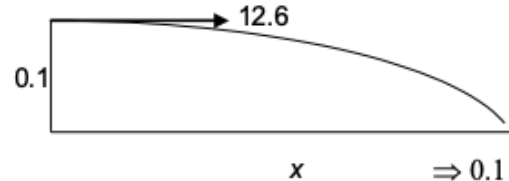
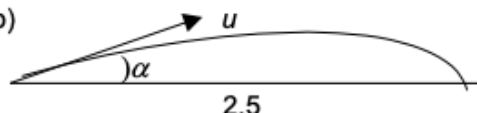


Projectiles - Edexcel Past Exam Questions **MARK SCHEME**
Question 1

Question Number	Scheme	Marks	
1.	(a) $\uparrow u_y = 32 \times \frac{3}{5} (=19.2)$ $-20 = 19.2t - 4.9t^2$ -1 each error $t \approx 4.8$ or 4.77 (s)	B1 M1 A2(1, 0) A1 <u>5</u>	
	(b) $\rightarrow u_x = 32 \times \frac{4}{5} (=25.6)$ $d = 25.6 \times 4.77\dots$ ≈ 120 or 122 (m)	B1 M1 A1 <u>3</u>	
	(c) $\uparrow v_y^2 = 19.2^2 + 2 \times 9.8 \times 4$ [$v_y^2 = 447.04, v_y \approx 21.14$] $V^2 = 447.04 + 25.6^2$ $V = 33$ or 33.2 (ms^{-1})	M1 M1 A1 A1 <u>4</u>	
	(d) $\tan \theta = \frac{21.14}{25.6}$ (or $\cos \theta = \frac{25.6}{33.2}, \dots$) ft their compone or resultant $\theta \approx 40^\circ$ or 39.6°	M1 A1ft A1 <u>3</u>	
	Alternative for (c) $\frac{1}{2}m(V^2 - 32^2) = mg \times 4$ $V^2 = 1102.4$ $V = 33$ or 33.2 (ms^{-1})	M1 A1 M1 A1 <u>4</u>	
	<i>There is a maximum penalty of one mark per question for not rounding to appropriate accuracy.</i>		

Question 2

	<p>(a)</p>  <p> $\rightarrow 12.6t = x$ $\downarrow 0.1 = 4.9t^2$ </p> <p> $\Rightarrow 0.1 = 4.9 \times \frac{x^2}{12.6^2}$ </p> <p> $\Rightarrow x = 1.8 \text{ m}$ </p>	B1 B1 M1 A1 (4)	
	<p>(b)</p>  <p> $\rightarrow u \cos \alpha t = 2.5$ $\uparrow u \sin \alpha t = \frac{1}{2}gt^2$ </p> <p> $u \cdot \frac{24}{25}t = 2.5$ </p> <p> $u \cdot \frac{7}{25} = 4.9 \cdot \frac{2.5 \cdot 25}{24u}$ </p> <p> $u^2 = \frac{4.9 \times 2.5 \times 25^2}{7 \times 24}$ </p> <p> $\Rightarrow u \approx 6.75 \text{ or } 6.8 \text{ m s}^{-1}$ </p>	M1 A1 M1 A1 M1 A1 (6)	

Question 3

Question Number	Scheme	Marks
3.	<p>(a) $u_x = 11 \cos 30^\circ$</p> <p>$\rightarrow 11 \cos 30^\circ \times t = 10 \Rightarrow t = 1.05 \quad (\text{s})$</p> <p>cao</p> <p>(b) $s = 11 \sin 30^\circ \times t - 4.9t^2 \approx 0.37$</p> <p>$(2 - 1) - 0.37 = 0.63 \quad (\text{m})$</p> <p>(c) $V \cos 30^\circ \times t = 10 \quad \left(t = \frac{10}{V \cos 30^\circ} \right)$</p> <p>$s = V \sin 30^\circ \times \frac{10}{V \cos 30^\circ} - \frac{4.9 \times 100}{V^2 \cos^2 \theta} = 1$</p> <p>$V^2 = 136.86$</p> <p>$V \approx 12$</p> <p>accept 11.7</p> <p>(d) <i>B</i> and/or <i>T</i> are not particles</p> <p>(They have extension giving a range of answers)</p>	<p>B1</p> <p>M1 A1</p> <p>(3)</p> <p>B1 M1 A1</p> <p>A1</p> <p>(4)</p> <p>M1 A1</p> <p>M1 A1</p> <p>M1</p> <p>A1</p> <p>(6)</p> <p>B1</p> <p>(1)</p> <p>14</p>

