Conservation of momentum

Learning objectives:

1. **To describe what happens when two objects collide**
2. **To calculate the momentum before and after a collision**

Conservation of momentum

"The total momentum of a system before a collision is equal to the total momentum after a collision"

Momentum before collision =

Momentum after collision =

Conservation of momentum: **momentum before = momentum after**

Worked example:

Moving trolley

0.5kg

1.2m/s

Stationary trolley

1.5kg

0m/s

They stick together after the impact

Worked example:

Moving trolley (A)

Stationary trolley (B)

A's momentum = 0.5kg x 1.2m/s

B's momentum = 0

= *What's the unit?*

Total momentum = *What's the unit?*

The momentum must remain the same after the impact.

Worked example:

Moving trolleys stuck together (A + B)

Total momentum = 0.5kg x 1.2m/s = 0.6 **Ns**

Remember momentum = mass x velocity

$$\frac{Total\ momentum}{Total\ mass} = total\ velocity$$

So 0.6/2.0 = 0.3 **m/s**

Now you try:

Mass = 40 kg

Velocity = 0 m/s

Mass = 160kg

Velocity = 5 m/s

What is the momentum of the rugby player before the impact? And the speed of the two together after the impact?

800 Ns

4 m/s

Two momentums…

Mass = 800 kg

Velocity = 10 m/s

Momentum = 8000 Ns

Mass = 1200 kg

Velocity = -5 m/s

Momentum = -6000 Ns

What is the momentum of each of the skaters before the impact? And the speed of the two together after the impact?

1m/s

And if they don't stick…

Mass = 3500 kg

Velocity = 30 m/s

Momentum = 105000 Ns

Mass = 120kg

Velocity = -15 m/s

Momentum = -1800 Ns

What is the momentum of each of the skaters before the impact? And the speed of the elephant if the penguin goes 50m/s after the impact?

27.8m/s

Example1

A ball of mass 0.2 kg falls 1.25m vertically downwards to the ground starting from rest. It hits the ground and rebounds. The downwards momentum of the ball changes by 1.6Ns in the bounce
What height does the ball reach after this bounce?

$s = 1.25m$

u = 0

v =?

a = 10

t =

m = $0.2kg$

$v^2 = u^2 + 2as$ $= 0 + 2 \cdot 10 \cdot 1.25$

$v = 5ms^{-1}$

$Momentum = m \cdot v$ $= 0.2 \cdot 5$ = 1 Ns

$Momentum = 1 - 1.6$ = -0.6 Ns Direction has reversed so the sign changes

$Momentum = m \cdot v$

$u = -3ms^{-1}$ a = 10 $v = 0$

$v = \frac{-0.6}{0.2} = -3ms^{-1}$

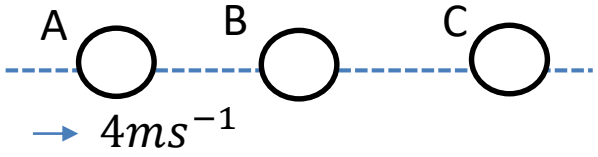
$v^2 = u^2 + 2as$

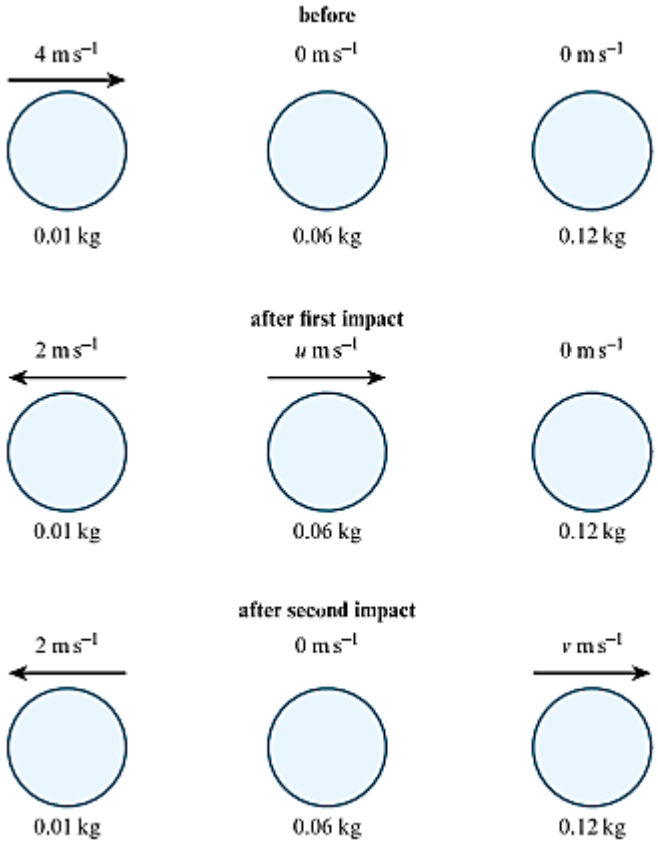
$s = -0.45m$

$s = 0.45m$

Example2

Particle A,B and C of masses 0.01kg, 0.06 kg and 0.12 kg respectively, are at rest in a straight line on a smooth horizontal surface , with B between A and C. A is given an initial velocity of $4ms^{-1} towards\ B$. After this impact A rebounds with velocity $2ms^{-1}$ and B goes on to hit C . After the second impact B comes to rest. Find the speed of C after the second impact.





Total momentum before the first collision

$$4 \cdot 0.01 = 0.04Ns$$

The velocity of Particle after the second collision be V

Total momentum after the second collision

$$0.12v + 0.01 \cdot (-2) = 0.12v - 0.02$$

$$0.04 = 0.12v - 0.02$$

$$\boldsymbol{v = 0.5ms^{-1}}$$

Small smooth spheres A and B, of equal radii and of masses 5 kg and 3 kg respectively, lie on a smooth horizontal plane. Initially B is at rest and A is moving towards B with speed $8.5\,\text{m s}^{-1}$. The spheres collide and after the collision A continues to move in the same direction but with a quarter of the speed of B.

(a) Find the speed of B after the collision. [3]

(a)	Conservation of momentum	**M1**	3 terms; allow M1 if speed of A after collision is $\frac{1}{4}\times 8.5$. Allow $5\times 8.5 = 5X + 3Y$ where $\lvert X\rvert$ and $\lvert Y\rvert$ are different which may be seen by later work. If $\lvert X\rvert$ and $\lvert Y\rvert$ are subsequently used as being equal then M0.
	$5\times 8.5 = 5\times 0.25v + 3v$	**A1**	OE e.g. $5\times 8.5 = 5V + 3\times 4V$
	Speed of $B = 10\,\text{ms}^{-1}$	**A1**	Do not award if 10 from using mgv, maximum 2/3 -10 is A0 as speed required not velocity
		3	