

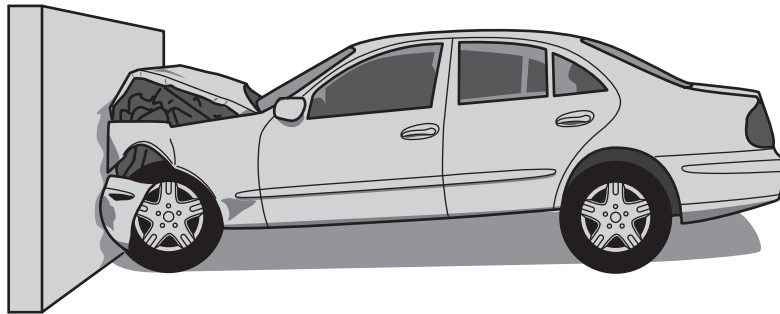
1 (a) (i) Define *linear momentum*.

.....  
..... [1]

(ii) Linear momentum is a vector quantity. Explain why.

.....  
.....  
..... [2]

(b) The crumple zone of a car is a hollow structure at the front of the car designed to collapse during a collision. In a laboratory road-test, a car of mass 850 kg was driven into a concrete wall. A video recording of the impact showed that the car, initially travelling at  $7.5 \text{ ms}^{-1}$ , was brought to rest in 0.28 s when it hit the wall.



(i) Calculate

1 the deceleration of the car, assuming it to be uniform

deceleration = .....  $\text{ms}^{-2}$  [1]

2 the average force exerted by the wall on the car.

force = ..... N [2]

- (ii) The crumple zone of the car is designed to absorb 0.45 MJ of energy before any distortion of the passenger cabin occurs. For this design of crumple zone, calculate the maximum speed of the car at impact.

speed = .....  $\text{ms}^{-1}$  [2]

- (c) In a different test, another car of mass 850 kg is travelling at a speed of  $7.5 \text{ m s}^{-1}$ . It makes a head-on collision with a stationary car of mass 1200 kg. Immediately after the impact, both cars move off together with a common speed  $v$ . Calculate this speed.

$v =$  .....  $\text{ms}^{-1}$  [2]

[Total: 10]

2 (a) (i) State the principle of *conservation of linear momentum*.

.....  
.....  
..... [2]

(ii) Explain what is meant by an *inelastic collision*.

.....  
..... [1]

(iii) Fig. 1.1 shows the head-on-collision of two blocks on a frictionless surface.

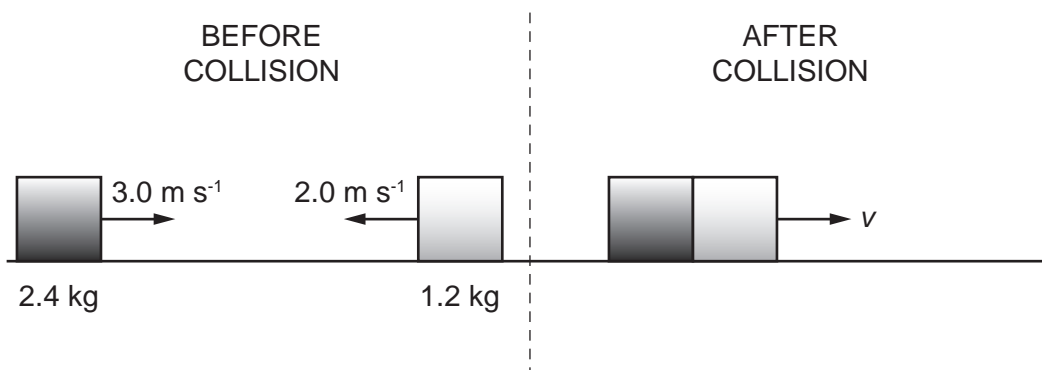


Fig. 1.1

Before the collision, the 2.4 kg block is moving to the right with a speed of  $3.0 \text{ m s}^{-1}$  and the 1.2 kg block is moving to the left at a speed of  $2.0 \text{ m s}^{-1}$ . During the collision the blocks stick together. Immediately after the collision the blocks have a common speed  $v$ .