Question 4

<p>4. (a)</p>	$x_A = 28t \qquad x_B = 35 \cos \alpha t$ $\text{Meet} \Rightarrow 28t = 35 \cos \alpha t \Rightarrow \cos \alpha = 28/35$ $= 4/5 *$	<p>B1 B1 M1 A1 (4)</p>
<p>(b)</p>	$y_A = 73.5 - \frac{1}{2}gt^2 \qquad y_B = 21t - \frac{1}{2}gt^2$ $\text{Meet} \Rightarrow 73.5 = 21t \Rightarrow t = \underline{3.5 \text{ s}}$	<p>B1 B1 M1 A1 (4)</p>

Question 5

Question Number	Scheme	Marks
5.	(a) Energy $\frac{1}{2}m(24.5^2 - u^2) = mg \times 15$ $u^2 = 24.5^2 - 30g = 306.25$ $u = \sqrt{306.25} = 17.5$ ★	M1 A1=A1 A1 <u>4</u>
	(b) $\rightarrow u_x = u \cos \theta = 17.5 \times 0.8 = 14$ $\psi = \arccos \frac{14}{24.5} \approx 55^\circ$ accept 55.2° (0.96 rads, or 0.963 rads)	B1 M1 A1 <u>3</u>
	(c) $\uparrow u_y = u \sin \theta = 17.5 \times 0.6 = 10.5$ $s = ut + \frac{1}{2}at^2 \Rightarrow -45 = 10.5t - 4.9t^2$ leading to $t = 4.3$, awrt $t = 4.3$ or $t = 4\frac{2}{7}$ $\rightarrow BD = 14 \times 4\frac{2}{7}$ (14 x t) ft their t $= 60$ (m) only	B1 M1 A1 A1 M1 A1ft A1 <u>7</u> 14
	Alternative for (a) $\rightarrow u_x = u \cos \theta = 0.8u$, $\uparrow u_y = u \sin \theta = 0.6u$ $v_y^2 = 0.36u^2 + 2 \times 9.8 \times 15 = 0.36u^2 + 294$ $24.5^2 = u_x^2 + v_y^2 = 0.64u^2 + 0.36u^2 + 294$ $u^2 = 306.25 \Rightarrow u = 17.5$ ★	M1 A1,A1 A1 <u>4</u>
	Alternative for (b) $\rightarrow u_x = u \cos \theta = 17.5 \times 0.8 = 14$ $\uparrow v_y^2 = u^2 \sin^2 \theta + 2 \times 9.8 \times 15 = 404.25$ $\psi = \arctan \frac{\sqrt{404.25}}{14} \approx 55^\circ$ accept 55.2°	B1 M1 A1 <u>3</u>
	Alternative for (c) Use of $y = x \tan \theta - \frac{g \sec^2 \theta}{2u^2} x^2$ $-45 = \frac{3}{4}x$, $-\frac{g}{2 \times 17.5^2} \times \frac{25}{16} x^2$ $x^2 - 30x - 1800 = 0$ o.e. Factors or quadratic formula BD = 60 (m)	M1 B1,A1 A1 M1 A1ft A1

Question 6

Question Number	Scheme	Marks
(a)	$0 = (35 \sin \alpha)^2 - 2gh$ $h = \underline{40 \text{ m}}$	M1 A1 A1 (3)
(b)	$x = 168 \Rightarrow 168 = 35 \cos \alpha \cdot t \quad (\Rightarrow t = 8\text{s})$ $\text{At } t = 8, \quad y = 35 \sin \alpha \times t - \frac{1}{2}gt^2 \quad (= 28.8 - \frac{1}{2}g \cdot 8^2 = -89.6 \text{ m})$	M1 A1 M1 A1
(c)	$\text{Hence height of } A = \underline{89.6 \text{ m}} \text{ or } 90 \text{ m}$ $\frac{1}{2}mv^2 = \frac{1}{2}m \cdot 35^2 + mg \cdot 89.6$ $\Rightarrow v = \underline{54.6 \text{ or } 55 \text{ m s}^{-1}}$	DM1 A1 (6) M1 A1 A1 (3)

