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0 5 **Figure 8** shows the H-shaped posts used in a game of rugby.

Figure 8

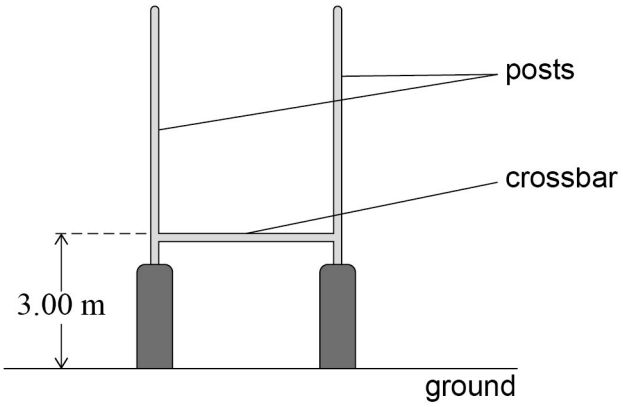
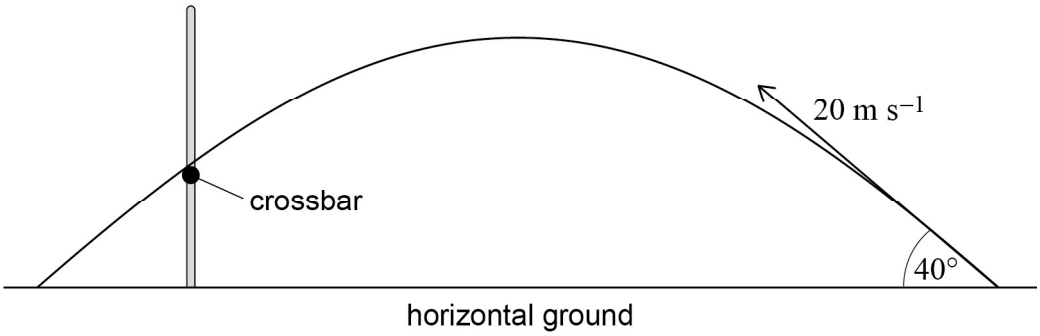


Figure 9 shows the path of a ball that is kicked and just passes over the crossbar. The initial velocity of the ball is $20.0\ \text{m s}^{-1}$ at an angle of $40.0°$ to the ground.

You should consider air resistance to be negligible and treat the ball as a simple projectile.

Figure 9



The top of the crossbar is $3.00\ \text{m}$ above the horizontal ground.

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0 5 . 1 Show that the minimum speed of the ball in flight is about $15\ \text{m s}^{-1}$.

Explain your answer.

[2 marks]

0 5 . 2 The ball just passes over the crossbar at a time t after it is kicked.

Show that t must satisfy the following equation:

$$4.91t^2 - 12.9t + 3.00 = 0$$

[2 marks]

Question 5 continues on the next page

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0 5 . 3 There are two solutions to the equation

$$4.91t^2 - 12.9t + 3.00 = 0$$

Discuss which of the two solutions is the time taken for the ball to pass over the crossbar from when it is kicked.

In your answer you should

- state the value for t given by each solution
- explain the physical significance of the other solution.

[4 marks]

solution 1 = _____ s

solution 2 = _____ s

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0 5 . 4 Another attempt is made to kick the ball over the crossbar. The initial velocity of the ball is the same as in the first attempt.
This kick is made from a horizontal distance of $38\ \text{m}$ from the posts.

Deduce whether the ball can pass over the crossbar.

