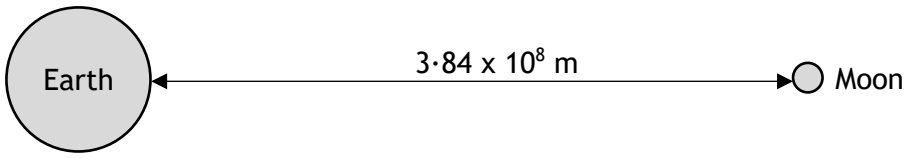
Key Area 4 - Gravitation

Multiple Choice Questions 1 → 10

1. The Moon, with a mass of $7{\cdot}3 \times 10^{22}$ kg, orbits the Earth, with a mass of $6{\cdot}0 \times 10^{24}$ kg, at an orbital distance of $3{\cdot}84 \times 10^{8}$ m.



Calculate the force of gravitational attraction between the two bodies.

A $1{\cdot}27 \times 10^{4}$ N

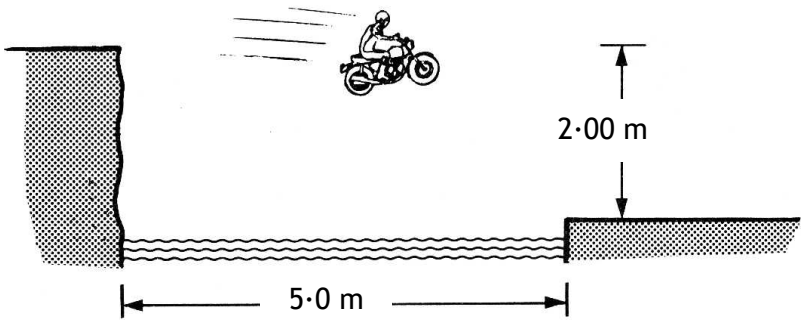
B $1{\cdot}04 \times 10^{6}$ N

C $1{\cdot}98 \times 10^{20}$ N

D $7{\cdot}61 \times 10^{28}$ N

E $2{\cdot}97 \times 10^{30}$ N

2. A stunt motorcyclist attempts to jump a river which is 5·0 m wide. The bank from which he will take off is 2·00 m higher than the bank on which he will land, as shown below.



Calculate the minimum horizontal speed he must achieve just before take-off to avoid landing in the river.

A $1{\cdot}9\ ms^{-1}$

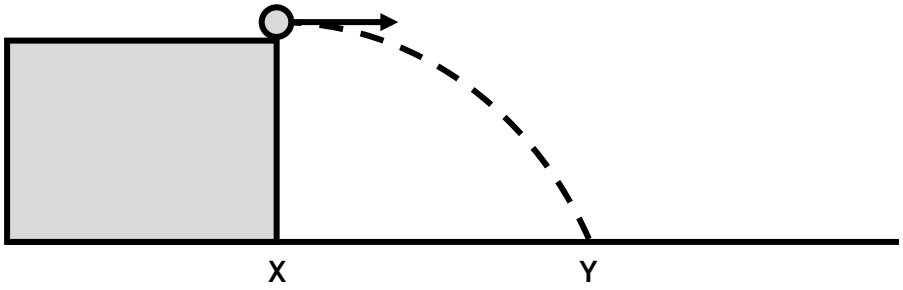
B $3{\cdot}1\ ms^{-1}$

C $7{\cdot}8\ ms^{-1}$

D $9{\cdot}8\ ms^{-1}$

E $12{\cdot}3\ ms^{-1}$

3. A ball is projected, with a horizontal velocity from a bench. The ball travels a horizontal distance, XY, as shown.



Identify which of the following statements is/are used to calculate the distance XY.

I the mass of the ball
II the height of the table
III the horizontal velocity of the ball

