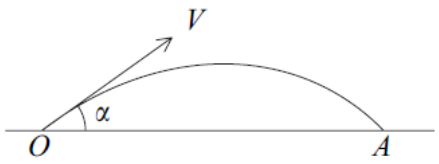
# Projectiles Questions

**5** A golf ball is projected from a point $O$ with initial velocity $V$ at an angle $\alpha$ to the horizontal. The ball first hits the ground at a point $A$ which is at the same horizontal level as $O$, as shown in the diagram.




It is given that $V\cos\alpha = 6u$ and $V\sin\alpha = 2.5u$.

(a) Show that the time taken for the ball to travel from $O$ to $A$ is $\dfrac{5u}{g}$. *(4 marks)*

(b) Find, in terms of $g$ and $u$, the distance $OA$. *(2 marks)*

(c) Find $V$, in terms of $u$. *(2 marks)*

(d) State, in terms of $u$, the least speed of the ball during its flight from $O$ to $A$. *(1 mark)*

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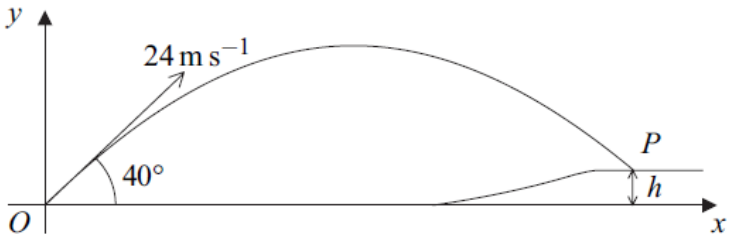
**7** A golf ball is struck from a point $O$ with velocity $24\,\text{m s}^{-1}$ at an angle of $40°$ to the horizontal. The ball first hits the ground at a point $P$, which is at a height $h$ metres above the level of $O$.




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)*

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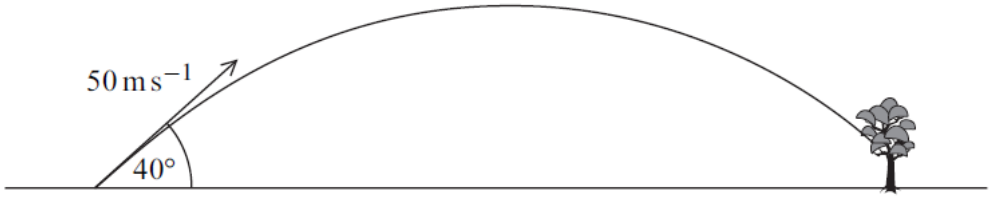
**7** A golf ball is struck from a point on horizontal ground so that it has an initial velocity of $50\,\text{m}\,\text{s}^{-1}$ at an angle of 40° above the horizontal.

Assume that the golf ball is a particle and its weight is the only force that acts on it once it is moving.

(a) Find the maximum height of the golf ball. *(4 marks)*

(b) After it has reached its maximum height, the golf ball descends but hits a tree at a point which is at a height of 6 metres above ground level.




Find the time that it takes for the ball to travel from the point where it was struck to the tree. *(6 marks)*

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**7** An arrow is fired from a point $A$ with a velocity of $25\,\text{m}\,\text{s}^{-1}$, 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)*

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# Projectiles Answers

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| **5(a)** | $s = ut + \frac{1}{2}at^2$ | | | |
| | $0 = 2\frac{1}{2}ut - \frac{1}{2}gt^2$ | M1<br>A1 | | full method required for time<br>(equation of motion, or standard result) |
| | $0 = t\left(2\frac{1}{2}u - \frac{1}{2}gt\right)$ | m1 | | |
| | $t = \frac{5u}{g}$ | A1 | 4 | (if $g = 9.8$ used, lose last A1) |
| **(b)** | $OA = 6u \times \frac{5u}{g}$ | M1 | | |
| | $= \frac{30u^2}{g}$ | A1 | 2 | cao |
| **(c)** | $\text{speed}^2 = (6u)^2 + \left(2\frac{1}{2}u\right)^2$ | M1 | | |
| | $\text{speed} = 6\frac{1}{2}u$ | A1 | 2 | cao |
| **(d)** | Least speed, at top, $= 6u$ | B1 | 1 | |
| | **Total** | | **9** | |