[1 mark]

Question 5 continues on the next page

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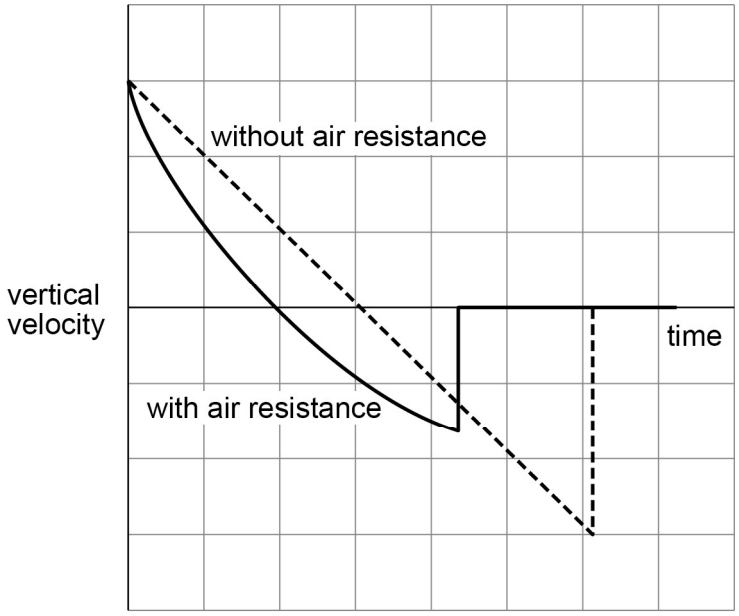
0 5 . 5 **Figure 10** shows the variations with time of the vertical velocity of a ball with and without air resistance.

Figure 10



Discuss the features of the motion of the ball shown by the two graphs.

In your answer you should refer to

- the gradients of the graphs
- the area between each line and the time axis.

[5 marks]

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Turn over for the next question

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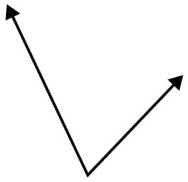
2 0 The diagram shows a vector diagram of two forces acting on an object.
The diagram is drawn to scale.
The magnitude of the smaller force is 5.0 N.



What is the magnitude of the resultant force on the object?

[1 mark]

A 3.2 N ⬭

B 7.5 N ⬭

C 8.6 N ⬭

D 9.6 N ⬭

Turn over for the next question

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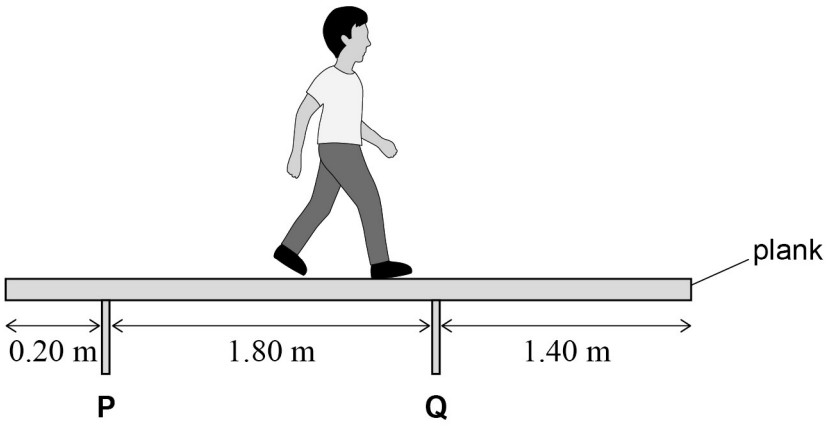
2 1 A uniform plank weighs $1200\ \text{N}$ and rests on two pillars **P** and **Q**.
P and **Q** are $1.80\ \text{m}$ apart.
P is $0.20\ \text{m}$ from one end of the plank. **Q** is $1.40\ \text{m}$ from the other end of the plank.
A man weighs $800\ \text{N}$ and walks along the plank away from pillar **P**.



What is the horizontal distance between pillar **P** and the centre of mass of the man when the plank starts to tip?

[1 mark]

A $0.45\ \text{m}$ ⬭

B $2.25\ \text{m}$ ⬭

C $2.45\ \text{m}$ ⬭

D $3.15\ \text{m}$ ⬭

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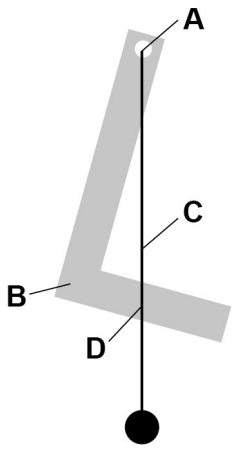
2 2 A uniform piece of card in the shape of the letter L is suspended freely from a horizontal pin.
A plumb line is also suspended from the pin.
The diagram shows the card in its equilibrium position.



