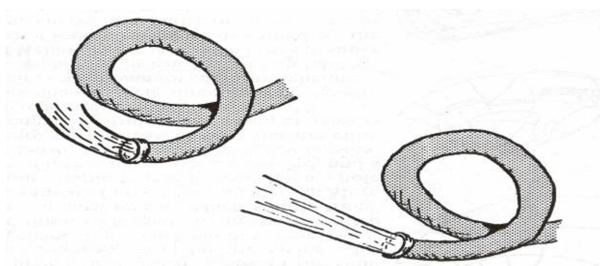
UNL2207 - The Nature of Natural Law: Tutorial 3

The Dynamics of Motion: Force & Momentum

1) A boulder is many times heavier than a pebble – that is, the gravitational force that acts on a boulder is many times that which acts on the pebble. Yet if you drop a boulder and a pebble at the same time, they will fall together with equal accelerations (neglecting air resistance). The principal reason the heavier boulder does not accelerate more than the pebble has to do with:

a) energy b) weight c) inertia d) surface area e) none of these.

2) Water is shooting out of a hose-pipe that has a kink in it.



Will the water shoot out of the pipe a) in a curved arc, or b) in a straight line? (Ignore the effect of gravity.)

3) The strong man is pulling the spring apart. Is there a force on the spring?

a) Certainly there is. b) There is no force on the spring.

4) The force exerted on the side of a house by a 120 km per hour hurricane is

a) equally b) twice c) three times d) four times

as strong as the force exerted on the same house by a 60 km per hour gale.

5) Can the man shown in the illustration below lift himself and the platform off the ground?

6) An hourglass is being weighed on a sensitive balance, first when all the sand is in the lower chamber, and then after the timer is turned over and the sand is falling steadily. Will the balance show the same weight in both cases?

a) Yes b) No

OPTIONAL FUN QUESTION (ie no marks for this one!)

A swarm of flies are captured in a closed jar. You place the jar on a scale. The scale will register the most weight when the flies are:

a) sitting on the bottom of the jar b) flying around inside the jar c) the weight of the jar is the same in both cases

7) Consider a block of ice on a frictionless frozen lake. Suppose a force acts continuously on the block. After the force has acted a certain amount of time, the speed of the block has increased by some amount.

(i) Now, if the force and the mass of the block are unchanged, but the time the force acts is doubled, then the increase in speed will be

a) unchanged b) doubled c)quadrupled d)halved

(ii) Next, if the force and the duration over which it acts are unchanged, but the mass of the block is doubled, then the speed increase will be

a) unchanged b) doubled c) quadrupled d) halved

(iii) Suppose now that only the force is doubled, while the time over which it acts and the mass are left unchanged. Then the increase in speed will be

a) unchanged b) doubled c) quadrupled d) halved

(iv) Finally, suppose the applied force, mass and duration are all as they were initially, but somehow the force of gravity is doubled (as if the experiment were being performed on another planet). Then the increase in speed would be

a) unchanged b) doubled c) quadrupled d) halved

8) Water leaves a hose at a rate of 1.5 kg/s with a speed of 20 m/s and is aimed at the side of a car, which just stops the jet of water (ie we ignore any splashing back). What is the force exerted by the water on the car?

What if the water does splash back from the car. Will the force on the car be greater or less?

9) Will hanging a magnet in front of an iron cart with wheels, as shown here, make the cart go?

ANOTHER OPTIONAL FUN QUESTION (ie no marks for this one!)

If a can of compressed air is punctured and the escaping gas blows to the right, the can will move to the left in a rocket-like manner. Consider instead a vacuum can that is punctured. The air blows towards the left as it enters the can. Once the vacuum is filled, the can will

a) be moving to the left b) moving to the right c) not be moving.

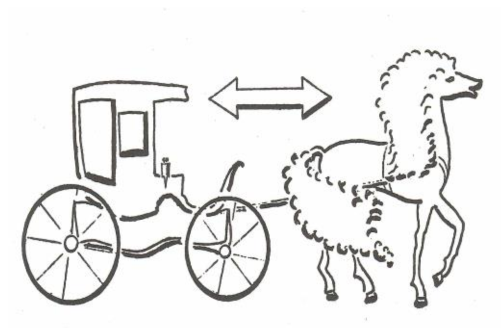
10) If you heat a single 'unpopped' pop-corn kernel in a frying pan, the kernel will 'pop' and shoot off in one direction, say sideways. Doesn't this violate the Principle of Momentum conservation?

11) A sled with a mass of 1 kg is set in motion over frictionless ice by a miniature rocket motor. After the rocket fuel is expended, the sled coasts along over the ice surface at 1 m/sec. How much force did the rocket exert on the sled?

a) 1 Newton b) less than 9.8 Newtons c) more than 9.8 Newtons d) There is no way to tell from the information given.

12) An *isolated system* is one in which the only forces present are those between the objects of the system; in other words, there are no external forces acting on the system.

Analyse the two, apparently symmetrical, situations depicted below:



Justify, employing Newton's third law, why one would intuitively expect the carriage to move forward in the direction of the horse while on the other hand, the sailor to fall into the water.

In physics it is interesting and often useful to obtain the same result in different ways. For example, we see that the Law of Conservation of Momentum can be derived from (or is equivalent to) Newton's Third Law. It is also possible to obtain or to understand the Conservation of Momentum from using Galilean Relativity (as the following three problems suggest). This principle says that the outcome of an experiment in mechanics cannot depend on whether we observe it from rest or from the point of view of an observer who moves past the experiment at a constant velocity.

13) Suppose that two identical, perfectly elastic, billiard balls move towards one another at the same speed and collide head-on. (Perfectly elastic implies that the kinetic energy in such a collision is conserved.) After the collision, both balls are observed to recoil with their original speed (simply by using the symmetry of the situation instead of momentum conservation, you could argue that they must recoil with equal speeds).

What happens if one of the balls is at rest and you shoot the other one at it with a speed of 4 m s^{-1}?

14) Two identical sticky billiard balls have the property that if they are fired at each other with equal speeds, they stick together upon colliding and the resulting compound ball is stationary. If such a ball is fired at another identical sticky ball and the two stick together, with what speed and in what direction will the compound ball move after the collision?

15) Imagine we have two perfectly elastic balls, one very large and the other very small. If the big ball is stationary and the small one is fired directly at it, the small ball simply bounces back in the direction it came from with the same speed, while the big ball remains at rest. (Think of throwing a tennis ball directly at a bowling ball for instance.)

With what speed will each ball move after the collision, if instead the small ball is stationary while the big ball rolls towards it at a speed of 4 m s^{-1}?

What happens if the big and little ball approach one another with the same speed, say 2 m s^{-1}?

16) When a small ball is placed on top of a large ball and the two are dropped together, something dramatic happens when the combination rebounds from a hard floor. The small ball will take off and reach a height almost nine times the original height from which it was dropped! Assuming that all collisions (ball to ball and ball to floor) are perfectly elastic and that the mass of the small ball is negligible compared to the large ball, explain the rebound height.