# KS5 "Full Coverage": Projectiles (Year 2)

This worksheet is designed to cover one question of each type seen in past papers, for each A Level topic. This worksheet was automatically generated by the DrFrostMaths Homework Platform: students can practice this set of questions interactively by going to www.drfrostmaths.com, logging on, *Practise* → *Past Papers* (or *Library* → *Past Papers* for teachers), and using the 'Revision' tab.

---

## Question 1

**Categorisation: Determine the vertical height at a given final speed, given an unknown angle of projection.**

*[Edexcel M2 June 2014 Q6a]*

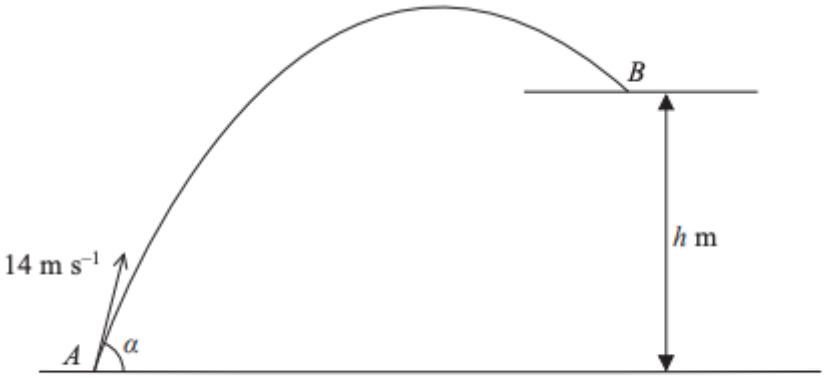



**Figure 2**

A small ball is projected with speed 14 m s $^{-1}$ from a point $A$ on horizontal ground. The angle of projection is $\alpha$ above the horizontal. A horizontal platform is at height $h$ metres above the ground. The ball moves freely under gravity until it hits the platform at the point $B$, as shown in Figure 2. The speed of the ball immediately before it hits the platform at $B$ is 10 m s $^{-1}$.

Find the value of $h$.

$h =$ ..... m

---

## Question 2

**Categorisation: Consider particles projected downwards.**

*[Edexcel A2 Specimen Papers P3 Q10a]*


**Figure 3**

A tennis player serves a ball so as to pass over the net.
The ball is given an initial velocity of 45 m s $^{-1}$ in a direction $10^{\circ}$ below the horizontal.

The ball is struck at a point $O$ which is 3.5 m vertically above the point $A$ which is on horizontal ground.
The bottom of the net is the point $B$ which is on the ground and $AB = 12$ m.
The height of the net is 1 m, as shown in Figure 3.

The ball is modelled as a particle moving freely under gravity.
The ball passes over the net at a point which is vertically above $B$ .

Using the model, find, in centimetres to 2 significant figures, the distance between the ball and the top of the net, as the ball passes over the net.

$d =$ ..... cm

---

## Question 3

**Categorisation: Determine the final speed.**

*[Edexcel A2 Specimen Papers P3 Q10b] (Continued from above)*

Using the model, find, to 2 significant figures, the speed of the ball as it passes over the net.

$v =$ ..... m s $^{-1}$

---

## Question 4

**Categorisation: Determine the initial speed.**

*[Edexcel A2 SAM P3 Q10a]*

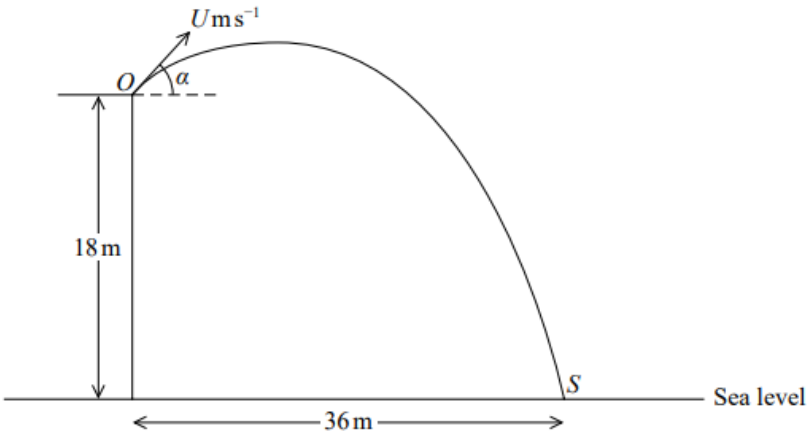



**Figure 2**

A boy throws a stone with speed $U$ m s$^{-1}$ from a point $O$ at the top of a vertical cliff. The point $O$ is 18 m above sea level.

