Momentum – Answers to Exercise B/Q3 and Q4

Exercise B

3.

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

Answer:

Crumple zones are areas in a car that are designed to deform and crumple during collisions.
By deforming and crumpling they increase the time taken to stop the car. This means the momentum of the car and the passengers is reduced to zero over a longer period of time compared to a collision without any crumple zone.

The size of the change in momentum of a passenger or a car during a collision will be the same regardless of whether there is any crumple zone or not.

Therefore, since

$$Force = \frac{Change\ in\ momentum}{Time\ taken}$$

when the time taken to reduce the momentum to zero is longer, the force applied on the passenger or car will be smaller.

4.

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.

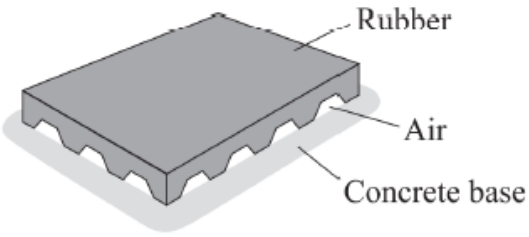
(a) (i) Calculate the momentum of the child as it hits with the ground.

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.

Answers:

(a) (i)

Momentum = Mass x Velocity

= 35 x 6

= 210 kgm/s

(ii)

Force = Change in momentum / Time taken

= (mv – mu) / t

= (35 x 0 – 35 x 6) / 0.25

= - 840 N

Force exerted by the ground = 840 N

(b) When a child falls off and hits the rubber tiles, the rubber tiles deform and squeeze out the trapped air. This increases the time take to stop the child. Therefore, the momentum of the child is reduced to zero over a longer period of time compared to when the child falls on a ground with no rubber tiles.

The size of the change in momentum of the child will be the same regardless of whether there are rubber tiles or not on the ground.

Therefore, since

$$Force = \frac{Change\ in\ momentum}{Time\ taken}$$

when the time taken to reduce the momentum to zero is longer, the force applied on the child will be smaller. Hence the rubber tiles reduce the risk of children being seriously injured.