<p>M1 Use of $v^2 = u^2 + 2as$, or possibly a 2 stage method using $v = u + at$ and $s = ut + \frac{1}{2}at^2$</p> <p>A1 Correct expression. Alternatives need a complete method leading to an equation in h only.</p> <p>A1 40(m) No more than 2sf due to use of g.</p> <p>M1 Use of $x = u \cos \alpha \cdot t$ to find t.</p> <p>A1 $168 = 35 \times \text{their } \cos \alpha \times t$</p> <p>M1 Use of $s = ut + \frac{1}{2}at^2$ to find vertical distance for their t. (AB or top to B)</p> <p>A1 $y = 35 \sin \alpha \times t - \frac{1}{2}gt^2$ (u, t consistent)</p> <p>DM1 This mark dependent of the previous 2 M marks. Complete method for AB. Eliminate t and solve for s.</p> <p>A1 cso.</p> <p>(NB some candidates will make heavy weather of this, working from A to max height (40m) and then down again to B (129.6m))</p> <p>OR: Using $y = x \tan \alpha - \frac{gx^2 \sec^2 \alpha}{2u^2}$</p> <p>M1 formula used (condone sign error)</p> <p>A1 x, u substituted correctly</p> <p>M1 α terms substituted correctly.</p> <p>A1 fully correct formula</p> <p>M1, A1 as above</p> <p>M1 Conservation of energy: change in KE = change in GPE. All terms present. One side correct (follow their h). (will probably work A to B, but could work top to B).</p> <p>A1 Correct expression (follow their h)</p> <p>A1 54.6 or 55 (m/s)</p> <p>OR: M1 horizontal and vertical components found and combined using Pythagoras</p> <p>$v_x = 21$</p> <p>$v_y = 28 - 9.8 \times 8$ (-50.4)</p> <p>A1 v_x and v_y expressions correct (as above). Follow their h, t.</p> <p>A1 54.6 or 55</p> <p><i>NB Penalty for inappropriate rounding after use of g only applies once per question.</i></p>	
--	--

Question 7

Question Number	Scheme	Marks
	<p>(a)</p> $\begin{array}{l} \rightarrow 30 = 2ut \\ \uparrow -47.5 = 5ut - 4.9t^2 \\ -47.5 = 75 - 4.9t^2 \\ t^2 = \frac{75 + 47.5}{4.9} (= 25) \\ t = 5 \quad * \end{array}$ <p style="text-align: right;">eliminating u or t</p> <p style="text-align: right;">cso</p>	B1 M1 A1 DM1 DM1 A1 (6)
	<p>(b)</p> $30 = 2ut \Rightarrow 30 = 10u \Rightarrow u = 3$	M1 A1 (2)
	<p>(c)</p> $\begin{array}{l} \uparrow \dot{y} = 5u - 9.8t = -34 \\ \rightarrow \dot{x} = 2u = 6 \\ v^2 = 6^2 + (-34)^2 \\ v \approx 34.5 \text{ (ms}^{-1}\text{)} \end{array}$ <p style="text-align: right;">M1 requires both \dot{x} and \dot{y}</p> <p style="text-align: right;">accept 35</p>	M1 A1 A1 DM1 A1 (5)
	<p>Alternative to (c)</p> $\frac{1}{2}mv_B^2 - \frac{1}{2}mv_A^2 = m \times g \times 47.5 \text{ with } v_A^2 = 6^2 + 15^2 = 261$ $v_B^2 = 261 + 2 \times 9.8 \times 47.5 (= 1192)$ $v_B \approx 34.5 \text{ (ms}^{-1}\text{)} \quad \text{accept 35}$	[13] M1 A(2,1,0) DM1 A1 (5)
	<p>BEWARE : Watch out for incorrect use of $v^2 = u^2 + 2as$</p>	

Question 8

Question Number	Scheme		Marks
(a)	(↓)	$u_y = 25 \sin 30^\circ (=12.5)$ $12 = 12.5t + 4.9t^2$ Leading to $t = 0.743$, 0.74	B1 M1 A2, 1, 0 A1 (5)
(b)	(→)	$u_x = 25 \cos 30^\circ \left(= \frac{25\sqrt{3}}{2} \approx 21.65 \right)$ $OB = 25 \cos 30^\circ \times t (\approx 16.09458)$ $TB \approx 1.1$ (m)	B1 M1 A1ft A1 (4)
(c)	(→)	$15 = u_x \times t \Rightarrow t = \frac{15}{u_x} (= \frac{2\sqrt{3}}{5} \approx 0.693 \text{ or } 0.69)$	M1 A1
	either	(↓) $v_y = 12.5 + 9.8t (\approx 19.2896)$ $V^2 = u_x^2 + v_y^2 (\approx 840.840)$ $V \approx 29$ (ms^{-1}) , 29.0	M1 M1 A1 (5)
			(14 marks)

