Momentum

Imagine trying to catch a tennis ball and trying to catch a house brick. With one hand it is easy to catch a tennis ball and it should not injure your hand. A house brick travelling at the same velocity is a lot more difficult to catch because it has a higher mass. It is a lot more likely to cause you a serious injury! This is all down to the **momentum** of the object – a house brick has a lot more momentum than a tennis ball travelling at the same speed.

Introducing Momentum

The momentum, p, of an object depends on the **velocity (ms^{-1})** and the **mass (kg)** of the object:

$$p = mv$$

Momentum is a **vector** quantity measured in **kilograms metres per second (kg ms^{-1})**.

Worked Example

Calculate the momentum of a car of mass 1500 kg travelling at 15 m/s.

$$p = mv$$
$$p = 1500 \times 15$$
$$p = 22500 \text{kgms}^{-1}$$

Questions

1. Calculate the momentum of the following objects:

   a) A house brick with a mass of 1 kg travelling at 20 m/s

   b) A ship with mass of 10,000 kg travelling at 5 m/s

   c) A dog of mass 20 kg running at a speed of 7 m/s

   d) A tennis ball of mass 50 g travelling at 25 m/s (*remember to convert the mass to kg!*)

   e) A car of mass 750 kg travelling at 100 km/hr (*remember to convert speed to m/s!*)

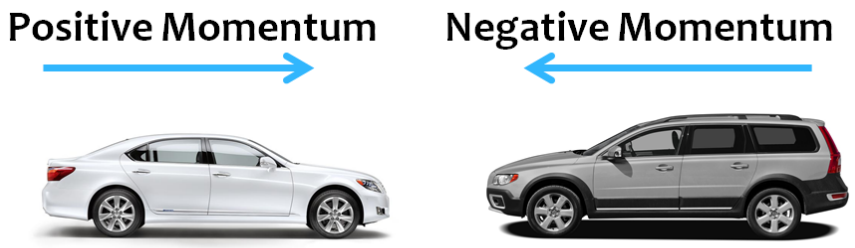
2. The momentum of a horse running across a field is 200 kg m/s. It has a mass of 80 kg. What is the velocity of the horse?

3. Find the mass of an object that has a momentum of 150 kg m/s when travelling at 30 m/s.

Total Momentum

In Higher Physics we will consider many examples with more than one object moving. In such cases the **total momentum** is obtained by adding up the momentum of each of the objects.

Remember that momentum is a **vector** quantity and as such direction is important. All problems considered here will be in one dimension, so it is possible to state that one direction is **positive** and the other is **negative**. For example, for the two cars below, the car travelling to the right has positive momentum and the car travelling to the left has negative momentum…



Worked Example

Calculate the total momentum of the two cars shown in the diagram below. Car A has a mass of 1200 kg and is travelling to the right at 20 m/s. Car B has a mass of 1100 kg and is travelling to the left at 15 m/s.

$p = mv$

$p = 1200 \times 20$

$p = 24{,}000 kgms^{-1}$

$p = mv$

$p = 1100 \times -15$

$p = -16{,}500 kgms^{-1}$

$$p_{total} = 24{,}000 - 16{,}500$$

$$p_{total} = 7500 kgms^{-1}$$

Questions

1. Two bricks of mass 2 kg each are thrown through the air. Each brick has a velocity of 11 m/s. Find the total momentum of each brick.

2. In a tennis match, the tennis ball of mass 0.05 kg is hit across the net with a velocity of 40 m/s. The player accidentally lets go of his racket which also travels across the net with a velocity of 10 m/s. Find the total momentum of the racket and the ball.

3. Two railway carriages are travelling in the same direction along a straight stretch of track. Each carriage has a mass of 8000 kg. One carriage has a velocity of 8 m/s and the other a velocity of 12 m/s. Calculate the total momentum of the carriages.

4. Two Eurofighter fighter jets flying are flying in formation. Each jet has a mass of 11,000 kg. If one is flying with a velocity of 150 m/s and the other has a velocity of 200 m/s in the same direction, what is the total momentum of the fighter jets?

5. A snooker ball has a mass of 160 g. After a shot is played, a red ball travels forwards with a velocity of 11 m/s. The cue ball travels backwards with a velocity is 4 m/s. Calculate the total momentum in this case.

6. Two cars are on a collision course. They are driving towards each other, each with a velocity of 30 m/s. If the mass of one of the cars is 1200 kg, and the mass of the other car is 800 kg, what is the resultant total momentum?