PROJECTILES

Wherever a numerical value is required, take $g = 9.8ms^{-2}$

All answers should be given to three significant figures, unless stated otherwise in the question.

1. A particle P is projected with velocity 40 ms^{-1} at an angle of elevation of 32º. Find the time of flight and its range on a horizontal plane.

[5]

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2. On a horizontal plane the range of a projectile is 160m and the time of flight is 4s. Find the initial velocity and the greatest height attained by the projectile above the plane.

[10]

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3. The horizontal and vertical initial components of the velocity of a projectile are 30 ms^{-1} and 40ms^{-1} respectively. Given that the horizontal range is 960m, find:

a) the time of flight

[2]

b) the greatest height attained during flight.

[2]

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4. A vase is thrown horizontally out of a window, which is 14m above the ground.

a) Find the time it takes to reach the ground.

[2]

b) Given that it was thrown with a speed of 12ms^{-1}, calculate the horizontal distance it travels before reaching the ground

[2]

c) State two assumptions you have made in your mathematical modelling in this question.

[2]

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5. A golf ball is struck so that it is given an initial velocity of 50 ms^{-1} at an angle of 60º to the horizontal. Assuming the golf course is a flat horizontal plane, calculate

a) the time for which the ball is in the air before it first strikes the ground

[4]

b) the distance from the golfer that the ball will first land.

[2]

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6. A cricket ball is struck at ground level by the batsman. The ball is in the air for 6 seconds, and lands 120 m away on the level field.

a) Find the angle of the ball's initial velocity to the horizontal, giving your answer to the nearest degree. [8]

b) Find the speed at which the ball was struck. [3]

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7. The record distance a batsman has hit a cricket ball on a level ground is 150 metres.

a) Given that the ball was hit at an angle of 50^0 to the horizontal, calculate the speed at which the ball left the bat. [7]

b) State two assumptions you have made in your mathematical modelling. [2]

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8. A ball is projected from a point on a flat horizontal plane at 30 ms^{-1}.

a) Find the greatest horizontal distance the ball can travel while in the air. [7]

b) Find the angle of projection required for this distance to be achieved. [1]

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9. A stone can be catapulted in any direction at 45 ms^{-1}.

a) Find the greatest height it can reach. [4]

b) Find the time taken to reach this height [2]

c) Find the height reached in this time by another stone which is catapulted at an angle of 60^o to the horizontal. [3]

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10. A golfer strikes a ball at an angle of 30^o to the horizontal. The ball has a horizontal range of 175 metres.

a) Find the speed of projection of the ball. [7]

b) Calculate the greatest height the ball reaches above the plane. [2]

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11. James Bond is trying to fire from ground level at a stationary helicopter, which is at a height of 10 metres above the horizontal ground and at a horizontal distance of 500 metres. His gun has a muzzle velocity of 150 ms^{-1}. Calculate the angle(s) at which he should fire, giving your answer to the nearest tenth of a degree.

[12]

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12. A girl throws a ball horizontally at a wall 7 metres away, and it hits the wall 0.5 m below the level of projection.

a) Find the speed with which she threw the ball

[6]

b) Find the velocity with which the ball hits the wall.

[6]

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13. A ball is projected horizontally over a cliff with a speed of 30 ms^{-1}. The cliff is of height 40m.

a) The ball lands D metres from the foot of the cliff. Find D, giving your answer correct to 2 significant figures.

[5]

b) State two assumptions that you have made in your mathematical modelling, and suggest what effect these could have on your answer.

[3]

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14. A stone is thrown upward with a speed of 15 ms^{-1} at an angle of 35^{o} to the horizontal, from the top of a cliff 65m above the sea.

a) Find the time taken for the stone to hit the sea [6]

A second stone is thrown at the same speed but horizontally

b) Find the distance between the points where the stones hit the sea.

[5]

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15. A bomber is diving at 300 ms^{-1}, at an angle of 15^{o} to the horizontal, when it releases its bomb. Given that the bomb travels a horizontal distance of 2 km before hitting a target on the ground, find the height of the bomber when it released the bomb.

[6]

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16. A ball is thrown from the roof of a tall building with a speed of 35 ms^{-1}, at an angle of elevation of 20^o. After time T, the direction of motion of the stone is at 45^0 below the horizontal.

a) Find the value of T

[6]

b) Find the vertical distance of the stone from its point of projection at this instant.

[2]

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17. A small bowl is thrown out of a window, which is 3 metres above the ground. It is thrown with a speed of 5 ms^{-1} at an angle of elevation of 20^o to the horizontal.

a) Find the time for which the bowl is more than 3 metres above the ground.

[4]

b) Find the time taken for the bowl to reach the ground.

[3]

c) Find the speed of the bowl when it reaches the ground.

[5]

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18. An egg is thrown out of a window, which is 3 metres above the ground. It is thrown with a speed of 8 ms^{-1} at an angle of elevation of 30^o to the horizontal. The egg moves in a vertical plane, towards a padded basket lying in the same plane whose centre is 9 metres horizontally from the window at ground level. The basket is 30cm wide.

a) Calculate the time for which the egg is airborne, before landing.

[4]

b) Find whether or not the egg lands in the basket.

[3]

c) State one assumption that you have used in your modelling.

[1]

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19. A boy throws a ball out of the middle of a 6^{th} floor window, at 8 ms^{-1} at an angle of elevation of 30^o to the horizontal. He is throwing the ball to his friend, who is waiting across the street at a 4^{th} floor window in the same vertical plane.
The bottom of the 6^{th} floor window is at a height of 15 metres and the bottom of the 4^{th} floor window is at a height of 12 metres. Both windows are 1 metre high. The street is exactly 9 metres wide.

a) Find whether or not the ball goes through the second window.

[7]

b) Find the velocity with which the ball reaches the second window.

[4]

The second boy catches the ball as it reaches the window.

c) State the velocity with which he should throw the ball to return it to its point of projection.

[2]

Some simplifying assumptions have been made in the mathematical modelling in this question.

d) Suggest what effects these assumptions may have on the answer to c).

[1]

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20. A girl throws a ball from a height of 1.2m to a boy who is standing 15m away. The ball is thrown with speed U and angle of elevation 60^o.

The boy is only able to catch the ball if it is less than 1.5m above the ground when it reaches him.

a) Find the maximum possible value of U

[7]

b) Find the maximum height reached by the ball

[3]

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21. A girl stands 10m from a wall. She throws a ball towards the wall from a height of 1.6m.
The ball is thrown with speed 15ms^{-1} at 30^0 the horizontal.

a) Find the height at which the ball hits the wall.

[6]

When the ball rebounds from the wall, it lands 2m in front of the girl. Assuming the ball rebounds horizontally from the wall,

b) Calculate the speed with which the ball rebounds from the wall

[5]

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22. A particle is projected from ground level with speed U at angle α to the horizontal towards a vertical wall a distance X metres away. It hits the wall horizontally.

a) Find X in terms of U, α and g.

[5]

The ball's speed is halved when it rebounds horizontally from the wall. It lands on the ground 2 metres in front of the point of projection.

b) Show that $U = 2\sqrt{\frac{g}{\sin\alpha\cos\alpha}}$

[7]

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23. Points A and B lie on a flat horizontal plane, and are 50m apart. A ball is thrown vertically upwards with a speed of $30ms^{-1}$ from point B. A second ball is projected from point A with a speed of Ums^{-1} at an angle of α to the horizontal. The two balls collide after one second.

a) Show that $\tan\alpha = \frac{3}{5}$.

[8]

b) Find the value of U

[2]
