Projectiles 001 worked

20 November 2020 15:08

7 An arrow is fired from a point A with a velocity of $25\,\text{m s}^{-1}$, at an angle of $40°$ above the horizontal. The arrow hits a target at the point B which is at the same level as the point A, as shown in the diagram.

(a) State **two** assumptions that you should make in order to model the motion of the arrow. *(2 marks)*

(b) Show that the time that it takes for the arrow to travel from A to B is 3.28 seconds, correct to three significant figures. *(4 marks)*

(c) Find the distance between the points A and B. *(2 marks)*

(d) State the magnitude ~~and~~ direction of the velocity of the arrow when it hits the target. *(2 marks)*

(e) Find the minimum speed of the arrow during its flight. *(2 marks)*

A) no air resistance, g is the only accel (or weight the only force), object acts as a point, object not spinning

b) $s = ut + \frac{1}{2}at^2$ $\quad$ $s = 0$ if consider y components only.

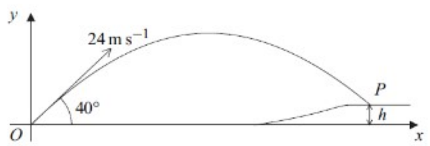
$0 = t\,25\sin(40) + \frac{1}{2}(-9.81)t^2 \Rightarrow t = 3.28\,s$

c) $v \times t = d$ $\quad t = 3.28\,s$ $\quad v_x = 25\cos 40 = 19.2$ (3sf)

D) the path is symmetrical, since vx doesn't change. Therefore the magnitude is 25m/s and the angle is 40° to the horizontal, but reflected

e) It says 'speed' so we don't care about direction - just size. So min size will be at the top of the parabola since v =0 and vx is constant

7 A golf ball is struck from a point O with velocity $24\,\text{m s}^{-1}$ at an angle of $40°$ to the horizontal. The ball first hits the ground at a point P, which is at a height h metres above the level of O.



The horizontal distance between O and P is 57 metres.

(a) Show that the time that the ball takes to travel from O to P is 3.10 seconds, correct to three significant figures. *(3 marks)*

(b) Find the value of h. *(3 marks)*

(c) (i) Find the speed with which the ball hits the ground at P. *(5 marks)*

(ii) Find the angle between the direction of motion and the horizontal as the ball hits the ground at P. *(2 marks)*

a) $s = ut + \cancel{\frac{1}{2}at^2}\,0$ $\quad s = 57\,m$ $\quad u_x = 24\cos(40)$

$\frac{s}{u} = t = 3.10\,s$ $\quad$ using x direction

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b) Now use $s = ut + \frac{1}{2}at^2$ in the y direction

$s = 3.1 \times 24 \sin(40) - \frac{1}{2} 9.8 \times 3.1^2$

s (i.e. h) $= 0.734\,m$ (3sf)

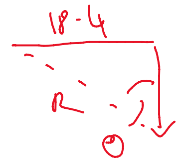
c) i $V_x = 24 \cos(40)$

to get V_y: $v_y = u_y + at$

$v_y = 24 \sin 40 + -9.81 \times 3.1$

$v_y = -14.98 = -15.0\,m/s$ (3sf)

$\therefore$



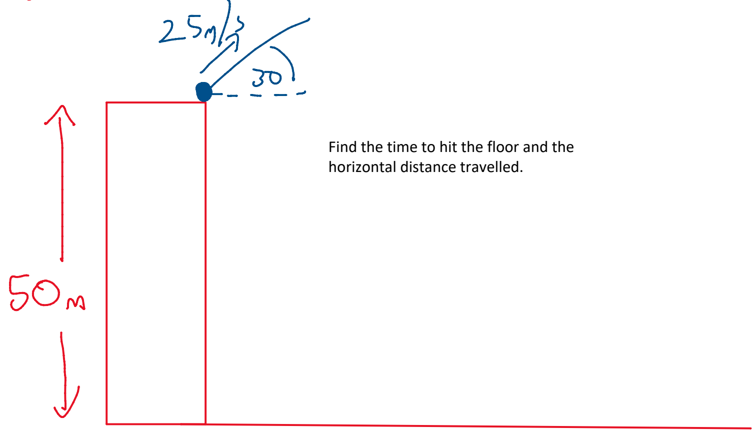
$R^2 = 18.4^2 + 15^2$

$R = 23.7\,m/s$

ii) $\tan^{-1}\left(\frac{18.4}{15}\right) = 50.8°$ so required angle

$= 90 - \theta = 39.2°$

3)



Find the time to hit the floor and the horizontal distance travelled.

$s = -50 \quad g = -9.81 \quad u = \overbrace{20\sin 30}^{10}$

$s = ut + \frac{1}{2}at^2$

$-50 = 10t + \frac{1}{2}(-9.81)t^2$

$-50 = 10t - 4.9t^2$

$\times -1$, rearrange:

$4.9t^2 - 10t - 50 = 0$

$a = 4.9, \quad b = -10 \quad c = -50$

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$t = \frac{10 \pm \sqrt{100 - 4 \times 4.9 \times (-50)}}{2 \times 4.9}$$

$$\therefore t = \frac{10 \pm 32.9}{9.8}$$

$t = 4.37$ sec

$t = -2.3$ sec

time to top:

$v = 0, \quad u = 20\sin 30, \quad g = -9.81$

$v = u + at \Rightarrow \frac{v - u}{a} = t \quad : \quad \underline{1.02 \text{ sec}}$

time from top to ground.

need height at top

$$\frac{v^2 - u^2}{2a} = \frac{0^2 - (20\sin 30)^2}{2 \times (-9.81)} = \underline{5.1\,m}$$

so $s = 5.1 + 50 = 55.1\,m \quad u = 0, v = ? \quad g = 9.81$

$v^2 = u^2 + 2as \Rightarrow v^2 = 2 \times 9.81 \times 55.1 \Rightarrow v = 32.88\,m/s$

time to fall $=$ $v = u + at$ $= \underline{3.35s}$

so time $= 4.37$ ✓✓

Negative time is 'before the event' - think count down to rocket launch.
The event was throwing the ball at 20m/s at 30 degrees 50m up.
So the negative time is the time it would have taken to come from the ground and to arrive at the point from which is was released.