The stone is thrown at an angle $\alpha$ above the horizontal, where $tan\,\alpha = \frac{3}{4}$.

The stone hits the sea at the point $S$ which is at a horizontal distance of 36 m from the foot of the cliff, as shown in Figure 2. The stone is modelled as a particle moving freely under gravity with $g = 10$ m s$^{-2}$

Find the value of $U$ .

$U =$ ..... m s$^{-1}$

---

## Question 5

**Categorisation: Determine the speed at a given height.**

*[Edexcel A2 SAM P3 Q10b Edited] (Continued from above)*

Find the speed of the stone when it is 10.8 m above sea level, giving your answer to 2 significant figures.

..... m s$^{-1}$

---

# Question 6

**Categorisation: Determine the horizontal distance travelled.**

*[Edexcel M2 June 2010 Q7b Edited]*

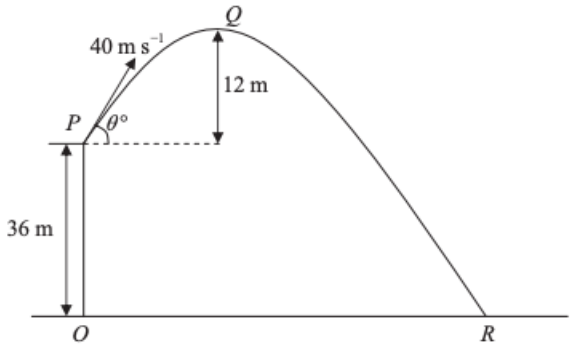



**Figure 3**

A ball is projected with speed 40 m s $^{-1}$ from a point $P$ on a cliff above horizontal ground.

The point $O$ on the ground is vertically below $P$ and $OP$ is 36 m. The ball is projected at an angle $\theta^\circ$ to the horizontal. The point $Q$ is the highest point of the path of the ball and is 12 m above the level of $P$. The ball moves freely under gravity and hits the ground at the point $R$, as shown in Figure 3.

Find the distance $OR$.

..... m

---

# Question 7

**Categorisation: Derive a formula involving projectile motion.**

*[Edexcel M2 June 2011 Q8a Edited]* A particle is projected from a point $O$ with speed $u$ at an angle of elevation $\alpha$ above the horizontal and moves freely under gravity. When the particle has moved a horizontal distance $x$, its height above $O$ is $y$.

Show that

$$y = x\tan\alpha - \frac{gx^2}{A\cos^2\alpha}$$

where $A$ is an expression to be found.

$A =$ .....

---

# Question 8

**Categorisation: As above.**

*[Edexcel M2 June 2018 Q7a Edited]* A particle, of mass 0.3 kg, is projected from a point $O$ on horizontal ground with speed $u$ .

The particle is projected at an angle $\alpha$ above the horizontal, where $tan\ \alpha = 2$ , and moves freely under gravity. When the particle has moved a horizontal distance $x$ from $O$ , its height above the ground is $y$ .

Show that $y = 2x - \frac{5g}{A}x^2$ where $A$ is an expression to be found.

$A =$ .....

---

# Question 9

**Categorisation: Determine the time/speed when the projectile is moving at a given angle.**

*[Edexcel M2 June 2012 Q7c Edited]*

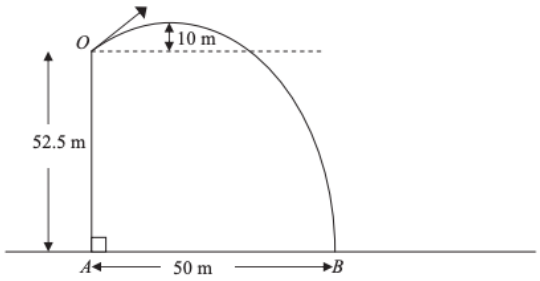



**Figure 4**

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.

It can be shown that the vertical component of the velocity of projection of the stone is 14 m $s^{-1}$ . Find the time after projection when the stone is moving parallel to $OB$ .

