Answers:

1.)A falling raindrop has more momentum than a supertanker tied at the dock does. Momentum is a measure that includes both the mass and the velocity of an object and it is directly proportional to each. Even though a supertanker has a far greater mass than a falling raindrop, it has no momentum because it has no velocity (its tied at the dock).

2.) The momentum of a car traveling south is different from the momentum of an identical car traveling north at the same speed. Similar to the [raindrop and the supertanker](http://www.edu.pe.ca/gray/class_pages/krcutcliffe/physics621/9%20momentum/9%20momentum%20written%20answers.htm" \l "1) question, momentum is a measure that includes both the mass and the velocity of an object. The two cars have identical mass but they do not have the same velocity as they are traveling in opposite directions. Therefore, they would have equal but opposite values for momentum.

3.) When a pitcher throws a fastball to a catcher, each player exerts the same impulse on the ball if we ignore air resistance. By ignoring air resistance, the ball will have the same momentum throughout its flight. Therefore the momentum the ball gained from the pitcher must be lost to the catcher (the ball starts and ends with zero momentum). Since impulse measures the change in momentum, each must be exactly the same.

4.)If you jump off a table, as your feet hit the floor, you let your legs bend at the knees in order to mimimize the force applied to your skeletal system. Just before you reach the floor your body has momentum. After you land, your body will have no momentum, so therefore there was a change in momentum and an **impulse** was necessary for this to happen. The impulse on your body in this case comes from the floor and the size of the impulse is constant. Since impulse is the product of the force and the time over which it acts, then force and time are inversely proportional. So, if the force acts over a longer time period, then it will have a smaller magnitude. If we didn't bend our knees, the force would act over a much shorter period of time and would thus be much greater in magnitude, great enough to break our bones.

5.) To catch a fast moving baseball barehanded you should move your hand in the same direction as the ball is moving. By moving your hand in the direction the ball is moving, you will increase the time it takes for your hand to apply the impulse necessary to bring the ball to a stop. By increasing the time, you will decrease the your hand applies to the ball (and by Newton's third law: the force the ball applies to your hand) and it will not hurt nearly so much

6.) It is possible for an object to obtain a larger impulse from a smaller force than it does from a larger force. Impulse is the product of both net force and time. A large impulse could be obtained from a small force if the small force acts for a long period of time. Similarly, a large force may act for a very short period of time and result in a small impulse.

7)If an archer shoots arrows of the same mass and velocity at a target and some arrows stick in the target while others bounce back off, the arrows that bounce off will give the greater impulse to the target. Impulse is the product of the net force and time, but it can also be defined as the change in momentum. Each arrow had the same mass and velocity before hitting the target, so they all have the same initial momentum. When an arrow hits and sticks, it's final momentum is zero. On the other hand, if an arrow bounces back off, it's final momentum is not zero but rather it has some momentum in the opposite direction to its initial momentum. The arrows that have bounced off have gone through a greater change in momentum and therefore must have given the target a greater impulse.

8.) Two soccer players come from opposite directions. They leap in the air to try to head the ball, but collide with each other instead, coming to rest in midair. According to the law of conservation of momentum, the two players must have had equal and opposite momenta before the collision. The system containing the two players is a closed and isolated system, therefore, the total momentum before the collision must be exactly the same as the total momentum after the collision. Since the total momentum after the collsion is zero, then the mathematical sum of their origianal momenta must be also be zero.

9) If someone throws a heavy ball to you when you are standing on a skateboard you will catch it and roll backward with the skateboard. But, if you were standing on the ground you would be able to avoid moving. This can be explained by the law of conservation of momentum. In the first case, the heavy ball, you and the skateboard are a closed, isolated system. The total momentum after you catch the ball will be the same as the total momentum before you catch the ball. In the second case, though, the earth is acting on you and thus either must be included in your system or be considered an external force, **nulifying the law**. If you include the earth in your system, then the heavy ball, you, the skateboard and the earth will move a tiny, tiny amount. Just enough so that the total momentum afterward equals the total momentum before.

1.) Which has more momentum, a supertanker tied securely at the dock or a falling raindrop?

2.) Is the momentum of a car traveling south different from that of an identical car moving north at the same speed? Explain.

3.) A pitcher throws a fastball to a catcher. Ignoring air resistance, which player exerts the larger impulse on the ball?

4.) When you jump off something like a table you let your legs bend at the knees when you strike the floor. Explain why you would do this.

5.) To catch a fast moving baseball barehanded should your hand be moving or should it be still at the time of contact? Why?

6.) Is it possible for an object to obtain a larger impulse from a smaller force than it does from a larger force?

7) An archer shoots arrows at a target. Some arrows stick in the target while others bounce back off. If the mass and velocity of each arrow is the same, which arrows would give the greater impulse to the target?

8.) Two-soccer players come from opposite directions. They leap in the air to try to head the ball, but collide with each other instead, coming to rest in midair. What can be concluded about their original momenta?

9.) Someone throws a heavy ball to you when you are standing on a skateboard. You catch it and roll backward with the skateboard. If you were standing on the ground, however, you would be able to avoid moving. Explain both situations using the law of conservation of momentum. (Keep in mind an isolated system)