driver and passenger movement.
4. Answers will vary.

Chapter 6 Assessment

Vocabulary

Section 6.1

1. Newton's first law
2. unbalanced forces
3. inertia

Section 6.2

4. Newton's second law

Section 6.3

5. Newton's third law
6. momentum

Concepts

Section 6.1

1. Friction acts as an unbalanced force that must be overcome to maintain constant speed.
2. The ball filled with sand would have more mass than the ball filled with feathers. According to Newton's first law, the ball with more mass will require a greater force to overcome its inertia. You could roll both balls. The ball that is harder to start rolling is the ball filled with sand.
3. The answers are a and d.
4. Mass and inertia are directly proportional, therefore if you decrease the mass you decrease the inertia.
5. Answers: (a) B; (b) U; (c) B; (d) U; (e) B; (f) U

Section 6.2

6. The answer is b.
7. Directly proportional means that if you increase one variable, the other variable increases by the same factor. Inversely proportional means that if you increase one variable, the other variable decreases by the same factor.
8. The net force is the sum of all the force vectors acting on the object added together as if they were one single force acting on the object. Acceleration is the motion due to the net force.
9. To accelerate a car, you can increase its speed, decrease its speed, or change its direction.

10. Yes, you are accelerating because you are changing speed. A negative acceleration is called a deceleration.
11. $a = F \div m$
12. The answer is c.

Section 6.3

13. Answers:
    a. The statement is incorrect. In an action-reaction pair, the forces work on different objects.
    b. The statement is incorrect. Every action force creates a reaction force and the two forces are equal in strength and opposite in direction.
14. The table is pushing up on and supporting the brick.
15. The answer is b.
16. Sample answer: When a bowling ball hits a stationary bowling pin, the ball slows down (loses momentum) because it has more inertia, and the pin moves quickly (gains the momentum lost by the bowling ball as long as friction is not considered).

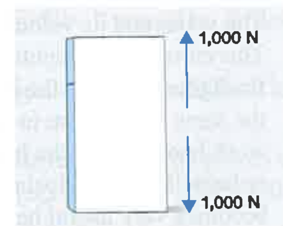
Problems

Section 6.1

1. 20 m/s; since the net force is zero, the object continues moving at a constant velocity.
2. The bowling ball has 100 times the inertia of the tennis ball. Inertia and mass are directly proportional.
3. Answers are:
    a. $(250 \text{ kg})(9.8 \text{ m/s}^2) = 2{,}400$ N down
    b. The normal force is equal and opposite to the weight: 2,400 N up
    c. The frictional force is equal and opposite to the engine force in order for the motorcycle to remain at constant speed: 1,700 N
4. The net force is150 N to the right.
5. Samples diagrams for (a) and (b):

A

B



Section 6.2

6. Filled in table:

Force (N)	Mass (kg)	Acceleration (m/s^2)
20	10	2
50	10	5
10	2	5
10	5	2
100	50	2
500	100	5

7. $F = m \times a = (1{,}000 \text{ kg})(5 \text{ m/s}^2) = 5{,}000$ N
8. $a = F \div m = (10{,}000 \text{ N}) \div (2{,}000 \text{ kg}) = 5 \text{ m/s}^2$
9. $m = F \div a = (20 \text{ N}) \div (140 \text{ m/s}^2) = 0.14$ kg
10. The net force is 50 N west. $a = F \div m = (50 \text{ N}) \div (10 \text{ kg}) = 5 \text{ m/s}^2$
11. $F = m \times a = (40 \text{ kg})(7 \text{ m/s}^2) = 280$ N
12. Answers are:
    a. a = change in v ÷ change in t = (29 - 5 m/s) ÷ (4 s) = 6 m/s^2
    b. –6 m/s^2; equal in strength but opposite in direction

Section 6.3

13. The rock exerts a 100-newton force on Jane because action-reaction forces are equal and opposite and do not depend on the mass of the object.
14. Answers:
    a. Sample answer: (1) Firefighter's hands acting on the hose (action) and the hose pushing back on the hands (reaction). (2) The water exiting the

hose pushes on the hose (action) and the hose pushes back on the water (reaction). (3) The weight of the firefighter's hat pushed down on his head (action) and his head pushes back on the hat (reaction).

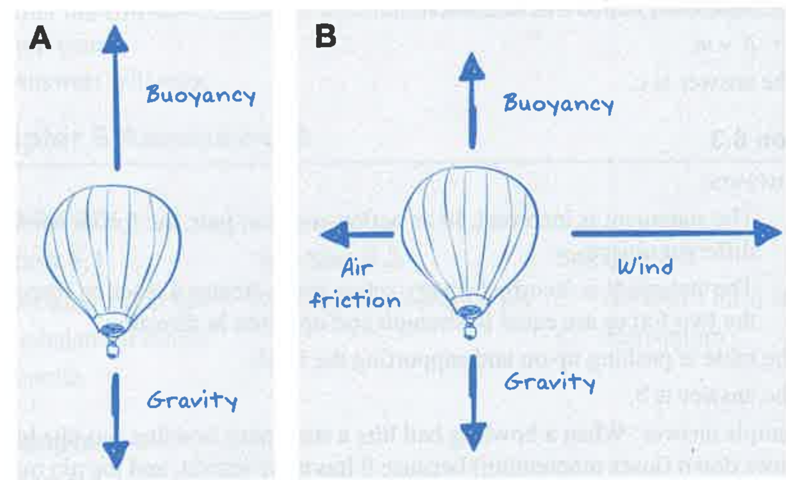
b. The water and its velocity moving out of the hose are very high. Therefore, the momentum of the water in the positive direction is high. A firefighter—due to the law of conservation of momentum—experiences the same momentum in the opposite direction. Therefore, he or she has to work hard to keep the hose steady. The firefighter needs to brace himself or herself to avoid losing control of the hose (in other words, friction becomes very useful here).