A I only

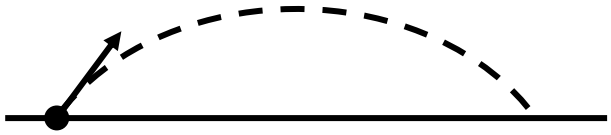
B II only

C III only

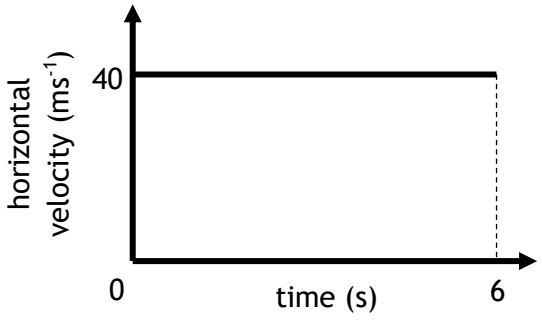
D I and III only

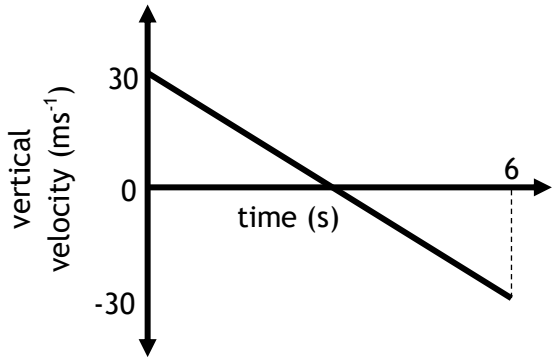
E II and III only

4. A golfer strikes a golf ball, which then moves off at an angle to the ground. The ball following the path shown below, lands 6 seconds later.



The graphs below show how the ball's horizontal and vertical components of velocity vary with time.





Determine the speed of the ball just before it hits the ground.

A 10 ms^{-1}

B 30 ms^{-1}

C 40 ms^{-1}

D 50 ms^{-1}

E 70 ms^{-1}

5. A ball is projected vertically upwards with an initial speed of 39·2 ms^{-1}.
Determine the time taken by the ball to rise to its highest point and return to the starting position.

A 2 s

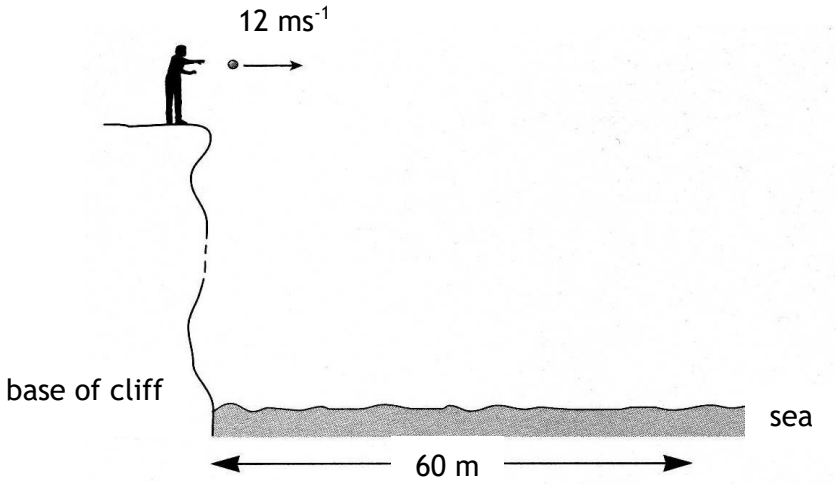
B 4 s

C 6 s

D 8 s

E 16 s

6. A stone is thrown horizontally with a speed of 12 ms^{-1} over the edge of a vertical cliff. It hits the sea at a horizontal distance of 60 m out from the base of the cliff.



Calculate the height from which the stone was projected above the level of the sea.

A 245·0 m

B 122·5 m

C 49·0 m

D 24·5 m

E 4·9 m

7. The weight of a 70 kg astronaut is equal to the force of gravitational attraction between the astronaut and the planet.
The mass of Mars is $6{\cdot}4 \times 10^{23}$ kg and the radius of Mars is $3{\cdot}4 \times 10^{6}$ m.
Calculate the gravitational field strength of Mars, at its surface.

A 3·69 Nkg^{-1}

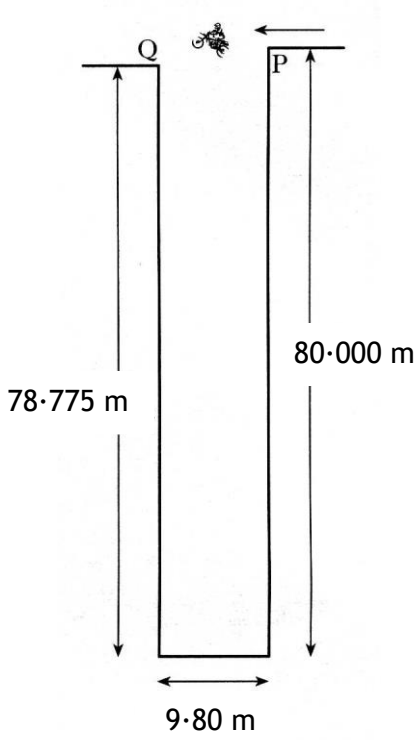
B 258 Nkg^{-1}

C $1{\cdot}26 \times 10^{7}$ Nkg^{-1}

D $8{\cdot}79 \times 10^{8}$ Nkg^{-1}

E $1{\cdot}88 \times 10^{17}$ Nkg^{-1}

8. A motorcycle stunt involves crossing a ravine from P to Q. The motorcycle is travelling horizontally when it leaves point P.



