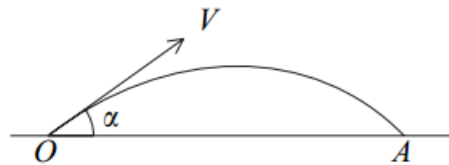

Mechanics 1: Projectiles

Past Paper Questions
2006 - 2013

Name:

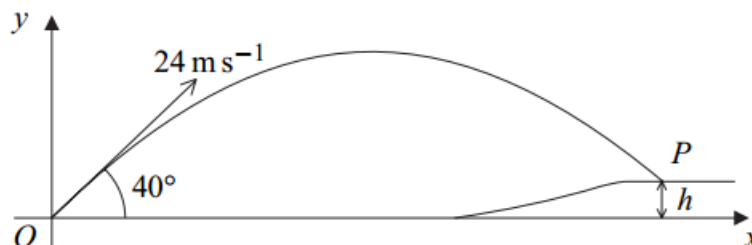
- 5 A golf ball is projected from a point O with initial velocity V at an angle α to the horizontal. The ball first hits the ground at a point A which is at the same horizontal level as O , as shown in the diagram.



It is given that $V \cos \alpha = 6u$ and $V \sin \alpha = 2.5u$.

- (a) Show that the time taken for the ball to travel from O to A is $\frac{5u}{g}$. (4 marks)
- (b) Find, in terms of g and u , the distance OA . (2 marks)
- (c) Find V , in terms of u . (2 marks)
- (d) State, in terms of u , the least speed of the ball during its flight from O to A . (1 mark)

- 7 A golf ball is struck from a point O with velocity 24 m s^{-1} at an angle of 40° to the horizontal. The ball first hits the ground at a point P , which is at a height h metres above the level of O .



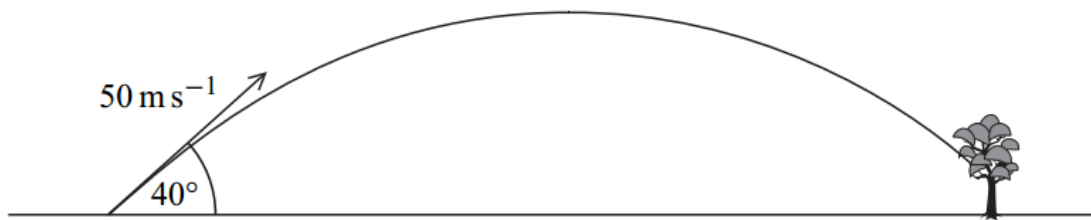
The horizontal distance between O and P is 57 metres.

- (a) Show that the time that the ball takes to travel from O to P is 3.10 seconds, correct to three significant figures. (3 marks)
- (b) Find the value of h . (3 marks)
- (c) (i) Find the speed with which the ball hits the ground at P . (5 marks)
- (ii) Find the angle between the direction of motion and the horizontal as the ball hits the ground at P . (2 marks)

- 7 A golf ball is struck from a point on horizontal ground so that it has an initial velocity of 50 m s^{-1} at an angle of 40° above the horizontal.

Assume that the golf ball is a particle and its weight is the only force that acts on it once it is moving.

- (a) Find the maximum height of the golf ball. (4 marks)
- (b) After it has reached its maximum height, the golf ball descends but hits a tree at a point which is at a height of 6 metres above ground level.



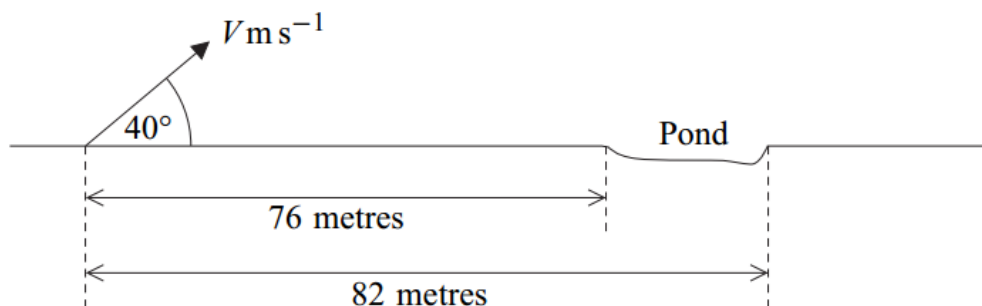
Find the time that it takes for the ball to travel from the point where it was struck to the tree. (6 marks)

- 7 An arrow is fired from a point A with a velocity of 25 m s^{-1} , at an angle of 40° above the horizontal. The arrow hits a target at the point B which is at the same level as the point A , as shown in the diagram.



