

# Motion of a Projectile 1

Q1.

A particle is projected with speed  $15 \text{ m s}^{-1}$  at an angle of  $\theta^\circ$  above the horizontal. At the instant 4 s after projection the speed of the particle is  $30 \text{ m s}^{-1}$ .

- (i) Find  $\theta$ . [4]
  - (ii) Show that at the instant 4 s after projection the particle is 33.75 m below the level of the point of projection and find the direction of motion at this instant. [4]
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Q2.

A particle is projected from a point on horizontal ground with speed  $15 \text{ m s}^{-1}$  at an angle of  $\theta^\circ$  above the horizontal. The particle strikes the ground 2 s after projection.

- (i) Find  $\theta$ . [2]
  - (ii) Calculate the time after projection at which the direction of motion of the particle is  $20^\circ$  below the horizontal. [4]
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Q3.

A small ball  $B$  is projected with speed  $30 \text{ m s}^{-1}$  at an angle of  $60^\circ$  above the horizontal from a point  $O$ . At time  $t$  s after projection the horizontal and vertically upwards displacements of  $B$  from  $O$  are  $x$  m and  $y$  m respectively.

- (i) Express  $x$  and  $y$  in terms of  $t$  and hence find the equation of the trajectory of the ball. [4]
  - (ii) Find the value of  $x$  for which  $OB$  makes an angle of  $45^\circ$  above the horizontal. [3]
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Q4.

A small ball is projected from a point  $O$  on horizontal ground at an angle of  $30^\circ$  above the horizontal. At time  $t$  s after projection the horizontal and vertically upwards displacements of the ball from  $O$  are  $x$  m and  $y$  m respectively. It is given that  $x = 40t$ .

- (i) Calculate the initial speed of the ball, and express  $y$  in terms of  $t$ . [3]
  - (ii) Hence find the equation of the trajectory of the ball. [2]
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Q5.

A particle is projected from a point  $O$  on horizontal ground with speed  $V \text{ m s}^{-1}$  at an angle of  $60^\circ$  above the horizontal. At the instant 3 s after projection the direction of motion of the particle is  $30^\circ$  below the horizontal.

(i) Find  $V$ . [3]

(ii) Calculate the distance of the particle from  $O$  at the instant 3 s after projection. [3]

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Q6.

A particle  $P$  is projected with speed  $u$  at an angle of  $30^\circ$  above the horizontal from a point  $O$  on a horizontal plane and moves freely under gravity. The particle reaches its greatest height at time  $T$  after projection.

Find, in terms of  $u$ , the speed of  $P$  at time  $\frac{2}{3}T$  after projection. [5]

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Q7.

A particle  $P$  is projected with speed  $u$  at an angle  $\theta$  above the horizontal from a point  $O$  on a horizontal plane and moves freely under gravity. The direction of motion of  $P$  makes an angle  $\alpha$  above the horizontal when  $P$  first reaches three-quarters of its greatest height.

(a) Show that  $\tan \alpha = \frac{1}{2} \tan \theta$ . [6]

(b) Given that  $\tan \theta = \frac{4}{3}$ , find the horizontal distance travelled by  $P$  when it first reaches three-quarters of its greatest height. Give your answer in terms of  $u$  and  $g$ . [4]

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Q8.

A particle  $P$  is projected with speed  $u$  at an angle  $\alpha$  above the horizontal from a point  $O$  on a horizontal plane and moves freely under gravity. The horizontal and vertical displacements of  $P$  from  $O$  at a subsequent time  $t$  are denoted by  $x$  and  $y$  respectively.

(a) Derive the equation of the trajectory of  $P$  in the form

$$y = x \tan \alpha - \frac{gx^2}{2u^2} \sec^2 \alpha. \quad [3]$$

The point  $Q$  is the highest point on the trajectory of  $P$  in the case where  $\alpha = 45^\circ$ .

(b) Show that the  $x$ -coordinate of  $Q$  is  $\frac{u^2}{2g}$ . [3]

(c) Find the other value of  $\alpha$  for which  $P$  would pass through the point  $Q$ . [4]

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