15. 3,000 kg (4 m/s) + 5,000 kg (0 m/s) = 3,000 kg (–1 m/s) + 5,000 kg (v_2)
(v_2) = 3 m/s

Applying Your Knowledge

Section 6.1

1. Information about Sir Isaac Newton can be found in the local library or on the Internet. Additionally, this program comes with biographies about important scientists; one biography is about Newton. Newton is considered to be as (or more influential) to science growth and development as Einstein.
2. Sample answer: Most likely the magician has rigged the ramp so that midway down it there is enough friction force to stop the ball from moving. He might have attached some double-sided tape or another sticky substance to stop the ball from moving down the ramp.
3. Answers:
   a. On the ground: the hot-air balloon has the downward force of weight (gravity), the upward normal force of the ground, and the forces from any ropes that are being used to keep the balloon upright and tethered to the ground.
   b. In the sky: the hot-air balloon has the downward force of weight (gravity), the upward force due to the buoyancy of the balloon in the air, and any forces from winds blowing against the balloon.
   c. and d. sample diagrams. Air friction opposes the wind.



Section 6.2

4. Sample answers:
   a. Career: Airline pilot. Types of motion-related tasks: Understand how to use the speed of the plane, wings, and air resistance to get the plane to take-off and land, accelerate, decelerate, and turn.
   b. How understanding Newton's laws of motion might help accomplish accelerating the plane: The pilot would know that the plane needs to provide a net force for the plane to speed up, slow down, or turn. The pilot would then know that she needs to apply more thrust to get the plane to speed up (and overcome air resistance) or less thrust to get the plane to slow down. Turning the plane requires understanding how to use the moveable parts of the wings of the plane.
   c. Extension: Student answers will vary.
5. Sample answers:
   a. The robot mail cart could have a larger motor so that it could accelerate faster. However, the motor shouldn't have so much mass that it takes the cart too long to accelerate and uses too much fuel.
   b. The robot mail cart can have a small, low-mass motor. It will not need to accelerate quickly. However, it might need to be fast to get to all the offices as long as its movement isn't a safety concern in the small space.
   c. This robot should be large enough so that the children see it. The robot mail cart should move slowly so as to not endanger the children as they walk in the halls. The motor can be medium-sized. The cart may need to accelerate quickly so that it can respond quickly in case it runs into a person. You would want the cart to back up quickly, for example, if it ran over a person's foot! So, this cart's motor and electronics would also have to be designed so that it can respond and avoid dangerous situations.

Section 6.3

6. Sample answer:
   Action-reaction pairs in a soccer game might be—feet-ground, foot-ball during a kick, hands-ball when the goalie stops the ball at the goal, player-player as players collide, two hands clapping, and the referee blowing air into a whistle-the whistle.
7. Sample answers:
   a. A ball that can be throw through a hoop: Once thrown the ball might not make it into the hoop because the pull of gravity would be much less and the ball might not follow the path of a projectile. It would be difficult to make a basket in space.
   b. Building blocks: The blocks would be weightless and would float around so it would be hard to stack them.
   c. A board game with game pieces for each player: The game pieces would probably float off the board unless the players held them down with their hands. The board might float too.
   d. A deck of cards: Playing cards might be do-able in space as long as the players held on to the cards. But, if you had to discard cards in a pile, they would float away.
8. Student answers will vary.
   Auto manufacturers conduct crash tests to help them improve the design of cars. Some safety features that have been added to cars to make sure they are safe in the event of a collision are: seat belts, safety glass, airbags, antilock brakes, special bumpers that collapse and crunch if hit (and absorb the force rather than the whole car or the people inside!), and reinforcements on the sides of the cars in the event of a side collision.
   To note: Riding in a vehicle with a large mass does not guarantee passengers will be safe in a collision. Larger cars or vans may be more likely to roll over during accidents. Therefore, auto designers have to pay attention to how the mass of a car is distributed to make it safe as well.
9. A building has so much mass (inertia) that it would take a similarly large mass or an object at very high speed to move it. If you push or run into a building, you experience all the momentum before and after the collision. This is why colliding with massive objects is very harmful and dangerous. Note: When you push on the building, it does push back on you! This is due to the atoms in the material of the building pushing back on you as you push on them.
10. Sample answer: My favorite law of motion is Newton's first law because I like the idea of objects either resting in motion if they are already at rest or continuing in motion if they are already in motion. I also like knowing how to change the motion of objects—I just add a force! [A possible brochure idea might be that a student offers specials or sales for buying a force to change the motion of an object.]