- (a) State **two** assumptions that you should make in order to model the motion of the arrow. (2 marks)
- (b) Show that the time that it takes for the arrow to travel from A to B is 3.28 seconds, correct to three significant figures. (4 marks)
- (c) Find the distance between the points A and B . (2 marks)
- (d) State the magnitude and direction of the velocity of the arrow when it hits the target. (2 marks)
- (e) Find the minimum speed of the arrow during its flight. (2 marks)

- 7 A golfer hits a ball which is on horizontal ground. The ball initially moves with speed $V \text{ m s}^{-1}$ at an angle of 40° above the horizontal. There is a pond further along the horizontal ground. The diagram below shows the initial position of the ball and the position of the pond.



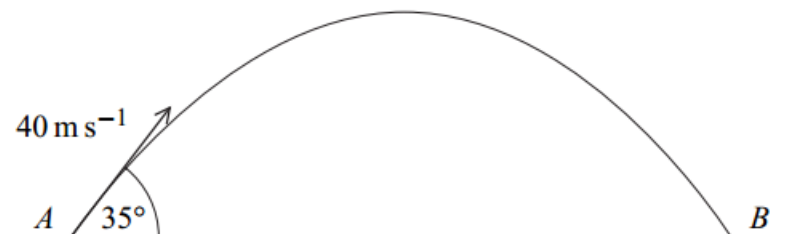
- (a) State **two** assumptions that you should make in order to model the motion of the ball. (2 marks)
- (b) Show that the horizontal distance, in metres, travelled by the ball when it returns to ground level is

$$\frac{V^2 \sin 40^\circ \cos 40^\circ}{4.9} \quad (6 \text{ marks})$$

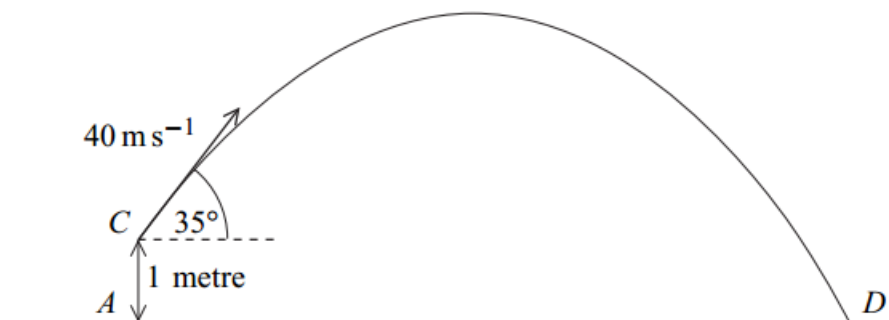
- (c) Find the range of values of V for which the ball lands in the pond. (4 marks)

- 7 A ball is hit by a bat so that, when it leaves the bat, its velocity is 40 m s^{-1} at an angle of 35° above the horizontal. Assume that the ball is a particle and that its weight is the only force that acts on the ball after it has left the bat.

- (a) A simple model assumes that the ball is hit from the point A and lands for the first time at the point B , which is at the same level as A , as shown in the diagram.



- (i) Show that the time that it takes for the ball to travel from A to B is 4.68 seconds, correct to three significant figures. (4 marks)
- (ii) Find the horizontal distance from A to B . (2 marks)
- (b) A revised model assumes that the ball is hit from the point C , which is 1 metre above A . The ball lands at the point D , which is at the same level as A , as shown in the diagram.

