MOMENTUM QUESTIONS

1. Which has greater momentum: a train at rest or a moving skateboard?

Since the train is not moving, it has zero momentum. The skateboard, as long as it has some speed, will have more momentum, since p = m*v.

2. What are the ways to increase impulse?

Impulse depends on the magnitude of the applied external force and the time that the force acts on the system. By increasing either of those, impulse on a system will be increased, and the system's momentum will change accordingly.

3. For the same force, why does a long rifle impart more speed to a bullet than a short pistol?

The long barrel means that the force of the expanding gases from the gunpowder is able to push for more time on the bullet (since the push will continue as long as the bullet is in the barrel). Impulse = (Applied Force)*(time)

4. When you are in the way of a moving object and a collision is sure to occur, are you better off decreasing its momentum over a short time or over a long time? Explain.

The amount of force you will feel is the same as the force you apply to the object. So if you decrease its momentum over a long time, less force is needed to act. So, you would be "better off" exerting a small force for a long time.

5. Why is it a good idea to have your hand extended forward when you are getting ready to catch a fast-moving baseball with your bare hand?

Having your hand forward means that you can move your hand back with the ball, slowing it down over a greater distance – and also over a greater time. This reduces the force you need to apply to the ball, and consequently reduces the force you feel.

6. Why would it be a poor idea to have the back of your hand up against the outfield wall when you catch a long fly ball?

The ball will be moving pretty quickly, so to stop it you will need to remove quite a bit of momentum. If your hand is against the wall, the ball will be stopped very quickly since there is not much room for your hand to move while stopping the ball. (In fact, the only movement would be a squashing of your hand.) Stopping the ball quickly means that a large force must act, and a force of equal magnitude will therefore act on your hand.

7. What does it mean to say that momentum (or any quantity) is conserved?

If a quantity is conserved it just means that that quantity does not change.

8. To bring an oil-tanker to a stop, its engines are typically cut off about 25 km from port. Why is it so difficult to stop or turn a supertanker?

A supertanker has a huge mass, and therefore its momentum is enormous. To bring it to rest (removing all the momentum) a force will have to act over a long period of time to provide enough impulse to stop it.

9. In terms of impulse and momentum, why do air bags in cars reduce the chance of injury in accidents?

Since the person has to lose a certain amount of momentum, an equivalent amount of impulse must act on them, regardless of how quickly or slowly they stop. However, if less force acts (for a longer time) less damage will occur to the person – and this is what an airbag does. The airbag increases the time over which the person will be stopped in comparison to them hitting the steering wheel or windshield.

10. In terms of impulse and momentum, why are nylon ropes, which stretch considerably under tension, favored by mountain climbers?

If you fall while climbing, and are using nylon ropes, you will be brought to rest more slowly as the rope stretches, so less force will act on you. Therefore it will hurt less, and will also possibly prevent the rope from snapping since less force (tension) acts.

11. Automobiles were previously manufactured to be as rigid as possible, whereas today's autos are designed to crumple upon impact. Why?

Again, by crumpling, the time of the collision is extended and so less force must act on the car to slow it to a stop, which is better for the passengers too.

12. A Mars rover is tested on Earth at a speed of 2.5 km/h. When it travels as fast on Mars, is its momentum more, less, or the same?

The same: $p = m*v$ and mass does not depend upon where you are.

13. Why is it difficult for a firefighter to hold a hose that ejects large amounts of water at high speed?

The water exiting the hose is being pushed forward by the water behind it in the hose, so it pushes back on that water (and the hose). Since it is a large mass of water being ejected at a high speed, the impulse it feels is large and forward, and the water then provides a large impulse back on the hose, which makes it hard to hold.

14. You are at the front of a floating canoe, close to the shore. You jump, expecting to land on the beach easily. Instead you land in the water. Explain.

When you jump forwards you push back on the canoe, which then tends to drift backward as you jump off. So, effectively, you move slower relative to the water since the base you are jumping from is moving backwards. Of course, the canoe moves backwards to be consistent with conservation of momentum. Originally there was no momentum when you were standing still, so if you gain momentum forwards, the canoe must gain momentum backwards, assuming no external forces are acting.

15. If you throw a ball horizontally while standing on roller skates, you roll backward with a momentum that matches that of the ball. Will you roll backward if you go through the motions of throwing the ball, but instead hold on to it?

You will move back while your hand is "throwing" the ball forwards. But as you bring your hand and the ball to a stop, your whole body will stop too.You must keep the total momentum equal to zero at all times.

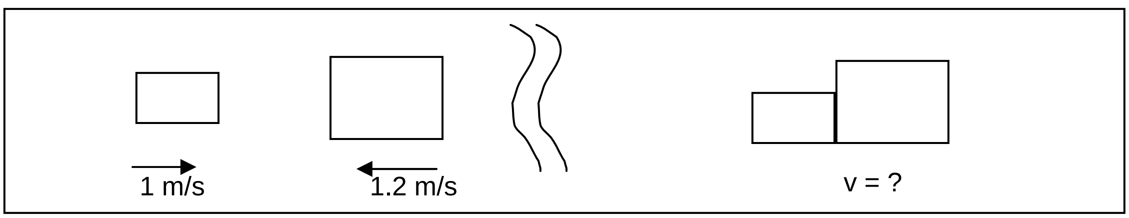
16. Your friend says that the law of momentum conservation is violated when a ball rolls down a hill and gains momentum. What do you say?

The Law of Momentum Conservation states that if no external forces act on a system, then the system's momentum will not change. If you treat the ball as your system, it is clear that the gravitational force is acting on the ball, provides an impulse, and therefore changes the ball's momentum. But this is not a violation of the Conservation of Momentum because there is an external force acting.

17. Would a head-on collision between two cars be more damaging to the occupants if the cars stuck together or if the cars rebounded upon impact? (Assume the time of the collision is the same.)

When the cars rebound away from each other there has been a greater change in momentum occurring for each car when compared to a collision where they collide and stick together. So a greater impulse acts on the cars. And if the time of the collision is the same for both, a greater force must act when they bounce in order to provide that greater impulse and greater change in momentum. This greater force (in the rebound) would be more dangerous.

18. A 0.5-kg cart on an air track moves 1.0 m/s to the right, heading toward a 0.8-kg cart moving to the left at 1.2 m/s. What is the direction of the two-cart system's momentum just before they collide? How much momentum is there? If they collide and stick, how much momentum is in the system right after the collision? How fast do they move after the collision?



The bigger mass has more speed, so its momentum is larger than the smaller one. The overall momentum must be to the left.

The initial momentum is: (0.5 kg)(1 m/s) – (0.8 kg)(1.2 m/s) = - 0.46 kgm/s

After the collision there must be exactly the same momentum = - 0.46 kgm/s

Stuck together, so the final momentum must also be: (0.5 kg + 0.8 kg)(v) = 1.3kg (v)

So: 1.3 kg (v) = -0.46 kgm/s => v = -0.46/1.3 = - 0.35 m/s (i.e. to the left)