Projection at Any Angle

We can solve problems with particles projected at any angle by resolving the initial velocity into horizontal and vertical components.

Range = distance from point at which the particle was projected to the point where it strikes the horizontal plane

Time of Flight = time taken by particle to move from its point of projection to the point where it strikes the horizontal plane

A projectile reaches its point of greatest height when the vertical component of its velocity, $u_y = 0$.

Example

[Textbook] A particle P is projected from a point O on a horizontal plane with speed 28 ms^{-1} and with angle of elevation $30°$. After projection, the particle moves freely under gravity until it strikes the plane at a point A. Find:

(a) the greatest height above the plane reached by P

(b) the time of flight of P

(c) the distance OA

Example

[Textbook] A particle is projected from a point O with speed V ms^{-1} and at an angle of elevation of θ, where $\tan\theta = \frac{4}{3}$. The point O is 42.5m above a horizontal plane. The particle strikes the plane at a point A, 5 s after it is projected.

(a) Show that $V = 20$.(b) Find the distance between O and A.

Example

[Textbook] A particle is projected from a point O with speed 35 ms^{-1} and at an angle of elevation of $30°$. The particle moves freely under gravity. Find the length of time for which the particle is 15 m or more above O.

Test Your Understanding *(EdExcel M2 May 2012 Q7)*

A small stone is projected from a point O at the top of a vertical cliff OA. The point O is 52.5 m above the sea. The stone rises to a maximum height of 10 m above the level of O before hitting the sea at the point B, where $AB = 50$ m, as shown in Figure 4. The stone is modelled as a particle moving freely under gravity.

(a) Show that the vertical component of the velocity of projection of the stone is 14 m s^{-1}.

(3)

(b) Find the speed of projection.

(9)

(c) Find the time after projection when the stone is moving parallel to OB.

(5)

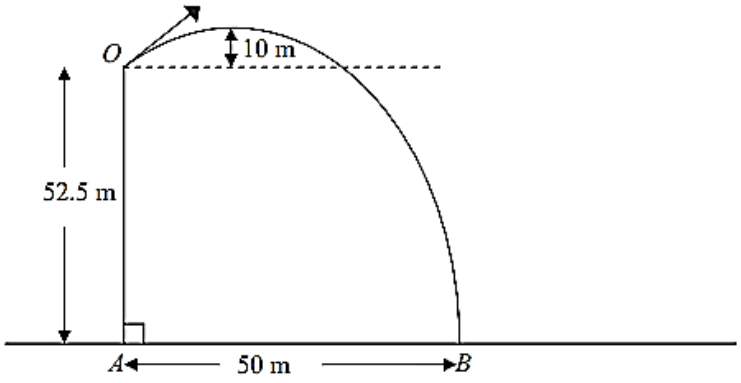

Figure 4

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Extension Question:

A ball is projected from ground level at an angle of θ. Prove that when the ball hits the ground, the distance the ball has travelled along the ground is maximised when $\theta = 45°$. (Year 2 differentiation knowledge required)