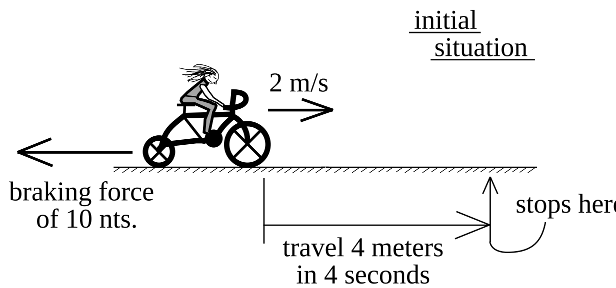
Momentum -- Conceptual Questions

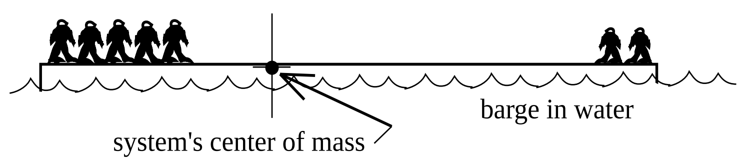
1.) A net force F stops a car in time t and distance d. If you multiply that force by the time over which it is applied, what will that quantity tell you?

2.) Your little sister is riding her trike. She is moving with velocity 2 m/s. She wants to stop, so she lightly engages the brake pedal. A net force of 10 newtons is applied to the wheels bringing the trike to a stop in 4 seconds over a distance of 4 meters. She decides to experiment (she's a precocious little thing), so:



a.) She doubles her trike speed to 4 m/s and tries to stop the trike in twice the time (8 seconds), distance be damned. How large a force must she apply?
b.) To make things even more exciting, she gets the trike back up to 4 m/s again and tries to stop it over twice the distance (8 meters), time be damned. How large a force must she apply?
c.) Is there a difference in these two force quantities and, if so, why?

3.) Five 300 pound football players stand at one end of a relatively light barge (a few thousand pounds) facing two 200 pound football players at the other end. The center of mass of the barge/player system is shown in the sketch. Someone blows a whistle and the five 300 pounders run toward the two terrified, stationary 200 pounders, tackling them in a heap at the right end of the barge. Ignoring the frictional effect water would bring to the system (this would probably be considerable, but ignore it anyway):



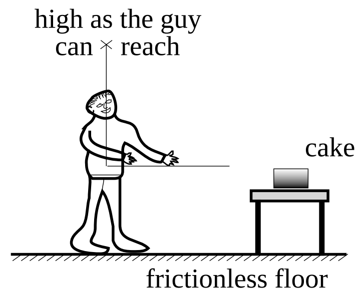
a.) In which direction has the center of mass of the barge/players system shifted as a consequence of the motion of the five monsters?
b.) How would this have changed if, when the horde was halfway to the other end, the two 200 pound players had jumped off the barge (one off each side--not off the end)?
c.) Would Part b have changed if the 200 pounders had jumped off the end, not the side?

4.) A car initially sitting still on a road accelerates to velocity v. The change of the car's momentum is mv. The earth's momentum change is (a) zero, (b) less than mv, (c) mv, (d) more than mv.

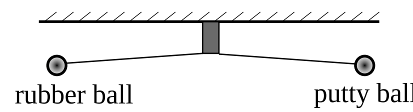
5.) The mass and velocity of a golf ball, and the mass and velocity of a basketball both multiply out to equal 12 kg·m/s.

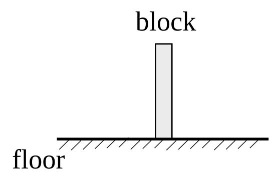
a.) Which will have the larger velocity?

b.) Assuming you exert the same force, which will take more time to stop?



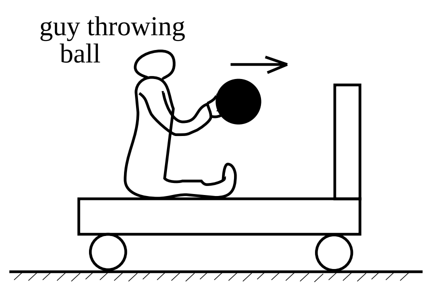
6.) A rubber ball on a string of length L and a wad of putty on a string of length L have the same mass. If both are pulled to the position shown and released at the same time, both will swing down and strike the wooden block simultaneously. Upon impact, which way, if any, would you expect the block to topple? Explain.





7.) Assuming both are moving with the same speed, which takes more force to stop, a large truck or a small car? If you said the large truck, you may be wrong. How so?

8.) A guy finds himself sitting motionless on a sled. He takes a massive medicine ball (this is like a very heavy basketball) sitting on the sled and throws it against the front wall. It collides and bounces back to him. All collisions are elastic (i.e., energy is conserved), and assume the wheels are frictionless.



a.) What is the motion of the cart, if any, after you throw the ball but before it hits the front wall?

b.) What is the motion of the cart after the ball has hit the front wall but before he catches it upon its return?

c.) What is the motion of the cart after he catches the ball off the rebound?

d.) Might this be a way to get the sled's center of mass to move to the right? Explain the usefulness of this approach, if any.