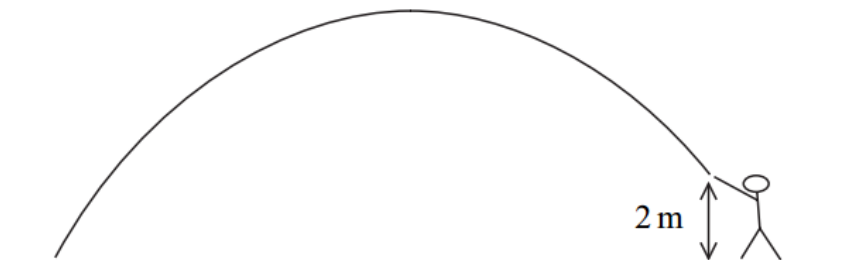


Find the time that it takes for the ball to travel from C to D .

(6 marks)

- 8** A cricket ball is hit at ground level on a horizontal surface. It initially moves at 28 m s^{-1} at an angle of 50° above the horizontal.

- (a) Find the maximum height of the ball during its flight. (4 marks)
- (b) The ball is caught when it is at a height of 2 metres above ground level, as shown in the diagram.

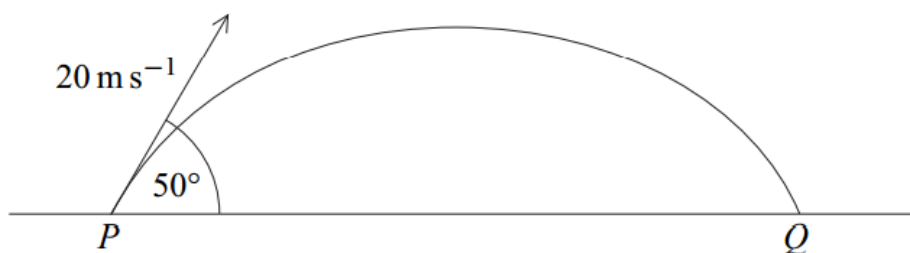


Show that the time that it takes for the ball to travel from the point where it was hit to the point where it was caught is 4.28 seconds, correct to three significant figures.

(5 marks)

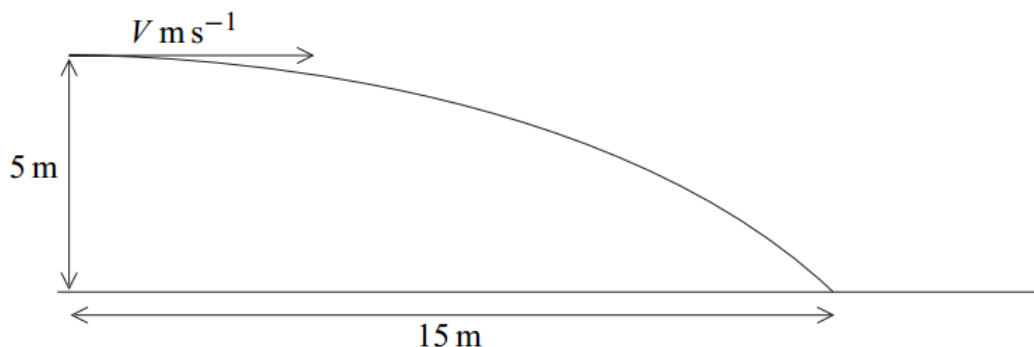
- (c) Find the speed of the ball when it is caught. (5 marks)

- 6** A ball is kicked from the point P on a horizontal surface. It leaves the surface with a velocity of 20 m s^{-1} at an angle of 50° above the horizontal and hits the surface for the first time at the point Q . Assume that the ball is a particle that moves only under the influence of gravity.