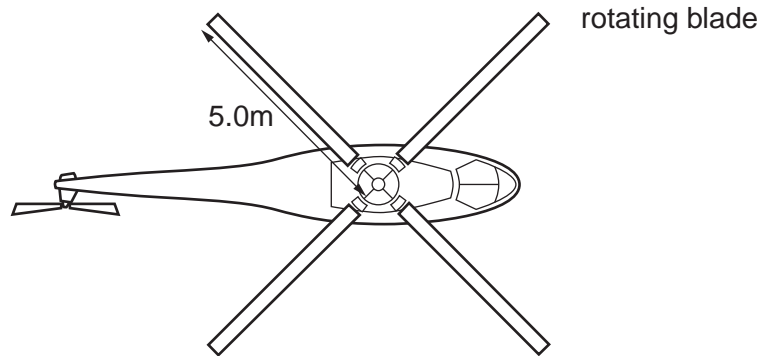
1 Calculate the speed  $v$ .

$v = \dots\dots\dots \text{ m s}^{-1}$  [2]

2 Show that this collision is inelastic.

[2]

(b) Fig. 1.2 shows a helicopter viewed from above.



**Fig. 1.2**

The blades of the helicopter rotate in a circle of radius 5.0 m. When the helicopter is hovering, the blades propel air vertically downwards with a constant speed of  $12 \text{ m s}^{-1}$ . Assume that the descending air occupies a uniform cylinder of radius 5.0 m.

The density of air is  $1.3 \text{ kg m}^{-3}$ .

- (i) Show that the mass of air propelled downwards in a time of 5.0 seconds is about 6000 kg.

[2]

(ii) Calculate

1 the momentum of this mass of descending air

momentum = .....  $\text{kgms}^{-1}$  [1]

2 the force provided by the rotating helicopter blades to propel this air downwards

force = ..... N [2]

3 the mass of the hovering helicopter.

mass = ..... kg [1]

[Total: 13]

3 (a) State Newton's second and third laws of motion.



*In your answer, you should use appropriate technical terms spelled correctly.*

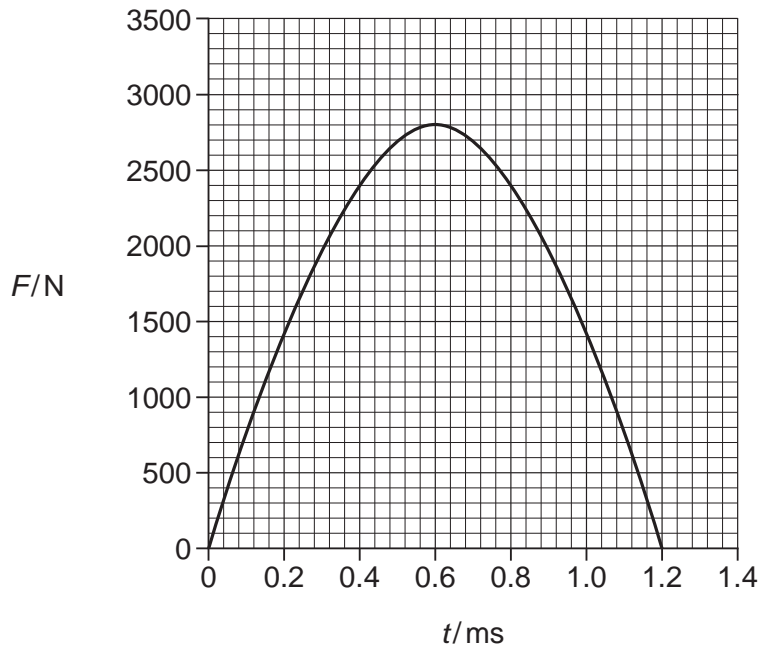
(i) second law

.....  
.....  
..... [1]

(ii) third law

.....  
.....  
..... [1]

(b) A golfer uses a golf club to hit a stationary golf ball off the ground. Fig. 1.1 shows how the force  $F$  on the golf ball varies with time  $t$  when the club is in contact with the ball.



**Fig. 1.1**

(i) Estimate the area under the graph.

area = ..... Ns [2]

(ii) Name the physical quantity represented by the area under the graph in (i).



*In your answer, you should use appropriate technical terms spelled correctly.*

..... [1]

(iii) Show that the speed of a golf ball, of mass 0.046 kg, as it leaves the golf club is about  $50 \text{ m s}^{-1}$ .

speed = .....  $\text{m s}^{-1}$  [2]

(iv) The ground is level. The ball leaves the ground at a velocity of  $50 \text{ m s}^{-1}$  at an angle of  $42^\circ$  to the horizontal. Determine the horizontal distance travelled by the ball before it hits the ground.

State **one** assumption that you make in your calculations.

distance = ..... m

assumption .....

..... [5]

[Total: 12]