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|---|---|---|---|---|
| **7(a)** | $57 = 24\cos 40° \times t$ | M1<br>A1 | | Component attempted and acceleration $= 0$<br>All correct |
| | $t = 3.10$ sec | A1 | 3 | CAO |
| **(b)** | $h = 24\sin 40° \times 3.1 - \frac{1}{2} \times 9.8 \times 3.1^2$ | M1<br>A1 | | Component attempted & acceleration = 9.8<br>All correct |
| | $h = 0.734$ m | A1F | 3 | FT one slip e.g. +9.8 used<br>Accept 2 s.f. answer, AWRT $0.71 - 0.74$ |
| **(c)(i)** | horizontal, $u = 24\cos 40° = 18.39$ ms$^{-1}$ | B1 | | Seen anywhere in (c) accept 18.4 |
| | vertical, $v = 24\sin 40° - 9.8 \times 3.1$ | M1 | | Component attempted & acceleration = 9.8 |
| | $v = -14.95$ ms$^{-1}$ | A1 | | (Accept $-15.0$) |
| | $V = \sqrt{(18.39)^2 + (-14.95)^2}$ | M1 | | Use of candidate's $u$ and new $v$ (when $t = 3.1$) |
| | $V = 23.7$ ms$^{-1}$ | A1F | 5 | FT use of candidate's $u$ and $v$ and new $v$ when $t = 3.1$ |
| **(ii)** | $\tan\theta = \frac{14.95}{18.39}$ | M1 | | Use of candidate's $u$ and $v$<br>Accept inverted ratio |
| | $\theta = 39.1°$ or $39.2°$<br>Also $140.8°$ or $140.9°$ } accept ± | A1F | 2 | FT use of candidates $u$ and $v$ and $V$ |
| | **Total** | | **13** | |

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|---|---|---|---|---|
| **7(a)** | $0^2 = (50\sin 40°)^2 + 2\times(-9.8)h$ | M1A1 | | Equation for $h$ with $v = 0$ and a component of velocity. Correct equation |
| | $h = \dfrac{(50\sin 40°)^2}{2\times 9.8} = 52.7$ | dM1<br>A1 | | Solving for $h$<br>Correct $h$ |
| | **Alt** | | | |
| | $0 = 50\sin 40° - 9.8t$ | (M1) | | Equation for $t$ with $v = 0$ and a component of velocity |
| | $t = \dfrac{50\sin 40°}{9.8} = 3.280$ | (A1) | | Correct $t$ |
| | $h = 50\sin 40°\times 3.280 - \dfrac{1}{2}\times 9.8\times 3.280^2$ | (dM1) | | Expression for $h$ with a component of velocity |
| | $= 52.7$<br>ALLOW 52.6 | (A1) | 4 | Correct $h$ |
| **(b)** | $6 = 50\sin 40°t - 4.9t^2$ | M1A1 | | Forming a quadratic in $t$. Correct terms with any signs |
| | $0 = 4.9t^2 - 50\sin 40°t + 6$ | A1 | | Correct equation |
| | $t = \dfrac{50\sin 40° \pm \sqrt{(50\sin 40°)^2 - 4\times 4.9\times 6}}{2\times 4.9}$ | dM1 | | Solving quadratic |
| | $= 0.192$ or $6.37$ | | | |
| | $t = 6.37$ | A2 | 6 | Correct solution selected |
| | **Alt** | | | |
| | $46.7 = 4.9t_1^2$ | (M1) | | Finding two times |
| | | (dM1) | | Equation for time to go down |
| | $t_1 = 3.087$ | (A1) | | Correct time |
| | $t_2 = 3.280$ | (A1) | | Time to go up |
| | $t = 3.087 + 3.280 = 6.37$ | (A2) | | Correct total |
| | **Total** | | **10** | |

| | | | | |
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| **7(a)** | A particle or no spin<br>No air resistance or no wind or only gravity acting | B1<br>B1 | 2 | First assumption<br>Second assumption<br><br>If more than 2 assumptions given, subtract one mark for each incorrect additional assumption |
| **(b)** | $0 = 25\sin 40°t - 4.9t^2$<br>$0 = t(25\sin 40° - 4.9t)$<br>$t = 0 \quad \text{or} \quad t = \dfrac{25\sin 40°}{4.9}$<br>Time of flight = 3.28 s | M1<br>A1<br>dM1<br><br>A1 | 4 | Equation for time of flight<br>Correct equation<br>Solving for $t$<br><br>AG Correct final answer from correct working<br>(Verification method M1A1M1A0) |
| **(c)** | $s = 3.28 \times 25\cos 40° = 62.8$ m | M1<br>A1 | 2 | Finding range<br>Correct range |
| **(d)** | 25 $ms^{-1}$ at 40° **below** the horizontal | B1<br>B1 | 2 | Speed<br>Direction |
| **(e)** | $v_{min} = 25\cos 40° = 19.2$ $ms^{-1}$<br>**OR**<br>$v_{min} = \dfrac{62.807}{3.2795} = 19.2$ $ms^{-1}$ | M1<br>A1 | 2 | Horizontal component of velocity<br>Correct speed<br>Accept 19.1 $ms^{-1}$ |
| | **Total** | | **12** | |