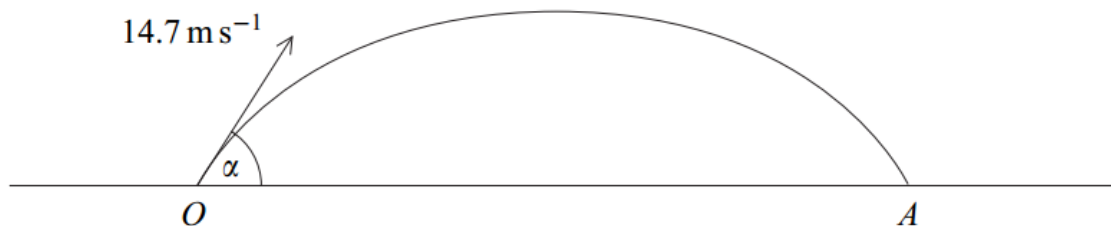
- (a) Show that the time that it takes the ball to travel from P to Q is 3.13 s, correct to three significant figures. (4 marks)
- (b) Find the distance between the points P and Q . (2 marks)
- (c) If a heavier ball were projected from P with the same velocity, how would the distance between P and Q , calculated using the same modelling assumptions, compare with your answer to part (b)? Give a reason for your answer. (2 marks)
- (d) Find the maximum height of the ball above the horizontal surface. (3 marks)
- (e) State the magnitude and direction of the velocity of the ball as it hits the surface. (2 marks)

- 7 A ball is projected horizontally with speed $V \text{ m s}^{-1}$ at a height of 5 metres above horizontal ground. When the ball has travelled a horizontal distance of 15 metres, it hits the ground.



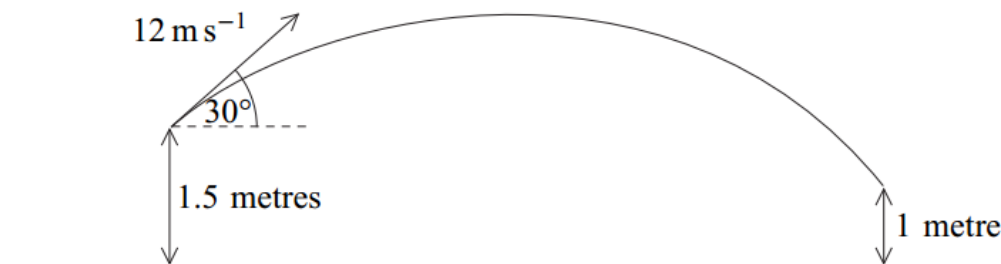
- (a) Show that the time it takes for the ball to travel to the point where it hits the ground is 1.01 seconds, correct to three significant figures. (3 marks)
- (b) Find V . (2 marks)
- (c) Find the speed of the ball when it hits the ground. (4 marks)
- (d) Find the angle between the velocity of the ball and the horizontal when the ball hits the ground. Give your answer to the nearest degree. (3 marks)
- (e) State two assumptions that you have made about the ball while it is moving. (2 marks)

- 8 A ball is struck so that it leaves a horizontal surface travelling at 14.7 m s^{-1} at an angle α above the horizontal. The path of the ball is shown in the diagram.



- (a) Show that the ball takes $\frac{3 \sin \alpha}{2}$ seconds to reach its maximum height. (3 marks)
- (b) The ball reaches a maximum height of 7 metres.
- (i) Find α . (5 marks)
- (ii) Find the range, OA . (3 marks)
- (c) State two assumptions that you needed to make in order to answer the earlier parts of this question. (2 marks)

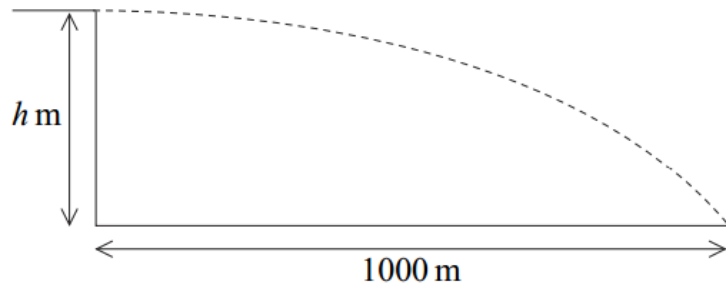
- 7** An arrow is fired from a point at a height of 1.5 metres above horizontal ground. It has an initial velocity of 12 m s^{-1} at an angle of 30° above the horizontal. The arrow hits a target at a height of 1 metre above horizontal ground. The path of the arrow is shown in the diagram.



Model the arrow as a particle.