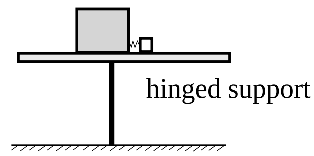
9.) Someone has built a miniature pistol that fires real bullets. Assuming the bullets have the same mass as the pistol, what little problem are you going to run into when you fire the gun?

10.) You are wearing a beltless pair of pants while standing on a frictionless sheet of ice. There is a table with a huge cake on it that is just out of reach (see sketch--it's to scale). How do you get to the table and the cake?

11.) A friend inadvertently shoots you with a low powered bee bee gun. In theory, which would hurt more, for the bee bee to hit and stick without penetrating or for the bee bee to hit and bounce? Explain.

12.) Jack (the idiot) fixes a large fan to his sailboat (note: he may be an idiot, but he's a rich idiot) thinking the boat will move forward if he directs the fan toward the sail. Will this work? Explain.

13.) What makes a padded dashboard in a car safer than a hard dash (yes, its the padding, but WHY is that safer)? Relate this to the idea of impulse.



14.) When a ball freefalls, is momentum conserved? Explain.

15.) A railroad engine is attached to a very long train. The engineer wants to move the train forward. Why does he first put the train engine in reverse and push everything backward just a hair before starting forward?

16.) Assuming both collide with the same initial speed and direction, and assuming both have the same mass and bounce off with the same speed, which applies a larger force to a wooden block, a rubber ball or a metal ball?

17.) Two objects have the same momentum. One is twice as massive as the other. Which requires more work to stop? Explain.

18.) Two objects have the same kinetic energy. One is twice as massive as the other. Which will experience the greater momentum change as they come to rest?

19.) A system of particles has some non-zero amount of mechanical energy involved within its assembly. Could the system's total momentum be zero? How about the other way around?

20.) Responding to a very early paper written by Robert Goddard (he would, with time, become the father of rocket science), a January 1920 editorial printed in the New York Times chided Goddard for suggesting that space travel was possible. The article pointed out that without atmosphere to push against, a rocket would go nowhere. Space travel is obviously possible, so how does a rocket go "without atmosphere to push against?"

21.) A frictionless beam is attached by a hinge to a thin post. Two blocks of unequal mass have a spring placed between then. They are forced together compressing the spring, then placed on the beam so that the beam balances without tipping.

a.) To begin with, where is the center of mass of the system?

b.) The system is then released with the spring accelerating the blocks outward away from one another. What will the hinged beam do as the blocks move outward (i.e., sit still, rotate, what?)? Use conservation principles to explain your response.

22.) Standing behind a jet engine, you register a force F due to the wind velocity produced by the jet. If the wind velocity doubles, how will the force change?

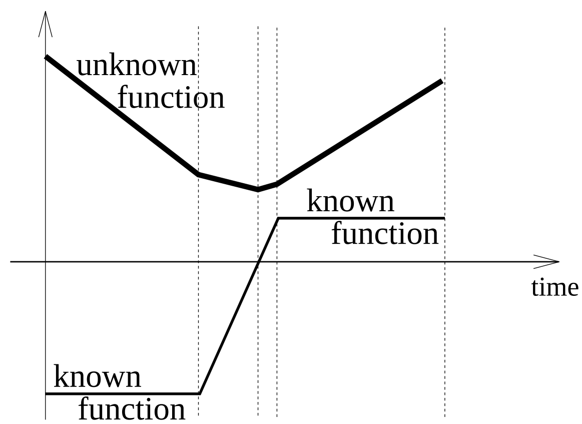
23.) A woman initially standing still on a frictionless ice patch pushes a box that is three times her mass.

a.) After the push, how will her momentum compare to the box's momentum (i.e., the same, her momentum is less, her momentum is more, what?)?

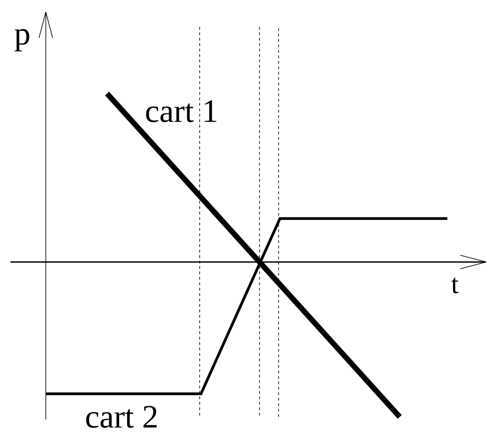
b.) Explain your response to Part a using the idea of impulse.

24.) Which would you prefer to tackle, a 100 kg (220 lb) football player running at 5 m/s or a 50 kg (110 lb) football player running at 10 m/s? Explain.

25.) If the "known function" on the graph to the right is the force applied to a cart, what might you expect the "unknown function" shown on the grid to characterize?



26.) There are two graphs to the right that show the momentum versus time of two independent carts. What would the FORCE VERSUS TIME graph look like for each cart?



27.) Would you prefer to be hit by a 8800 pound truck moving at 10 mph, or a marble moving with the same momentum?

28.) And the last, dying gasp: The momentum of a 1 kg ball moving straight upward is 12 kg·m/s.

a.) What will its momentum be 1 seconds later?

b.) Will the momentum 5 seconds later simply be 5 times the solution to Part a? Explain.