Momentum

Momentum measures how hard it is to start or stop something moving.

Newton originally called momentum **motion**.

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

1 Fill in the blanks to complete the equation.

momentum = ☐ × ☐

2 Calculate the momentum of a 30 kg child running at 2 m/s using an equation.

momentum (kg m/s)	=	mass (kg)	×	velocity (m/s)
☐	=	30	×	2

3 Calculate the momentum of a 0.4 kg football kicked at 20 m/s.

momentum (kg m/s)	=	mass (kg)	×	velocity (m/s)
☐	=	0.4	×	20

4 Calculate the momentum of a 500 kg shark swimming at 9 m/s.

Momentum is also the strength of resultant force needed to stop the object in one second.

5 Calculate the momentum of
(a) a 0.12 kg apple falling at 3.0 m/s,

(b) a 3.1 kg rabbit running at 3.0 m/s,

(c) a 3.1 kg cat running at 6.0 m/s,

6 Look at your answers to question 5 and complete these sentences.
Use the words **mass**, **velocity**, **harder**, **easier**, **higher** and **lower**.

(a) The apple is _____ to stop than the rabbit because it has a _____ _____.

(b) The rabbit is _____ to stop than the cat because it has a _____ _____.

7 How much force would it take to stop a 3.1 kg cat running at 6.0 m/s in one second?

8 For each pair, work out which one is harder to stop in terms of force.

(a) A 150 kg lion running at 14 m/s or an 80 kg warthog at 28 m/s.

(b) A 800 kg race car at 100 m/s or a $12\,000$ kg bus at 13 m/s.

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9 A school trolley requires a 4.5 N force to stop it in one second.

(a) Write down the momentum of the trolley when it was moving.

(b) The mass is 1.5 kg. Work out the velocity of the trolley using an equation.

momentum (kg m/s)	=	mass (kg)	×	velocity (m/s)
4.5	=	1.5	×	

(c) Complete the word equation: velocity = ____ ÷ ____.

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10 A falling brick has 30 kg m/s of momentum.

(a) If the mass is 3.0 kg, how fast is it going?

(b) How much resultant force is needed to stop it in one second?

(c) The force pushing the brick (to stop it in 1 s) is larger than your answer to (b). Why?

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11 A wrench moving across a space station requires a 3 N force to stop it in one second.

(a) Write down the momentum of the wrench when it was moving.

(b) The velocity was 1.5 m/s. Work out the mass of the wrench using an equation.

momentum (kg m/s)	=	mass (kg)	×	velocity (m/s)
3	=		×	1.5

(c) Complete the word equation: mass = ____ ÷ ____.

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12 Write momentum equations using symbols.
p is the momentum, m is the mass and v is the velocity.

(a) $p =$ (b) $v =$ (c) $m =$

A 100 kg rider and cycle at 12 m/s has $100 \times 12 = 1200$ kg m/s of momentum.

Stopping it in 1 s requires a 1200 N force.

Stopping it in 2 s requires a $1200 \div 2 = 600$ N force.

Stopping it in 3 s requires a $1200 \div 3 = 400$ N force.

13 A 40 kg person in a 20 kg wheelchair is going at 2.4 m/s.

(a) Calculate the total momentum.

(b) How much force would the brakes need to stop in 9 s?

(c) How much force would the brakes need to stop in 3 s?

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14 A 150 kg go-kart needs to accelerate from rest to 25 m/s in 5.0 s.

(a) Calculate the momentum it will have at 25 m/s.

(b) Calculate the force needed from the engine to accelerate it to 25 m/s in 5.0 s. Assume that there are no resisting forces.

A force of 100 N can make an object's momentum 100 kg m/s greater or less each second.

A go-kart starts at rest. A 200 N force accelerates it for 7.0 s.

Its momentum will now be $200 \times 7 = 1400$ kg m/s.

15 A model rocket motor provides an 8 N force for 0.3 s to a 0.080 kg rocket.

(a) How much momentum will the engine give the rocket?

(b) How fast will the rocket be moving after the engine has finished? Assume that there are no other forces.

A 100 kg motorcycle and rider at 15 m/s has a momentum of $100 \times 15 = 1500$ kg m/s.

A braking force of 250 N will stop it in $1500 \div 250 = 6$ s.

16 How much time does it take to stop a 250 000 kg train at 120 m/s with a 750 000 N braking force?