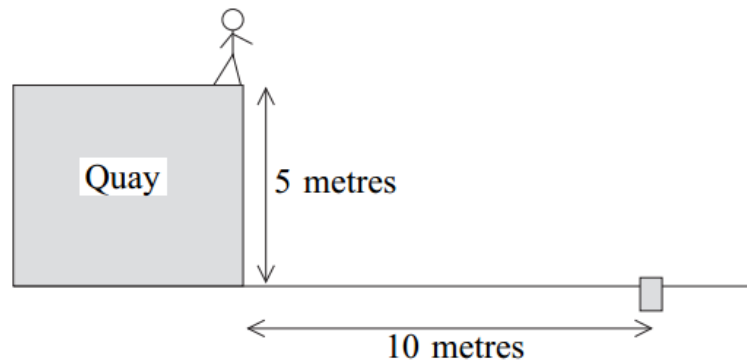
- (a)** Show that the time taken for the arrow to travel to the target is 1.30 seconds, correct to three significant figures. *(5 marks)*
- (b)** Find the horizontal distance between the point where the arrow is fired and the target. *(2 marks)*
- (c)** Find the speed of the arrow when it hits the target. *(4 marks)*
- (d)** Find the angle between the velocity of the arrow and the horizontal when the arrow hits the target. *(2 marks)*
- (e)** State one assumption that you have made about the forces acting on the arrow. *(1 mark)*

- 6** A bullet is fired horizontally from the top of a vertical cliff, at a height of h metres above the sea. It hits the sea 4 seconds after being fired, at a distance of 1000 metres from the base of the cliff, as shown in the diagram.

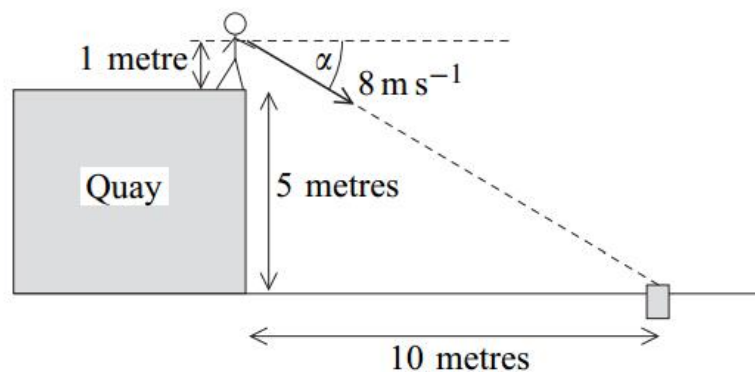


- (a)** Find the initial speed of the bullet. *(2 marks)*
- (b)** Find h . *(2 marks)*
- (c)** Find the speed of the bullet when it hits the sea. *(4 marks)*
- (d)** Find the angle between the velocity of the bullet and the horizontal when it hits the sea. *(3 marks)*

- 8** A girl stands at the edge of a quay and sees a tin can floating in the water. The water level is 5 metres below the top of the quay and the can is at a horizontal distance of 10 metres from the quay, as shown in the diagram.



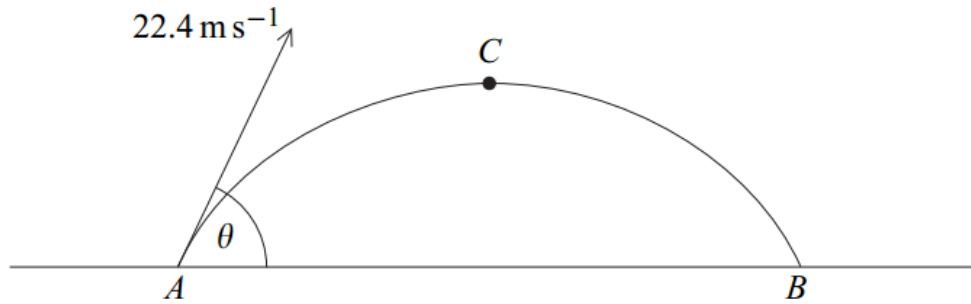
The girl decides to throw a stone at the can. She throws the stone from a height of 1 metre above the top of the quay. The initial velocity of the stone is 8 m s^{-1} at an angle α below the horizontal, so that the initial velocity of the stone is directed at the can, as shown in the diagram.