Neglecting air resistance, calculate the time taken to cross the ravine from P to Q.

A 0·125 s

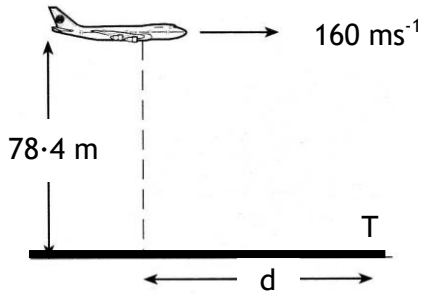
B 0·25 s

C 0·5 s

D 1·0 s

E 4·0 s

9. An aeroplane is flying at 160 ms^{-1} in level flight 78·4 m above the ground. It releases a package at a horizontal distance, d, from the target T.



The effect of air resistance can be ignored.
Calculate the distance, d, needed in order for the package to land on the target, T.

A 40 m

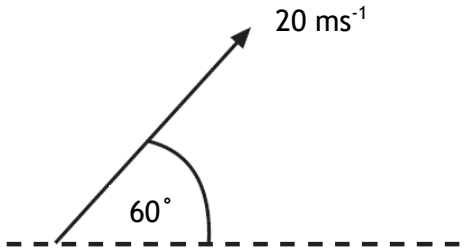
B 160 m

C 320 m

D 640 m

E 2560 m

10. A javelin is thrown at 60° to the horizontal with a speed of 20 ms^{-1}.



The javelin is in flight for 3.5 s and the air resistance is negligible.
Calculate the horizontal distance the javelin travels.

A 35·0 m

B 60·6 m

C 70·0 m

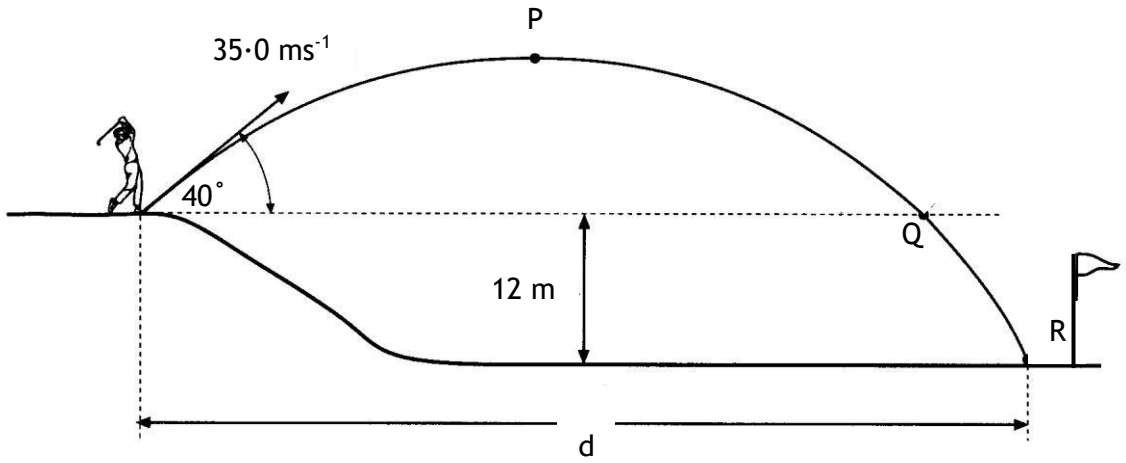
D 121 m

E 140 m

Full Response Questions 11 → 14

11. A golfer on an elevated tee hits a golf ball with an initial velocity of 35·0 ms^{-1} at an angle of 40° to the horizontal.
The ball travels through the air and hits the ground at point R.
Point R is 12 m below the height of the tee, as shown.

diagram not to scale



The effects of air resistance can be ignored.

(a) Calculate:

(i) the horizontal component of the initial velocity of the ball;

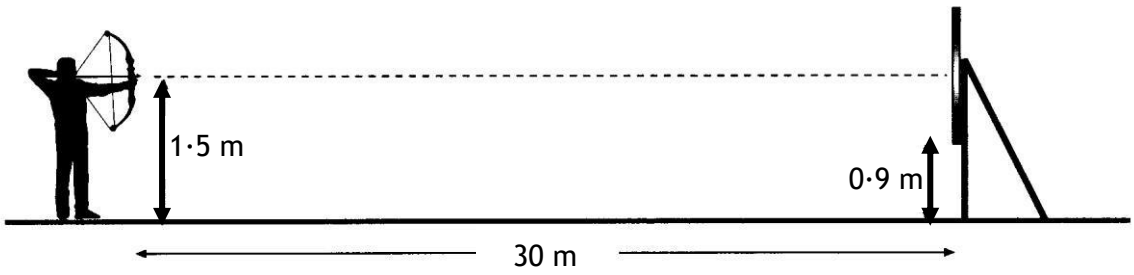
(ii) the vertical component of the initial velocity of the ball;

(iii) the time taken for the ball to reach its maximum height at point P.

