

5. Projectiles

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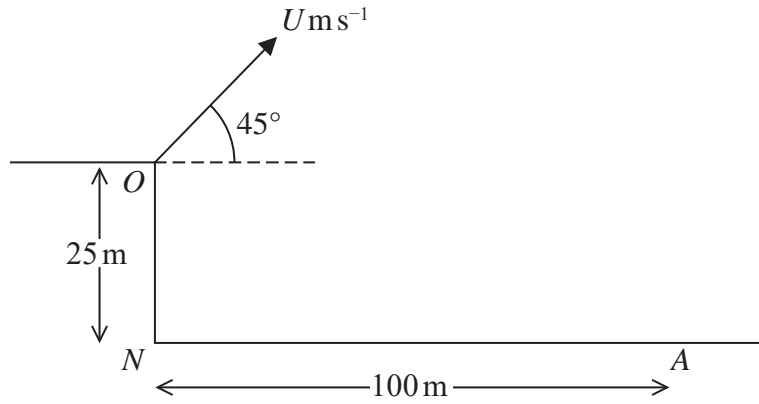


Figure 2

A small ball is projected with speed $U \text{ m s}^{-1}$ from a point O at the top of a vertical cliff. The point O is 25 m vertically above the point N which is on horizontal ground. The ball is projected at an angle of 45° above the horizontal. The ball hits the ground at a point A , where $AN = 100 \text{ m}$, as shown in Figure 2. The motion of the ball is modelled as that of a particle moving freely under gravity. Using this initial model,

(a) show that $U = 28$ (6)

(b) find the greatest height of the ball above the horizontal ground NA . (3)

In a refinement to the model of the motion of the ball from O to A , the effect of air resistance is included.

This refined model is used to find a new value of U .

(c) How would this new value of U compare with 28, the value given in part (a)? (1)

(d) State one further refinement to the model that would make the model more realistic. (1)

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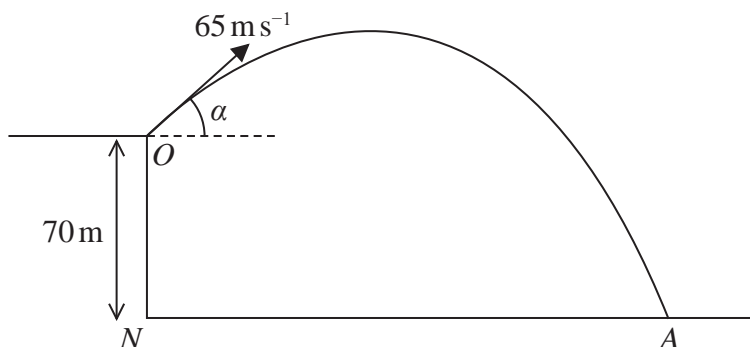


Figure 3

A small stone is projected with speed 65 m s^{-1} from a point O at the top of a vertical cliff.

Point O is 70 m vertically above the point N .

Point N is on horizontal ground.

The stone is projected at an angle α above the horizontal, where $\tan \alpha = \frac{5}{12}$

The stone hits the ground at the point A , as shown in Figure 3.

The stone is modelled as a particle moving freely under gravity.

The acceleration due to gravity is modelled as having magnitude 10 m s^{-2}

Using the model,

(a) find the time taken for the stone to travel from O to A , (4)

(b) find the speed of the stone at the instant just before it hits the ground at A . (5)

One limitation of the model is that it ignores air resistance.

(c) State one other limitation of the model that could affect the reliability of your answers. (1)

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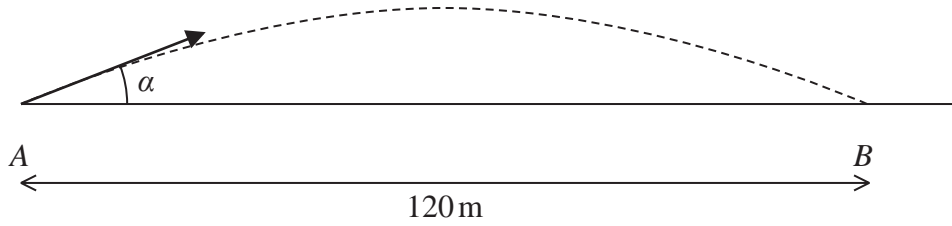


Figure 3

A golf ball is at rest at the point A on horizontal ground.

