

Momentum 3

1. Galileo was supposed to have conducted a famous experiment to demonstrate that all objects fell with the same acceleration on the Earth by dropping a heavy ball and a light ball of the leaning tower of Pisa.

If they both fall the same distance they will both have the same speed when they hit the ground (ignoring air resistance).

If they fall onto soft sand which one will sink in deeper or will they both sink in the same amount?

Explain your answer.

2. Calculate the momentum of each of the following objects:

- (a) A car of mass 1000 kg moving at 20 ms^{-1}
- (b) A ball of mass 150 g moving at 30 ms^{-1}
- (c) A particle of mass 10^{-3} g moving at 200 ms^{-1}
- (d) An electron of mass $9 \times 10^{-31} \text{ kg}$ moving at 10^7 ms^{-1}

3. Explain how an understanding of momentum relates to the following:

- (a) Rocket propulsion
- (b) Crash helmets
- (c) Running shoes
- (d) Jumping
- (e) Landing from a parachute jump
- (f) A bullet being fired from a pistol or a rifle

4. Two objects collide.

What can you say about the total momentum of the objects if the collision is:

- (a) perfectly elastic?
- (b) perfectly inelastic?

5. A 2 kg ball moving left to right at 2.5 ms^{-1} collides with a 5 kg ball also moving left to right at 1.5 ms^{-1} . If the 5 kg ball moves left to right at 2 ms^{-1} after the collision calculate the velocity of the 2 kg ball after the collision.

6. A truck of mass 2500 kg moving right to left at 15 ms^{-1} collides inelastically with a 1200 kg car moving left to right at 10 ms^{-1} . (That is they stick together after the impact). Calculate the velocity of the car and truck after the collision.

7. Use the idea of momentum to explain why you should hold the butt of the rifle against your shoulder when the rifle is fired.

8. A firework rocket moves upwards and then explodes into two unequal fragments at the top of its flight path. One moves horizontally to the left at 25 ms^{-1} and the other moves to the right at 75 ms^{-1} .

- (a) which fragment is the heaviest?
- (b) what is the ratio of the masses of the two fragments?

9. Another firework rocket explodes at the top of its flight path but this time the masses of the two fragments are equal. One moves upwards to the right at an angle of 40° to the horizontal and at a speed of 45 ms^{-1} .

What is the velocity of the other fragment?

10. How is the conservation of momentum important in the decay of a positron into two gamma rays?

11. A child throws a 200g snowball with a speed of 8 ms^{-1} so that it hits the 1.5 kg head of a snowman. The snowball sticks to the snowman's head and knocks it off. What is the initial velocity of the ball and head just after collision?
12. A gun of mass 250 kg fires a 4 kg shell at 150 ms^{-1} . What is the recoil velocity of the gun?
13. Two skaters standing face to face on the ice push each other away at the start of a free skating programme. One is a man of mass 75 kg and the other a woman of mass 55 kg. If the man moves off with an initial velocity of 2 ms^{-1} what is the initial velocity of the woman?
14. A raindrop of mass 0.5 g falling vertically hits a horizontal roof with a velocity of 4 ms^{-1} . What is the change in momentum of the raindrop if:
- (a) it is brought to rest
 - (b) it bounces back upwards at 3 ms^{-1} with no loss of mass
15. In a shooting game 0.75 kg wooden blocks are projected into the air and the players try to shoot them. In one case the block had just reached the top of its flight path and was moving at 15 ms^{-1} when it was hit from behind by a 4.0 g bullet travelling at 200 ms^{-1} at an angle of 20° to the vertical. If the bullet stays imbedded in the block calculate the initial velocity of the block and bullet just after impact?