(b) From its maximum height at point P, the ball falls to point Q, which is at the same height as the tee. The golf ball then takes a further 0·48 s to travel from Q unit it hits the ground at R.

Calculate the total horizontal distance d travelled by the ball.

12. An archer fires an arrow at a target which is 30 m away.

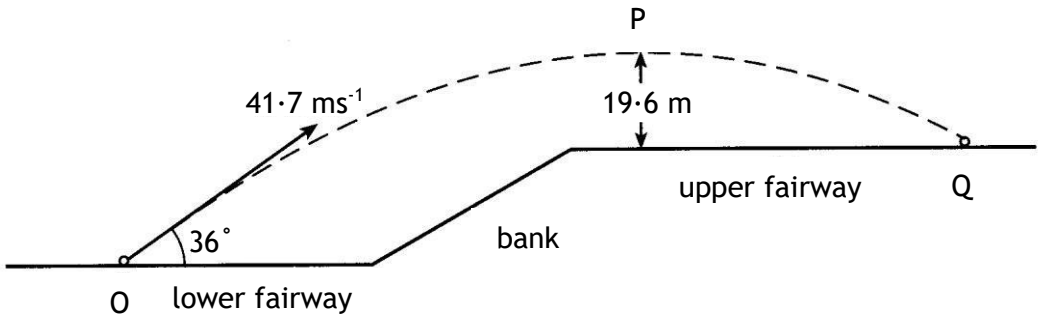


The arrow is fired horizontally from a height of 1·5 m and leaves the bow with a velocity of 100 m s^{-1}.

The bottom of the target is 0·90 m above the ground.

Show by calculation that the arrow hits the target.

13. The fairway on a golf course is in two horizontal parts separated by a steep bank as shown below.



A golf ball at point O is given an initial velocity of 41·7 m s^{-1} at 36° to the horizontal.

The ball reaches a maximum vertical height at point P above the upper fairway. Point P is 19·6 m above the upper fairway as shown. The ball hits the ground at point Q.

The effect of air resistance on the ball may be neglected.

(a) Calculate:

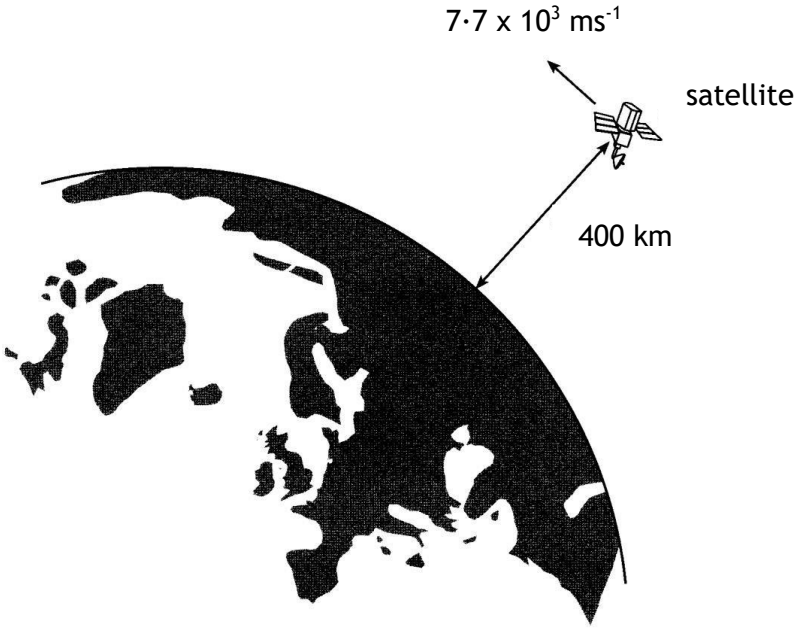
(i) the horizontal component of the initial velocity of the ball;

(ii) the vertical component of the initial velocity of the ball.

(b) Show that the time taken for the ball to travel from point O to point Q is 4·5 s.

(c) Calculate the horizontal distance travelled by the ball.

14. A satellite orbits 400 km above the surface of the Earth as shown.



The Earth has a mass of $6{\cdot}0 \times 10^{24}$ kg and a radius of $6{\cdot}4 \times 10^{6}$ m.

The satellite has a mass of 900 kg and a speed of $7{\cdot}7 \times 10^{3}$ ms^{-1}.

(a) Explain why the satellite remains in orbit around the Earth.

(b) Calculate the gravitational force acting on the satellite.