The ball is hit and initially moves at an angle α to the ground.

The ball first hits the ground at the point B , where $AB = 120\text{ m}$, as shown in Figure 3.

The motion of the ball is modelled as that of a particle, moving freely under gravity, whose initial speed is $U\text{ m s}^{-1}$

Using this model,

(a) show that $U^2 \sin \alpha \cos \alpha = 588$ (6)

The ball reaches a maximum height of 10 m above the ground.

(b) Show that $U^2 = 1960$ (4)

In a refinement to the model, the effect of air resistance is included.

The motion of the ball, from A to B , is now modelled as that of a particle whose initial speed is $V\text{ m s}^{-1}$

This refined model is used to calculate a value for V

(c) State which is greater, U or V , giving a reason for your answer. (1)

(d) State one further refinement to the model that would make the model more realistic. (1)

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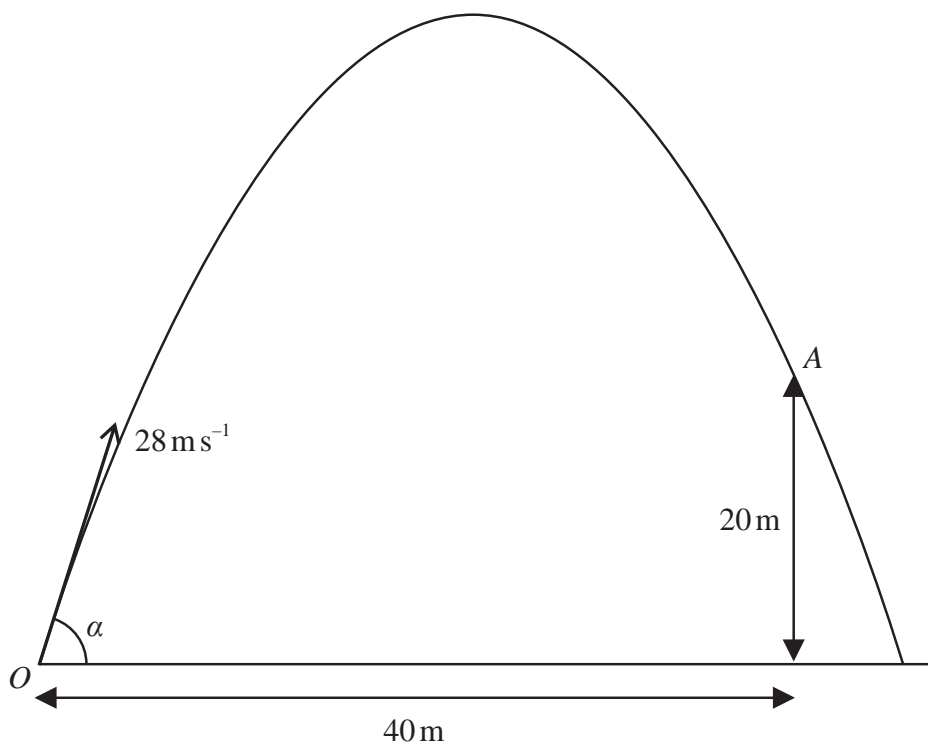


Figure 2

A small ball is projected with speed 28 m s^{-1} from a point O on horizontal ground.

After moving for T seconds, the ball passes through the point A .

The point A is 40 m horizontally and 20 m vertically from the point O , as shown in Figure 2.

The motion of the ball from O to A is modelled as that of a particle moving freely under gravity.

Given that the ball is projected at an angle α to the ground, use the model to

(a) show that $T = \frac{10}{7 \cos \alpha}$ (2)

(b) show that $\tan^2 \alpha - 4 \tan \alpha + 3 = 0$ (5)

(c) find the greatest possible height, in metres, of the ball above the ground as the ball moves from O to A . (3)

The model does not include air resistance.

(d) State one other limitation of the model. (1)

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