Momentum and Force

Unbalanced **forces** change an object's momentum.

momentum (in kg m/s) = mass (in kg) × velocity (in m/s).

1 A 50 kg cyclist is travelling at 4 m/s. They speed up to 6 m/s.

(a) Use the equation to calculate the change in velocity as they speed up.

new velocity (m/s)		old velocity (m/s)		velocity change (m/s)
6	−	4	=	

(b) Use the equation to calculate their momentum before they speed up.

momentum (kg m/s)	=	mass (kg)	×	velocity (m/s)
	=	50	×	4

(c) Calculate their momentum after they speed up.

(d) The change in momentum (in kg m/s) is [ ] − [ ] = [ ].

(e) What do you get when you multiply the mass by the velocity change?

mass (kg)	×	velocity change (m/s)	=	
50	×	2	=	

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change in momentum (in kg m/s) = mass (in kg) × change in velocity (in m/s).

2 A 25 kg lamb slows down from 4 m/s to 1 m/s.

(a) Calculate the change in velocity and give its direction.

(b) Calculate the change of momentum using the equation.

momentum change (kg m/s)	=	mass (kg)	×	velocity change (m/s)
	=	25	×	

(c) What was the lamb's momentum before it slowed down?

(d) What will the lamb's momentum be after it slowed down?

Here we subtract the momentum change from the old momentum to get the new momentum. This is because the momentum change is in the opposite direction to the original motion.

3 Calculate the change in momentum for:

(a) A 1.5 kg melon which speeds up from 2.0 m/s to 4.5 m/s.

(b) An 800 kg aeroplane which slows down from 25 m/s to 10 m/s.

(c) A 0.15 kg book which hits the floor at 1.2 m/s then stops.

Like velocity, momentum has a magnitude (size) and direction.

A 0.5 kg basketball falls on the floor at 2.0 m/s and bounces up at the same speed.

Before hitting the floor the momentum is 0.5 kg $\times$ 2.0 m/s $=$ 1.0 kg m/s **downwards**.

After bouncing, the momentum is 1.0 kg m/s upwards.

The total change of momentum is $1.0 + 1.0 = 2.0$ kg m/s **upwards**.

4 A 0.60 kg netball hits a wall at 3.5 m/s and bounces in the opposite direction at 2.5 m/s.

(a) Calculate the change in momentum as it stops on hitting the wall.

(b) Calculate the change in momentum as it speeds up from rest during the rebound.

(c) Calculate the total change in momentum.

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5 Calculate the change in momentum when a 0.060 kg tennis ball travelling at 35 m/s is struck and then goes the opposite way at 20 m/s.

The resultant force in newtons tells you how much the momentum will **change** each second.

6 A 2 kg trolley is moving at 0.5 m/s. It is then pushed forwards by a 1.5 N force for 2 s.

(a) Calculate the momentum before it is pushed.

(b) Calculate the change in momentum using the equation

$$\text{momentum change (kg m/s)} = \text{force (N)} \times \text{time (s)}$$

$$\square = 1.5 \times \square$$

(c) Calculate the momentum after it has been pushed.

7 A trolley's momentum changes from 2.5 kg m/s to 1.0 kg m/s in 3.0 s.

(a) Write the size and direction of the change in momentum.

(b) Calculate the force using the equation

momentum change (kg m/s)	=	force (N)	×	time (s)
	=		×	3

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8 A 30 000 kg aircraft is moving at 40 m/s. Its engines then provide an extra force of 30 000 N for fifteen seconds.

(a) Calculate the momentum of the aircraft before the extra force.

(b) Calculate the change in momentum caused by the extra force.

(c) Calculate the momentum of the aircraft after the fifteen seconds.

(d) Calculate the new speed of the aircraft.

9 A 60 kg skateboarder travelling at 2.5 m/s pushes themselves forward with a 25 N force for 1.5 s. Calculate their momentum afterwards.

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10 A 1200 kg car slows down from 30 m/s to 20 m/s in 15 s.

(a) Calculate the size of the change in momentum and state its direction.

(b) Calculate the force needed to slow the car down.

(c) Calculate the force needed to slow the car down in 5 s instead of 15 s.

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11 Write a word equation containing **mass**, **resultant force**, **time** and **velocity change**.