Momentum

Exercise A

1. Calculate the momentum of the following objects:

   (a) A ball of mass 1.5 kg moving at 10 m/s.

   (b) A stone of mass 0.3 kg moving at 6 m/s.

   (c) A toy car of mass 500 g moving at 2 m/s.

2. The momentum of a ball is 20 kgm/s. Its mass is 2.5 kg. Calculate the velocity of the ball.

3. The momentum of a car and the passengers is 9600 kgm/s. Given that velocity of the car is 8 m/s, calculate the mass of the car and the passengers.

4. A stone of mass 400 g is dropped from the top of a building. The momentum of the stone just before it hits the ground is 8 kgm/s. Calculate the speed of the stone just before it hits the ground.

5. Which of the following two objects that move in the same direction has a higher momentum?

   Object A: mass = 800 g, velocity = 50 m/s

   Object B: mass = 1.2 kg, velocity = 30m/s

6. The velocity of a 14 kg object increases from 5 m/s to 8 m/s. Calculate the increase in its momentum.

7. An object of mass 5 kg moves along a straight line with a deceleration. It passes point A with a speed of 12 m/s. In the next 10 seconds its momentum decreases by 24 kgm/s. Calculate the speed of the object 10 seconds after passing point A.

8. Two trolleys, A and B, move in the same direction along a straight line. Trolley A has a mass of 3 kg and trolley B has a mass of 4 kg. Trolley A is behind trolley B, but A moves faster and collides with B. Just before the collision, the speed of A and B are 5 m/s and 2 m/s respectively.

   Calculate the total momentum of the trolleys just before they collide.

9. A ball of mass 5kg moves along a straight line with a velocity of 3 m/s. Another ball of mass 8 kg moves with a velocity of 4 m/s in the opposite direction, towards the first ball, along the same straight line.

   Calculate the total momentum of the two balls just before they collide.

Exercise B

1 In a game of croquet a player hits her ball at $6\ \text{m s}^{-1}$ directly towards her opponent's stationary ball. After the collision the hitter's ball continues with its speed reduced to 1 m/s. The mass of each ball is 0.5kg. Find how fast the opponent's ball moves.

2 A punt of mass 800 kg moving at $3\ \text{m s}^{-1}$ rams into the back of another punt of mass 1000 kg moving at $1\ \text{m s}^{-1}$ in the same direction. The speed of the ramming punt is reduced to $1\frac{1}{2}\ \text{m s}^{-1}$ by the collision. How fast is the rammed punt then moving?

3 Two trucks are in line on the same rail track. A truck of mass 600 kg moving at $7\ \text{m s}^{-1}$ catches up a truck of mass 400 kg moving at $2\ \text{m s}^{-1}$. When the trucks collide they couple together and move on as a single unit. How fast are they then moving?

4 In an ice-dancing manoeuvre, a male dancer skates directly towards his partner, who is stationary, and lifts her clear of the ice. He approaches her at a speed of $3\ \text{m s}^{-1}$, and their masses are 70 kg and 50 kg respectively. Find their common speed after the manoeuvre.

5 A block of mass 3 kg travelling at $5\ \text{m s}^{-1}$ catches up another block of mass 7 kg travelling at $2\ \text{m s}^{-1}$ along the same line and in the same direction.

If after the collision the second block has increased its speed to $3\ \text{m s}^{-1}$, what is the speed of the first block?

6 Ike and Jim are sitting in toy trucks; the masses are 60 kg and 40 kg respectively. The trucks are moving at $8\ \text{m s}^{-1}$ along a track, with Ike's behind Jim's. Ike pushes Jim's truck away with a pole, and Jim moves off $2\ \text{m s}^{-1}$ faster than Ike. What is Jim's new speed?

7 A block of mass 4 kg travelling at $15\ \text{m s}^{-1}$ collides with another block of mass 3 kg travelling at $8\ \text{m s}^{-1}$ in the opposite direction. Find the velocity of the 3 kg block after the collision if the 4 kg block

(a) comes to rest after the collision,

(b) changes direction and rebounds with a speed of $3\ \text{m s}^{-1}$,

(c) continues to move in the same direction with its speed reduced to $3\ \text{m s}^{-1}$.

8 A cannon of mass 500 kg fires a cannonball of mass 5 kg. The cannon is mounted on wheels, so that it can recoil backwards when the shot is fired.

(a) What is the total momentum of the cannon and the cannonball before firing?

(b) If the cannonball is fired horizontally, and leaves the muzzle of the cannon moving at $200\ \text{m s}^{-1}$, with what speed does the cannon recoil?

9 A solid sphere of mass 5 kg travelling at $5\ \text{m s}^{-1}$ collides with a hollow sphere travelling at $4\ \text{m s}^{-1}$ in the opposite direction. After the collision both spheres change their direction of motion, and their speeds are $1\ \text{m s}^{-1}$ and $6\ \text{m s}^{-1}$ respectively. Find the mass of the hollow sphere.

Exercise C

1.

Two cars, **A** and **B**, are crash tested by scientists. **Car A** has a crumple zone but **car B** does not.

car A: crumple zone

car B: no crumple zone

Here is some information about the two crash tests.

	Car A	Car B
Mass of car in kg	1500	1500
Mass of driver in kg	80	80
Starting velocity of car in m/s	20	20
Time taken to stop in s	0.8	0.2

Calculate the forces exerted on the drivers during the crash tests.

2.

Crumple zones in cars are designed to reduce the forces during a collision. Explain how they do this.

3.

The diagram shows a child on a playground swing.
The playground has a rubber safety surface.

(a) The child, with a mass of 35 kg, falls off the swing and hits the ground at a speed of 6 m/s.

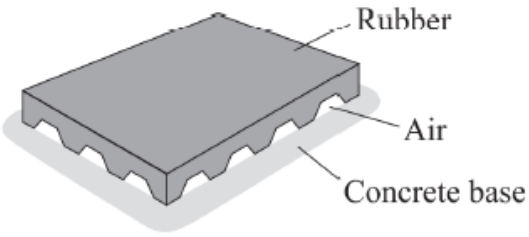
(a) (i) Calculate the momentum of the child as it hits with the ground.

Show clearly how you work out your answer.

(ii) After hitting the ground, the child slows down and stops in 0.25s.

Calculate the force exerted by the ground on the child.

(b) The diagram shows the type of rubber tile used to cover the playground surface.



Explain how the rubber tiles reduce the risk of children being seriously injured when they fall off the playground equipment.