

## Dynamics

Momentum and Impulse.....	1
Momentum.....	1
Example 12.....	1
Change in Momentum.....	2
Example 13.....	2
Impulse.....	3
Example 14.....	3
Example 15.....	4

### Momentum and Impulse

#### Momentum

The momentum of a body of mass  $m$ , having a velocity  $v$  is  $mv$ . The units of momentum are Newton seconds (Ns).

$$\text{Momentum} = mv$$

The momentum of a body is dependent upon its velocity therefore momentum is a vector quantity. This implies that direction is very important and great care must be taken with signs.

#### Example 12

Find the momentum of a hockey ball of mass  $0.9\text{kg}$  hit at  $18\text{ms}^{-1}$ .

$$\text{Momentum} = \text{mass} \times \text{velocity}$$

$$\text{Momentum} = 0.9 \times 18 = 16.2\text{Ns}$$

### Change in Momentum

If a particle experiences a change in velocity then, by definition, its momentum must change. Let the initial velocity be  $u$  and the final velocity be  $v$  then the change in momentum is given by:

$$\text{Change in Momentum} = mv - mu = m( v - u )$$

### Example 13

If the hockey ball from example 12 hits a wall directly and returns with a velocity of  $12\text{ms}^{-1}$ . Find the change in momentum.

Always draw a diagram.



Taking left to right as positive, therefore  $u = 18$ ,  $v = -12$

$$\text{Change in Momentum} = m( v - u )$$

$$= 0.9 \times (-12 - 18 )$$

$$= -27\text{Ns}$$

The wall in the above example has experienced a force as the hockey ball hits it. This action takes place in a very short time period and is called the impulse.

Impulse

When a force  $F$ , is applied to a particle for a period of time  $t$ , then this quantity is defined as the impulse of the force.

Obviously an impulse will bring about a change in velocity and therefore momentum will change.

Therefore:

$$\text{Impulse} = F \times t = m(v - u)$$

The derivation of the formula comes from the equation of motion and constant acceleration equations:

$$F = ma$$

$$v = u + at$$

$$a = \frac{v - u}{t}$$

$$F = m \left( \frac{v - u}{t} \right)$$

Therefore  $Ft = m(v - u)$

Example 14

A particle of mass  $7.5\text{kg}$  is acted on by a force for  $6$  seconds and in the process its velocity increases from  $6\text{ms}^{-1}$  to  $15\text{ms}^{-1}$ . Find the magnitude of the force.

$$\text{Impulse} = \text{change in momentum}$$

$$F \times t = m(v - u)$$

$$F \times 6 = 7.5 (15 - 6)$$

$$F = 11.25\text{N}$$

**Example 15**

A ball of mass 1.2kg is moving vertically with a speed of  $14 \text{ ms}^{-1}$  when it hits a smooth horizontal floor. It rebounds with a speed  $8 \text{ ms}^{-1}$ . Find the magnitude of the impulse exerted by the floor on the ball.

**Take care with signs**

Assuming down to be positive

$$\text{Impulse} = \text{Change in Momentum}$$

$$= m(v - u)$$

$$= 1.2(-8 - 14)$$

$$= 1.2(-22)$$

$$= -26.4 \text{ Ns}$$