

A-Level Applied Mathematics

Year 2 Mechanics Kinematics III

P • R • O • J • E • C • T • I • L • E • S



PROJECTILES

(Kinematics III)

Lesson 1

A-Level Applied Mathematics : Mechanics : Year 2

Projectiles (Kinematics III)

1.1 Introduction

In the Year 1 Applied course we looked at one dimensional kinematics problems in which a particle was projected vertically upwards, reached a maximum height and then, under the influence of gravity alone, came straight back down.

In Year 2 we extend this work to look at particles launched, not vertically, but horizontally, and then at any angle in between. The key idea is to analyse the resulting motion by separating out what happens vertically (using Year 1 knowledge) from what happens horizontally where, because there is no acceleration,

$$Distance = Speed \times Time$$

1.2 Example (Horizontal Projection)

A football is kicked horizontally at 12 m s^{-1} off the edge of a 75 m high seacliff.

- (i) Find the time before the particle strikes the sea. [3 marks]
- (ii) How far out to sea does the ball land ? [1 mark]
- (iii) With what speed does the ball enter the sea ? [3 marks]
- (iv) Suggest four modelling assumptions that have been made. [4 marks]

1.3 Exercise (Horizontal Projection)

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

Marks Available : 36

Question 1

A Golden Eagle is flying horizontally over the sea at 4 m s^{-1} when it drops a mouse. The mouse travels a distance of 20 metres horizontally before hitting the sea. At what height above the sea was the Golden Eagle flying when it dropped the mouse ?

[5 marks]

Question 2

A golf ball is projected horizontally from a cliff edge with speed 32 m s^{-1} . The golf ball takes 2.5 seconds to reach the sea surface.

Find (i) The height of the cliff.

[3 marks]

(ii) The horizontal distance travelled by the golf ball.

[1 mark]

(iii) The magnitude and angle of depression of the velocity with which the golf ball hits the sea.

[4 marks]

Question 3

A cannon ball is projected horizontally by a cannon from a hill fort, 160 metres above the sea. The cannon ball strikes a rowing boat which is at a horizontal distance of 640 metres from the cannon.

Find the speed of projection of the cannon ball.

[4 marks]

Question 4

A tangerine is thrown horizontally by an annoying boy sitting in a tangerine tree. It hits the head of a 1.4 metre high girl 0.7 seconds later.

From how high up in the tree was the tangerine thrown ?

[3 marks]

Question 5

A stone is projected with a velocity of $(8\mathbf{i} + 0\mathbf{j}) \text{ m s}^{-1}$ from a point with position vector $(20\mathbf{i} + 30\mathbf{j})$ metres where $\mathbf{i}$ and $\mathbf{j}$ are unit vectors in the horizontal and upwards vertical directions respectively.

- (i) Is the stone projected horizontally ?

Justify your answer.

[2 marks]

- (ii) Find the position vector of the particle after 1.5 seconds.

Give your answer in the form $\mathbf{r}_{t=1.5} = p\mathbf{i} + q\mathbf{j}$ where p and q are numbers which are to be determined.

[5 marks]

Question 6

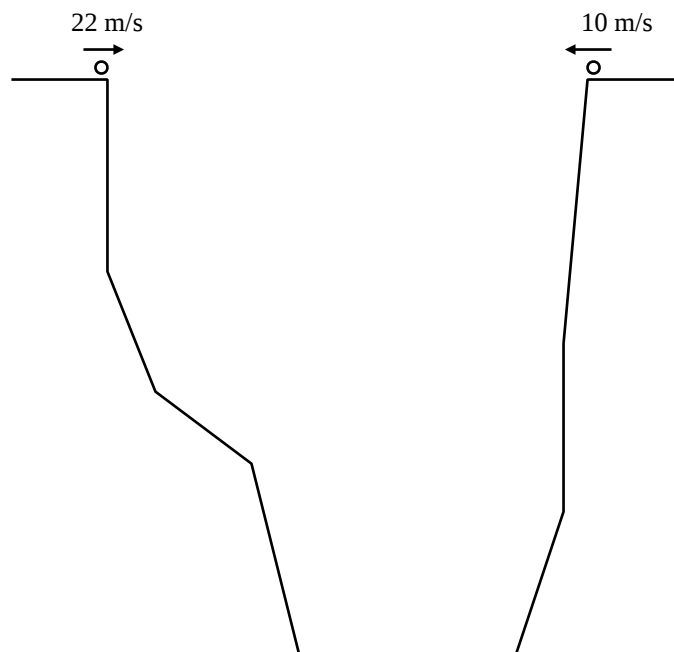
At time $t = 0$ a particle is projected horizontally from X with position $(5\mathbf{i} + 30\mathbf{j})$ metres where $\mathbf{i}$ and $\mathbf{j}$ are unit vectors in the horizontal and upwards vertical directions respectively.

Later, it passes through Y with position vector $(17\mathbf{i} + 10.4\mathbf{j})$ metres.

Find the time taken to travel from X to Y and the speed of projection.

[5 marks]

Question 7



Two footballs are simultaneously kicked horizontally from opposite sides of a ravine which is 250 metres wide at the top.

One football is kicked at 22 m s^{-1} , the other at 10 m s^{-1}

The footballs collide mid-air.

(i) After how many seconds do the footballs collide ?

[1 mark]

(ii) At what height below the top of the ravine do the footballs collide ?

[3 marks]