$t =$ ..... seconds

---

## Question 10

**Categorisation: Consider the collision of multiple projectiles.**

*[Edexcel M2 June 2017 Q6a]*

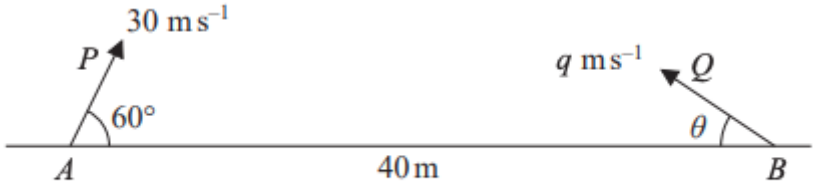



**Figure 4**

The points $A$ and $B$ lie 40 m apart on horizontal ground. At time $t = 0$ the particles $P$ and $Q$ are projected in the vertical plane containing $AB$ and move freely under gravity. Particle $P$ is projected from $A$ with speed 30 m s $^{-1}$ at $60^\circ$ to $AB$ and particle $Q$ is projected from $B$ with speed $q$ m s $^{-1}$ at angle $\theta$ to $BA$, as shown in Figure 4.

At $t = 2$ seconds, $P$ and $Q$ collide.

Find the size of angle $\theta$ and the value of $q$.

$\theta =$ ..... $^\circ$

$q =$ .....

---

## Question 11

**Categorisation: Use vectors within projectile motion.**

*[Edexcel M2 June 2016 Q6a]*

*[In this question,* **i** is a horizontal unit vector and **j** is an upward vertical unit vector.]

A particle $P$ is projected from a fixed origin $O$ with velocity $(3\mathbf{i} + 4\mathbf{j})$ m s $^{-1}$. The particle moves freely under gravity and passes through the point $A$ with position vector $\lambda(\mathbf{i} - \mathbf{j})$ m, where $\lambda$ is a positive constant.

Find the value of $\lambda$.

$\lambda =$ .....

---

## Question 12

**Categorisation: As above.**

*[Edexcel M2 June 2016 Q6b Edited]* (Continued from above)

Find the speed of $P$ at the instant when it passes through $A$ and the direction of motion of $P$ at the instant when it passes through $A$.

.....

---

## Question 13

**Categorisation: Determine the initial speed/angle of projection given a later speed and angle.**

*[Edexcel M2 June 2015 Q7a]*

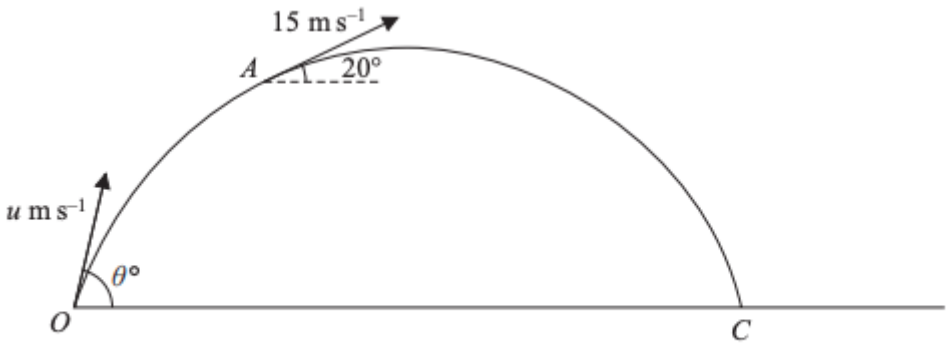



**Figure 3**

At time $t = 0$, a particle is projected from a fixed point $O$ on horizontal ground with speed $u$ m s $^{-1}$ at an angle $\theta^{\circ}$ to the horizontal. The particle moves freely under gravity and passes through the point $A$ when $t = 4$ s. As it passes through $A$ $^{-1}$, as shown in Figure 3.

Find the value of $u$ and the value of $\theta$.

$u =$ ..... m s $^{-1}$

$\theta =$ ..... $^{\circ}$

---

# Answers

## Question 1

$h =$ 4.9 m

| | | | |
|---|---|---|---|
| Initial $v_y = 14\sin\alpha$ Final $v_y = \sqrt{100 - 14^2\cos^2\alpha}$<br>$100 - 196\cos^2\alpha = 196\sin^2\alpha - 2gh$<br>$h = \frac{48}{g} = 4.90$ | M1A2<br>A1<br>(4) | Using $v^2 = u^2 + 2as$ on the vertical components of speed.<br>-1 each error in the unsimplified equation<br>Accept in exact form. Maximum 3 s.f. if they go in to decimals. |

## Question 2

$d =$ 2.5 cm

| | | |
|---|---|---|
| Using the model and horizontal motion: $s = ut$ | M1 | 3.3 |
| $12 = T$ x 45 cos10° | A1 | 1.1b |
| $T = 0.2707..$ | A1 | 1.1b |
| Using the model and vertical motion: $s = ut + \frac{1}{2}at^2$ | M1 | 3.4 |
| $s = 45T\sin10° + 4.9T^2$ | A1 | 1.1b |
| Correct strategy: sub for $T$ and find $s$ | M1 | 3.1b |
| $d =$ 3.5 – 2.4752 – 1 | M1 | 3.1b |
| = 2.5 (cm) (2 SF) | A1 | 2.2a |

