

Lesson 2

A-Level Applied Mathematics : Mechanics : Year 2

Projectiles (Kinematics III)

2.1 Launch at an angle

Example

A stone is launched from a catapult, held 2 metres above a flat playing field with a speed of 64 m s^{-1} and at an angle of 25° above the horizontal.

- (i) How long does the stone take to reach its maximum height ?
[4 marks]
- (ii) What is the maximum height reached, above the playing field ?
[3 marks]
- (iii) How far, horizontally, is the stone then away from its launch position ?
[1 mark]
- (iv) Explain why the horizontal range of the stone is more than twice your
part (iii) answer.
[2 marks]

2.2 Exercise

*Any solution based entirely on graphical
or numerical methods is not acceptable*

Marks Available : 40

Question 1

A cricket ball is projected from the origin at a velocity of $(5\mathbf{i} + 23\mathbf{j}) \text{ m s}^{-1}$ where $\mathbf{i}$ and $\mathbf{j}$ are unit vectors in the horizontal and upwards vertical directions respectively. Take the acceleration due to gravity to be of magnitude 9.8 m s^{-2} .

- (i) Find the particle's position vector after 2.5 seconds.

Write your answer in the form $\mathbf{r} = p\mathbf{i} + q\mathbf{j}$ where p and q are numbers the value of each to be found.

[4 marks]

- (ii) Find the particle's velocity vector after 2.5 seconds.

Write your answer in the form $\mathbf{v} = r\mathbf{i} + s\mathbf{j}$ where r and s are numbers the value of each to be found.

[3 marks]

Question 2

A golfer hits a golf ball resting on a tee with a velocity of 52 m s^{-1} at an angle of 58° above the horizontal. Amazingly, the ball lands in the hole; a hole-in-one !



Find the minimum distance the golfer walks to retrieve her ball.
Assume that the gold driving range is a sufficiently large flat horizontal surface.

[5 marks]

Question 3

A particle is projected with a speed of 26 m s^{-1} with angle of elevation θ . If the greatest height reached above the point of projection is 12 metres, find the value of θ .

[4 marks]

Question 4

A stone is thrown skywards with speed 28 m s^{-1} from a window which is 22 metres above horizontal ground. The stone hits the ground 4 seconds later.

- (i) Determine the angle of projection of the stone with respect to the positive x -axis direction.

[5 marks]

- (ii) Find the horizontal distance from the window to the point where the stone hits the ground.

[1 mark]

Question 5

A particle is projected from a point with position vector $(3\mathbf{i} + 5\mathbf{j})$ metres relative to a fixed origin O where $\mathbf{i}$ and $\mathbf{j}$ are unit vectors in the horizontal and upwards vertical directions respectively. The particle passes through the point with position vector $(15\mathbf{i} + 7\mathbf{j})$ metres after 2.5 seconds.

Find the particle's initial velocity vector.

Write your answer in the form $\mathbf{v} = p\mathbf{i} + q\mathbf{j}$ where p and q are numbers the value of each to be found.

[4 marks]

Question 6

A particle, which was launched horizontally across a region of flat level ground, lands with a speed of 35 m s^{-1} at an angle of 54° to the horizontal.

(i) What was its launch speed ?

[2 marks]

(ii) How far has it travelled horizontally ?

[3 marks]

(iii) At what height was it launched from ?

[2 marks]

Question 7

A particle is projected from a point with speed 21 m s^{-1} at an angle of elevation θ and moves freely under gravity. When the particle has moved a horizontal distance of x metres, its height above the point of projection is y metres.

(i) Show that, $y = x \tan \theta - \frac{x^2}{90} (1 + \tan^2 \theta)$

[4 marks]

(ii) Given that $y = 8.1$ when $x = 36$, find the value of θ

[3 marks]

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Teachers may obtain detailed worked solutions to the exercises by email from MHHShrewsbury@Gmail.com