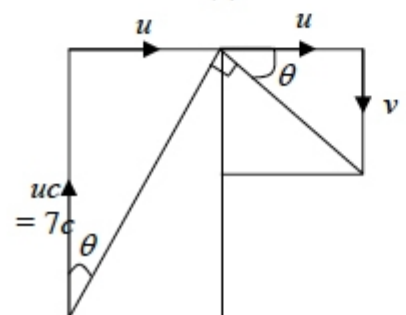
Question 9

Question Number	Scheme	Marks
(a)	Horizontal distance: $57.6 = p \times 3$ $p = 19.2$	M1 A1 (2)
(b)	Use $s = ut + \frac{1}{2}at^2$ for vertical displacement. $-0.9 = q \times 3 - \frac{1}{2}g \times 3^2$ $-0.9 = 3q - \frac{9g}{2} = 3q - 44.1$ $q = \frac{43.2}{3} = 14.4$ *AG*	M1 A1 A1 cso (3)
(c)	initial speed $\sqrt{p^2 + 14.4^2}$ $= \sqrt{576} = 24$ (m s ⁻¹)	(with their p) M1 A1 cao (2)
(d)	$\tan \alpha = \frac{14.4}{p} (= \frac{3}{4})$	(with their p) B1 (1)
(e)	When the ball is 4 m above ground: $3.1 = ut + \frac{1}{2}at^2$ used $3.1 = 14.4t - \frac{1}{2}gt^2$ o.e. ($4.9t^2 - 14.4t + 3.1 = 0$) $\Rightarrow t = \frac{14.4 \pm \sqrt{(14.4)^2 - 4(4.9)(3.1)}}{2(4.9)}$ $t = \frac{14.4 \pm \sqrt{146.6}}{9.8} = 0.023389... \text{ or } 2.70488...$ duration = $2.70488... - 0.023389...$ $= 2.47$ or 2.5 (seconds)	M1 A1 M1 seen or implied A1 awrt 0.23 and 2.7 M1 A1 (6)
or 6 (e)	M1A1M1 as above $t = \frac{14.4 \pm \sqrt{146.6}}{9.8}$ Duration $2 \times \frac{\sqrt{146.6}}{9.8}$ o.e. $= 2.47$ or 2.5 (seconds)	A1 M1 A1 (6)
(f)	Eg. : Variable 'g', Air resistance, Speed of wind, Swing of ball, The ball is not a particle.	B1 (1) [15]

Question 10

Question Number	Scheme	Marks
(a) (b)	$\rightarrow x = u \cos \alpha t = 10$ $\uparrow y = u \sin \alpha t - \frac{1}{2}gt^2 = 2$ $\Rightarrow t = \frac{10}{u \cos \alpha}$ $2 = u \sin \alpha \times \frac{10}{u \cos \alpha} - \frac{g}{2} \times \frac{100}{u^2 \cos^2 \alpha}$ $= 10 \tan \alpha - \frac{50g}{u^2 \cos^2 \alpha} \text{ (given answer)}$ $2 = 10 \times 1 - \frac{100g \times 2}{2u^2 \times 1}$ $u^2 = \frac{100g}{8}, u = \sqrt{\frac{100g}{8}} = 11.1 \text{ (m s}^{-1}\text{)}$ $\frac{1}{2}mu^2 = m \times 9.8 \times 2 + \frac{1}{2}mv^2$ $v = 9.1 \text{ms}^{-1}$	M1A1 M1A1 M1 A1 (6) M1A1 A1 M1A1 A1 (6) [12]

Question 11

Question Number	Scheme	Marks
(a)	$x = ut$ $y = cut - 4.9t^2$	B1 M1 A1
	eliminating t and simplifying to give $y = cx - \frac{4.9x^2}{u^2} **$	DM1 A1 (5)
(b)(i)	$0 = cx - \frac{4.9x^2}{u^2}$	M1
	$0 = x\left(c - \frac{4.9x}{u^2}\right) \Rightarrow R = \frac{u^2c}{4.9} = 10c$	M1 A1
(ii)	When $x = 5c$, $y = H$	M1
	$= 5c^2 - \frac{(5c)^2}{10} = 2.5c^2$	M1 A1 (6)
(c)	$\frac{dy}{dx} = c - \frac{9.8x}{u^2} = c - \frac{x}{5}$	M1 A1
	When $x = 0$, $\frac{dy}{dx} = c$	B1
	So, $c - \frac{x}{5} = \frac{-1}{c}$	DM1 A1
	$x = 5\left(c + \frac{1}{c}\right)$	A1 (6)
	<p>Alternative to 8(c)</p> 	$\tan \theta = \frac{u}{cu} = \frac{1}{c} = \frac{v}{u}$ $\Rightarrow v = \frac{u}{c} = \frac{7}{c}$ $v = u + at ; \quad -\frac{7}{c} = 7c - 9.8t$ $t = \frac{7}{9.8}\left(c + \frac{1}{c}\right)$ $x = ut = 7t ; \quad x = 5\left(c + \frac{1}{c}\right)$
[17]		