## Question 3

$v =$ 46 m s $^{-1}$

| | | |
|---|---|---|
| Using the model and vertical motion: $v = u + at$ | M1 | 3.3 |
| $v = 45\sin10° + 9.8T$ | A1 | 1.1b |
| Speed $= ((45\cos10°)^2 + v^2)^{0.5}$ | M1 | 3.1b |
| 46 (m s$^{-1}$) (2 SF) | A1 | 1.1b |

## Question 4

$U =$ 15 m s $^{-1}$

| | |
|---|---|
| Using the model and horizontal motion: $s = ut$ | M1 |
| $36 = U t\cos\alpha$ | A1 |
| Using the model and vertical motion: $s = ut + \frac{1}{2}at^2$ | M1 |
| $-18 = U t\sin\alpha - \frac{1}{2}gt^2$ | A1 |
| Correct strategy for solving the problem by setting up two equations in $t$ and $U$ and solving for $U$ | M1 |
| $U = 15$ | A1 |

# Question 5

19 m s $^{-1}$

| | |
|---|---|
| Using the model and horizontal motion: $U\cos\alpha$ (12) | B1 |
| Using the model and vertical motion:<br>$v^2 = (U\sin\alpha)^2 + 2(-10)(-7.2)$ | M1 |
| $v = 15$ | A1 |
| Correct strategy for solving the problem by finding the horizontal and vertical components of velocity and combining using Pythagoras: Speed = $\sqrt{(12^2 + 15^2)}$ | M1 |
| $\sqrt{369} = 19$ m s $^{-1}$ (2sf) | A1 **ft** |

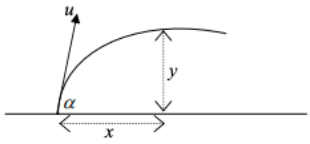
# Question 6

170 m

| | |
|---|---|
| Vert motion $P \to R$: $s = ut + \frac{1}{2}at^2$ | |
| $-36 = 40\sin\theta t - \frac{g}{2}t^2$ | M1 |
| $\frac{g}{2}t^2 - 40\sin\theta t - 36 = 0$ | A1 A1 |
| $t = \frac{40\sin 22.54 \pm \sqrt{(40\sin 22.54)^2 + 4 \times 4.9 \times 36}}{9.8}$ | |
| $t = 4.694...$ | A1 |
| Horizontal P to R: $s = 40\cos\theta t$ | M1 |
| $= 173$ m ( or 170 m) | A1 |

# Question 7

$A = 2u^2$




| | |
|---|---|
| Horiz: $x = u\cos\alpha t$ | B1 |
| Vert: $y = u\sin\alpha t - \frac{1}{2}gt^2$ | M1 |
| $y = u\sin\alpha \times \frac{x}{u\cos\alpha} - \frac{1}{2}g \times \frac{x^2}{u^2\cos^2\alpha}$ | DM1 |
| $y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\alpha}$ ** | A1 |

# Question 8

$A = 2u^2$

| | | |
|---|---|---|
| Horizontal distance: $x = u\cos\alpha t$ | B1 | $\frac{1}{\sqrt{5}}ut$ |
| Vertical distance: $y = u\sin\alpha t - \frac{1}{2}gt^2$ | M1A1 | $\frac{2}{\sqrt{5}}ut - \frac{1}{2}gt^2$<br>Condone sign errors and sin/cos confusion |
| $y = u\sin\alpha \times \frac{x}{u\cos\alpha} - \frac{g}{2} \times \left(\frac{x}{u\cos\alpha}\right)^2$<br>$= x\tan\alpha - \frac{gx^2}{2u^2} \times \frac{1}{\cos^2\alpha} = 2x - \frac{gx^2}{2u^2} \times \frac{1}{1/5}$ | DM1 | Substitute for $t$ and $\alpha$<br>Dependent on previous M1 |
| $= 2x - \frac{5g}{2u^2}x^2$ | A1 | Obtain **given answer** from exact working |