Assume that the stone is a particle and that it experiences no air resistance as it moves.

- (a)** Find α . (2 marks)
- (b)** Find the time that it takes for the stone to reach the level of the water. (6 marks)
- (c)** Find the distance between the stone and the can when the stone hits the water. (4 marks)

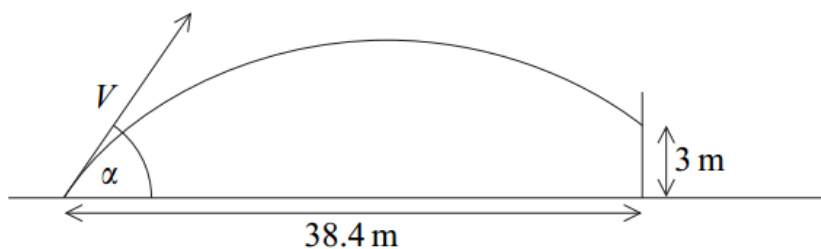
- 8** A particle is launched from the point A on a horizontal surface, with a velocity of 22.4 m s^{-1} at an angle θ above the horizontal, as shown in the diagram.



After 2 seconds, the particle reaches the point C , where it is at its maximum height above the surface.

- (a) Show that $\sin \theta = 0.875$. *(3 marks)*
- (b) Find the height of the point C above the horizontal surface. *(3 marks)*
- (c) The particle returns to the surface at the point B . Find the distance between A and B . *(3 marks)*
- (d) Find the length of time during which the height of the particle above the surface is greater than 5 metres. *(5 marks)*
- (e) Find the minimum speed of the particle. *(2 marks)*

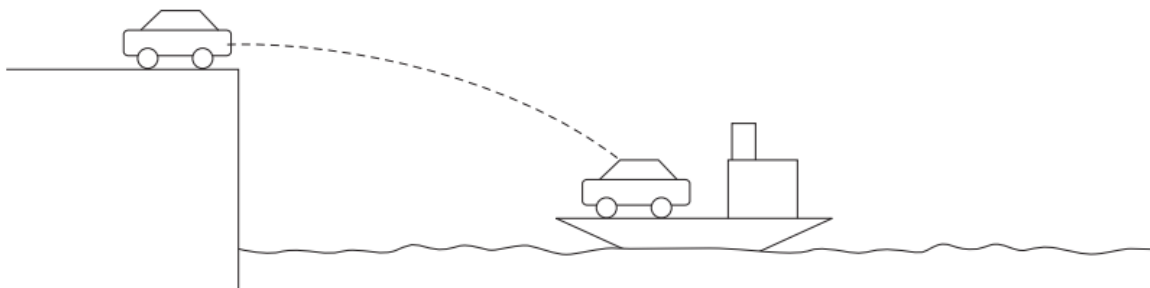
- 8** A golf ball is hit from a point on a horizontal surface, so that it has an initial velocity $V \text{ m s}^{-1}$ at an angle α above the horizontal. The ball travels through the air and after 2.4 seconds hits a vertical wall at a height of 3 metres. The wall is at a horizontal distance of 38.4 metres from the point where the ball was hit. The path of the ball is shown in the diagram.



Assume that the weight of the ball is the only force that acts on it as it travels through the air.

- (a) Find the horizontal component of the velocity of the ball. *(2 marks)*
- (b) Find V . *(5 marks)*
- (c) Find α . *(3 marks)*

- 6** In a scene from an action movie, a car is driven off the edge of a cliff and lands on the deck of a boat in the sea, as shown in the diagram.



To land on the boat, the car must move 20 metres horizontally from the cliff. The level of the deck of the boat is 8 metres below the top of the cliff. Assume that the car is a particle which is travelling horizontally when it leaves the top of the cliff and that the car is not affected by air resistance as it moves.

- (a) Find the time that it takes for the car to reach the deck of the boat. *(3 marks)*
- (b) Find the speed at which the car is travelling when it leaves the top of the cliff. *(3 marks)*
- (c) Find the speed of the car when it hits the deck of the boat. *(4 marks)*