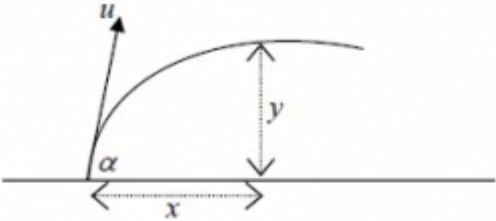
Question 12

Question Number	Scheme	Marks
(a)	Vertical motion: $v^2 = u^2 + 2as$ $(40 \sin \theta)^2 = 2 \times g \times 12$ $(\sin \theta)^2 = \frac{2 \times g \times 12}{40^2}$ $\theta = 22.54 = 22.5^\circ$ (accept 23)	M1 A1 A1 (3)
(b)	Vert motion $P \rightarrow R$: $s = ut + \frac{1}{2}at^2$ $-36 = 40 \sin \theta t - \frac{g}{2}t^2$ $\frac{g}{2}t^2 - 40 \sin \theta t - 36 = 0$ $t = \frac{40 \sin 22.54 \pm \sqrt{(40 \sin 22.54)^2 + 4 \times 4.9 \times 36}}{9.8}$ $t = 4.694\dots$ Horizontal P to R : $s = 40 \cos \theta t$ $= 173 \text{ m}$ (or 170 m)	M1 A1 A1 A1 M1 A1 (6)
(c)	Using Energy: $\frac{1}{2}mv^2 - \frac{1}{2}m \times 40^2 = m \times g \times 36$ $v^2 = 2(9.8 \times 36 + \frac{1}{2} \times 40^2)$ $v = 48.0\dots$ $v = 48 \text{ m s}^{-1}$ (accept 48.0)	M1 A1 A1 (3) [12]

Question 13

<p>(a)</p>	<p>Using $s = ut + \frac{1}{2}at^2$ clear $\mathbf{r} = (3t)\mathbf{i} + (10 + 5t - 4.9t^2)\mathbf{j}$</p> <p>Method must be Answer given</p>	<p>M1 A1 A1 (3)</p>
<p>(b)</p>	<p>j component = 0: $10 + 5t - 4.9t^2$ quadratic formula: $t = \frac{5 \pm \sqrt{25 + 196}}{9.8} = \frac{5 \pm \sqrt{221}}{9.8}$ $T = 2.03(\text{s}), 2.0(\text{s})$ positive solution only.</p>	<p>M1 DM1 A1 (3)</p>
<p>(c)</p>	<p>Differentiating the position vector (or working from first principles) $\mathbf{v} = 3\mathbf{i} + (5 - 9.8t)\mathbf{j}$ (ms^{-1})</p>	<p>M1 A1 (2)</p>
<p>(d)</p>	<p>At B the j component of the velocity is the negative of the i component: $5 - 9.8t = -3$, $8 = 9.8t$, $t = 0.82$</p>	<p>M1 A1 (2)</p>
<p>(e)</p>	<p>$\mathbf{v} = 3\mathbf{i} - 3\mathbf{j}$, speed = $\sqrt{3^2 + 3^2} = \sqrt{18} = 4.24(\text{m s}^{-1})$</p>	<p>M1A1 (2) [12]</p>

Question 14

Question Number	Scheme	Marks
(a)	 <p> Horiz: $x = u \cos \alpha t$ Vert: $y = u \sin \alpha t - \frac{1}{2} g t^2$ $y = u \sin \alpha \times \frac{x}{u \cos \alpha} - \frac{1}{2} g \times \frac{x^2}{u^2 \cos^2 \alpha}$ $y = x \tan \alpha - \frac{g x^2}{2 u^2 \cos^2 \alpha} \quad **$ </p>	B1 M1 DM1 A1 (4)
(b)	$y = -7: \quad -7 = \tan 45x - \frac{g x^2}{2 \times 7^2 \cos^2 45}$ $-7 = x - \frac{9.8 x^2}{7^2}$ $-7 = x - \frac{x^2}{5}$ $x^2 - 5x - 35 = 0$ $x = \frac{5 \pm \sqrt{25 + 4 \times 35}}{2}$ $x = 8.92 \text{ or } 8.9$	M1 A1 M1 M1 A1 (5)
(c)	Time to travel 8.922 m horizontally = $\frac{8.922}{7 \cos 45} = 1.802...s$ $v = \frac{8.922}{1.402}$ $= 6.36 \text{ or } 6.4 \text{ (m s}^{-1}\text{)}$	M1 M1 A1 ft A1 (4) 13