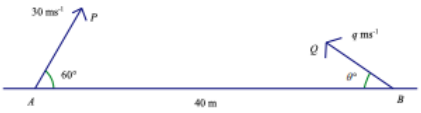
# Question 9

$t =$ 2.5 seconds

| | | |
|---|---|---|
| $\tan OBA = \frac{52.5}{50} = 1.05$ | B1 | Correct direction o.e. (accept reciprocal) |
| $v_V = 1.05 \text{ x } 10 = 10.5$ | M1 | Use trig. with their $u_H$ and correct interpretation of direction to find the vertical component of speed.<br>Working with distances is M0. (condone $10 \div 1.05$) |
| $(\uparrow),\ -10.5 = 14 - gt$ | DM1 | Use suvat to form an equation in t. Dependent on the preceding M. |
| | A1 | Correct equation for their $u_H$.<br>For incorrect direction give A0 here. |
| $t = 2.5$ | A1 | only |

# Question 10

$\theta =$ 79 ° and $q =$ 26.5




| | | |
|---|---|---|
| $30\cos 60 \times 2 + q\cos\theta \times 2 = 40$ | M1 | Equation for horizontal distance<br>Need to be using the 40 m |
| | A1 | Correct unsimplified |
| $30\sin 60 \times 2 - 4.9 \times 4 = q\sin\theta \times 2 - 4.9 \times 4$<br>$30\sin 60 = q\sin\theta$ | M1 | Equal vertical distance or initial vertical components of velocity |
| | A1 | Correct unsimplified (no error seen) |
| $q\cos\theta = \pm 5$<br>$q\sin\theta = 15\sqrt{3}$ | | |
| $\tan\theta = 3\sqrt{3}$<br>$(\tan\theta = 6\sin 60)$ | DM1 | Solve for $q$ or $\theta$<br>Dependent on both preceding M marks |
| $\theta = 79.1$ (79) | | (1.38 radians) or better |
| $q = 26.45... = 26.5$ | A1 | (26 or better) $(10\sqrt{7})$<br>Both correct and no error seen |

# Question 11

$\lambda =$ 4.3

| | | |
|---|---|---|
| Horizontal motion: $x = 3t$ | B1 | |
| Vertical motion: $y = 4t - \frac{g}{2}t^2$ | M1 | Correct use of *suvat*.<br>Condone sign error(s) |
| | A1 | |
| $\left(y = 4\times\frac{x}{3} - \frac{g}{2}\times\frac{x^2}{9}\right),\ \lambda = -\left(\frac{4\lambda}{3} - \frac{g\lambda^2}{18}\right)$ | M1 | Use $y = -x$ and form an equation in one variable |
| , $\frac{7\lambda}{3} = \frac{g\lambda^2}{18}$ | M1 | solve for $\lambda$ |
| $\lambda = \frac{42}{g}$ or 4.3 (4.29) | A1 (6) | Not $\frac{30}{7}$ |

# Question 12

"73.3" and "below"

| | | |
|---|---|---|
| At A: $v \rightarrow 3$ (m s$^{-1}$) | B1 | |
| $v\uparrow \quad 4-g\times\frac{14}{g}$ | M1 | Complete method using *suvat* to find $v\uparrow$ with their $t$ or $\lambda$ |
| $=-10$ (m s$^{-1}$) | A1 | Accept +10 with direction confirmed by diagram |
| Speed $=\sqrt{(\text{their } 10)^2+(3)^2}$ | DM1 | Dependent on the first M1 in (b) |
| $=\sqrt{109}$ (m s$^{-1}$) | A1 | (10.4) Allow for $v\uparrow=10$ |
| $\tan^{-1}\left(\frac{\text{their } 10}{3}\right)$ or $\tan^{-1}\left(\frac{3}{\text{their } 10}\right)$ | DM1 | Use trig to find a relevant angle. Dependent on the first M1 in (b) |
| Direction $=73.3°$ below the horizontal | A1 | (1.28 radians) Accept direction $3\mathbf{i}-10\mathbf{j}$ Do not accept a bearing |

# Question 13

$u =$ 72 m s $^{-1}$ and $\theta =$ 47 $^{\circ}$

| | | |
|---|---|---|
| After 4 seconds from O, horizontal speed $=u\cos\theta$ | B1 | |
| Vertical component of speed at $A = u+at$ | M1 | Complete method using *suvat* to find $v$. |
| $= u\sin\theta-4g$ | A1 | |
| At $A$, components are $15\cos 20$ (horizontal) and $15\sin 20$ (vertical) | B1 | |
| $u\cos\theta=15\cos 20$<br>$u\sin\theta=15\sin 20+4g$ | DM1 | Form simultaneous equations in $u$ and $\theta$ and attempt to solve for $u$ or $\theta$. Depends on the previous M1 |
| $\theta=72.4$ (72) | A1 | Remember - A0 for the first overspecified answer |
| $u=46.5$ (47) | A1 | |