Momentum

An object which is heavy and travelling fast, has a large momentum - it would require a large 'impulse' to slow it down or stop it.

Momentum is thus linked to MASS and VELOCITY, and it has a direction too - it can be positive or negative.

The units is Ns (or kg m s^{-1}).

Momentum = mass x velocity

e.g. A ball of 300g is travelling at 2ms^{-1}
What is its momentum?

u

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v

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m

I

F

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t

Impulse

An impulse is something which **changes the momentum of a particle**.

For example:
- A bat hitting a ball
- Two balls colliding in snooker
- A jerk in a string pulled tight
- A car crashing into a lamp post
- Something speeding up or slowing down

Impulse-momentum principle

Impulse = change in momentum

So, Impulse is the change in momentum

$$I = m(v - u)$$

But it seems like it is also linked to **force** and **time**

$$F = ma \qquad a = \frac{v - u}{t}$$

$$I = m(v - u)$$

$$Ft = m(v - u)$$

e.g. A car of mass 600kg is travelling at $9ms^{-1}$ when a hazard ahead is spotted and the brakes applied, causing a force of 900N resisting its motion. Work out how long it takes for the car to come to rest.

e.g. A ball of mass 2kg is falling vertically under gravity when it hits the ground soil at a speed of $15ms^{-1}$. The ball sinks into the soil, being brought to a stop after 0.4s. Work out the resistive force of the soil on the ball.

$I = mv - mu$ **$I = Ft$** **...therefore $Ft = mv - mu$**

Impulse is a vector! Directions matter!

1. A stone of mass 3 kg is falling at a speed of 18 ms^{-1} when it hits the floor. If the stone is brought to rest by the impact, find the magnitude of the impulse exerted by the floor.

2. A bullet of mass 30 g is fired into a block of wood at a speed of 400 ms^{-1}. The bullet is brought to rest in 0.02 s. Find the average resistance exerted by the block of wood.

3. A truck of mass 1400 kg moving on a straight horizontal track at 2 ms^{-1} runs into fixed buffers and rebounds at 1 ms^{-1}. The average force exerted by the buffers on the truck is 3500 N. How long were the buffers in contact with the truck?

Calculated the impulse exerted on the object in the following cases:

1. A force of 30N is exerted on an object for 0.5s
2. A ball of mass 3kg was travelling at 10m/s is hit and slows to 6m/s without changing direction.
3. A ball of mass 3kg was travelling at 10m/s is hit so that it returns in the opposite direction at a speed of 6m/s
4. A rocket of mass 100kg travelling at 2000m/s hits the ground and stops.

Which of these show the greatest change in momentum?
Can you order them from greatest to least change in momentum?

A particle of mass 1kg travelling at $12ms^{-1}$ and then coming to rest

A particle of mass 1kg travelling at $17ms^{-1}$ and then slowing down to $6ms^{-1}$

A particle of mass 2kg travelling at $4ms^{-1}$ and then rebounding at $3ms^{-1}$

A particle of mass 1kg travelling at $11ms^{-1}$ and then rebounding at $2ms^{-1}$