What is the position of the centre of mass of the piece of card?

[1 mark]

A ⬭

B ⬭

C ⬭

D ⬭

Turn over for the next question

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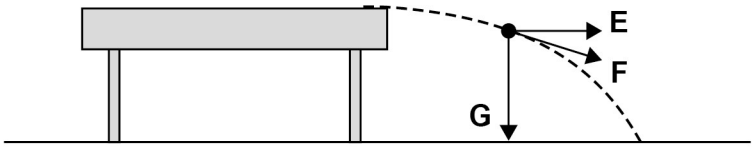
2 3 A coin is projected horizontally from the top of a desk.
The diagram shows the coin at one point in its path. The air resistance is negligible.



The arrows **E**, **F** and **G** represent different directions.

Which row gives the direction of the acceleration and the direction of the momentum of the coin at this point?

[1 mark]

	Acceleration	Momentum	
A	**F**	**F**	⬭
B	**F**	**E**	⬭
C	**G**	**F**	⬭
D	**G**	**E**	⬭

2 4 A Formula 1 racing car uses up its fuel during the race, causing its lap times to decrease.

The lap times decrease because

[1 mark]

A the acceleration of the car increases. ⬭

B the drag forces on the car decrease. ⬭

C the maximum speed of the car increases. ⬭

D the tyres become worn, reducing the friction with the road. ⬭

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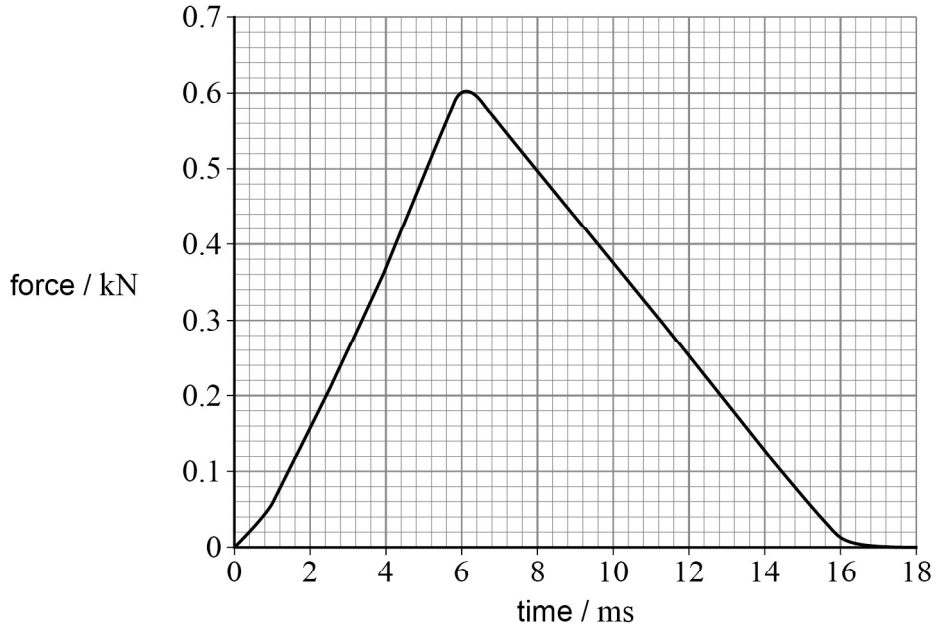
2 5 A golf ball has a mass of 46 g and is initially stationary.
The diagram shows the variation with time of the force acting on the golf ball as it is hit with a golf club.



What is an estimate of the kinetic energy of the golf ball immediately after it is hit?

[1 mark]

A 5 J ⬭

B 50 J ⬭

C 250 J ⬭

D 500 J ⬭

Turn over for the next question