ANSWERS

1. In words, the equation for momentum is \textit{momentum equals the mass of an object times its velocity}. As a formula, the equation is \( p = mv \).

2. A large truck is moving at 30 miles per hour, and a small truck is also moving at 30 miles per hour. The \textit{small} truck has the least momentum.

3. The momentum change of an object is equal to the \textit{impulse} acting on it.

4. A Ping-Pong\textsuperscript{TM} ball launcher is fired. Compared to the force on the ball, the force on the launcher is \textit{the same}.

5. A Ping-Pong\textsuperscript{TM} ball launcher is fired. Compared to the impulse on the ball, the impulse on the launcher is \textit{the same}.

6. A Ping-Pong\textsuperscript{TM} ball launcher is fired. Compared to the distance the ball travels, the distance the launcher travels is \textit{shorter}.

7. In an elastic collision, the two objects collide and \textit{come apart or bounce off each other}.

8. In an inelastic collision, the two objects collide and \textit{stick together}.

9. In all collisions, momentum is \textit{conserved}.

10. How does the momentum of an object change if
   a. its speed is doubled? \textit{It doubles}
   b. its speed is cut in half? \textit{It is cut in half}.

11. Describe the differences in momentum and impulse between a swing that produces a line drive and one that produces a bunt. \textit{The ball has the same mass regardless of the type of swing. The line drive swing produces more impact force and impact time. It will have more impulse. Since impulse equals a change in momentum, it will also have more momentum}.

12. Does a large force always produce a larger change in an object’s momentum than a smaller force does? Explain. \textit{Not always. The change in momentum is equal to the impulse, which is equal to the impact force times the impact time. A small force with a long time could produce more impulse and therefore a larger change in momentum than a large force with a short impact time}.

13. Gymnasts always perform on padded mats. Use the impulse-momentum theory to explain how these mats protect the athletes. \textit{When the gymnast lands, she experiences a certain change in her momentum. This requires a certain amount of impulse, which is the product of impact force and impact time. The mat provides a larger impact time than say a tile floor does. The longer impact time then results in a smaller impact force, so the gymnast experiences less force}.

14. Two objects have a head on collision. If you know the change in momentum of one object, can you find the change in momentum of the other object? Explain. \textit{Yes. The two objects experience the same force (NIH) and impact time, so they have the same impulse. Impulse equals the change in momentum, so the two objects have the same change in momentum}.

15. How is momentum conserved when two skaters initially at rest push against each other? \textit{The initial momentum of the system is 0. When the two skaters push off...}
against each other, they go in opposite directions, and have opposite momenta. The magnitude of each skater's momentum is the same, but the directions are opposite, so they add to 0, and momentum is conserved. The lighter skater will travel farther than the heavier one.

16. If two objects collide and one is initially at rest, is it possible for both to be at rest after the collision? Is it possible for one to be at rest after the collision? Explain. **No. The system has an initial momentum, and that momentum must be conserved. If both objects are at rest, the system, the final momentum would not be 0, which violates conservation of momentum.**

17. A deer with a mass of 146 kg is running head on towards you with a speed of 17 m/s. You are going north. What is the momentum of the deer? **2.5 \times 10^3 \text{kg m/s to the south}**

18. A 1210 kg car has a momentum of 5.6 \times 10^4 \text{kg m/s}. What is the car’s speed? **46 m/s**

19. A 0.50 kg football is thrown with a velocity of 15 m/s to the right. A stationary receiver catches the ball and brings it to rest in 0.020 s. What is the force exerted on the ball by the receiver? **3.8 \times 10^2 \text{N to the left}**

20. A 63.0 kg astronaut is on a spacewalk when the tether line to the shuttle breaks. The astronaut is able to throw a spare 10.0 kg oxygen tank in a direction away from the shuttle with a speed of 12.0 m/s, propelling the astronaut back to the shuttle. If the astronaut started from rest with respect to the shuttle, how fast is he going with respect to the shuttle after he throws the tank? **1.90 m/s**

21. A 1500 kg car traveling at 15.0 m/s to the south collides with a 4500 kg truck that is initially at rest at a stoplight. The car and truck stick together and move together after the collision. What is the final velocity of the two-vehicle system? **3.8 m/s to the south**

22. A 0.015 kg marble sliding to the right at 22.5 cm/s on a frictionless surface makes an elastic head-on collision with a 0.015 kg marble moving to the left at 18.0 cm/s. After the collision, the first marble moves to the left at 18.0 cm/s. Calculate the final velocity of the second marble after the collision. **22.5 cm/s to the right**