Question	Scheme	Marks	AOs
	Note that $g = 10$; penalise once for whole question if $g = 9.8$		
4(a)	Use $s = ut + \frac{1}{2}at^2$ vertically or any complete method to give an equation in t only	M1	3.4
	$-70 = 65\sin\alpha \times t - \frac{1}{2} \times g \times t^2$	A1	1.1b
		M (A)1	1.1b
	$t = 7$ (s)	A1	1.1b
		(4)	
4(b)	Horizontal velocity component at $A = 65\cos\alpha$ (60)	B1	3.4
	Complete method to find vertical velocity component at A	M1	3.4
	$65\sin\alpha - g \times 7$ **OR** $\sqrt{(-25)^2 + 2g \times 70}$ (45)	A1**ft**	1.1b
	Sub for trig and square, add and square root : $\sqrt{60^2 + (-45)^2}$	M1	3.1b
	75 Accept 80 (m s^{-1})	A1	1.1b
		(5)	
4(c)	e.g. an approximate value of g has been used, the dimensions of the stone could affect its motion, spin of the stone, $g = 10$ instead of 9.8 has been used, g has been assumed to be constant, wind effect, shape of the stone	B1	3.5b
		(1)	
			(10 marks)

Notes:		
4a	M1	Complete method, correct no. of terms, condone sign errors and sin/cos confusion
	A1	Correct equation in t only with at most one error
	M(A)1	Correct equation in t only
		N.B. For 'up and down' methods etc, the two A marks are for all the equations that they use, lose a mark for each error.
	A1	Cao ($g = 9.8$, 7.1 or 7.11) ($g = 9.81$, 7.1 or 7.12)
4b	B1	Seen, including on a diagram.
	M1	Condone sign errors and sin/cos confusion
	A1**ft**	Correct expression; accept negative of this, follow their t
	M1	Sub for trig and use Pythagoras
	A1	Cao ($g = 9.8$ or 9.81 , 75 or 74.8)

Question	Scheme	Marks	AOs
10(a)	Using the model and vertical motion: $0^2 = (U\sin\alpha)^2 - 2g\times(3-2)$	M1	3.3
	$U^2 = \dfrac{2g}{\sin^2\alpha}$ * GIVEN ANSWER	A1*	2.2a
		(2)	
(b)	Using the model and horizontal motion: $s = ut$	M1	3.4
	$20 = Ut\cos\alpha$	A1	1.1b
	Using the model and vertical motion: $s = ut + \dfrac{1}{2}at^2$	M1	3.4
	$-\dfrac{5}{4} = Ut\sin\alpha - \dfrac{1}{2}gt^2$	A1	1.1b
	sub for t: $-\dfrac{5}{4} = U\sin\alpha\left(\dfrac{20}{U\cos\alpha}\right) - \dfrac{1}{2}g\left(\dfrac{20}{U\cos\alpha}\right)^2$	M1 (I)	3.1b
	sub for U^2	M1(II)	3.1b
	$-\dfrac{5}{4} = 20\tan\alpha - 100\tan^2\alpha$	A1(I)	1.1b
	$(4\tan\alpha - 1)(100\tan\alpha + 5) = 0$	M1(III)	1.1b
	$\tan\alpha = \dfrac{1}{4} \Rightarrow \alpha = 14^0$ or better	A1(II)	2.2a
		(9)	
	N.B. For the last 5 marks, they may set up a quadratic in t, by substituting for $U\sin\alpha$ first, then solve the quadratic to find the value of t, then use $20 = Ut\cos\alpha$ to find α. The marks are the same but earned in a different order. Enter on ePen in the corresponding M and A boxes above, as indicated below.		
	Sub for $U\sin\alpha$ to give equation in t only	M1(II)	
	$-\dfrac{5}{4} = \sqrt{2g}t - \dfrac{1}{2}gt^2$	A1(I)	
	Solve for t	M1(III)	
	$t = \dfrac{5}{\sqrt{2g}}$ or 1.1 or 1.13 and use $20 = Ut\cos\alpha$	M1(I)	
	$\alpha = 14^0$ or better	A1(II)	
(b)	**ALTERNATIVE**		

	Using the model and horizontal motion: $s = ut$	M1	3.4
	$20 = Ut\cos\alpha$	A1	1.1b
	A to top: $s = vt - \frac{1}{2}at^2$ and top to T: $s = ut + \frac{1}{2}at^2$		
	$1 = \frac{1}{2}gt_1^2 \Rightarrow t_1 = \sqrt{\frac{2}{g}}$ and $\frac{9}{4} = \frac{1}{2}gt_2^2 \Rightarrow t_2 = \frac{3}{\sqrt{2g}}$ Total time $t = t_1 + t_2$	M1	3.4
	$= \sqrt{\frac{2}{g}} + \frac{3}{\sqrt{2g}}$ $(= \frac{5}{\sqrt{2g}})$	A1	1.1b
	$20 = U\frac{5}{\sqrt{2g}}\cos\alpha$ (sub. for t)	M1	3.1b
	$20 = \sqrt{\frac{2g}{\sin^2\alpha}}\frac{5}{\sqrt{2g}}\cos\alpha$ (sub. for U)	M1	3.1b
	$\tan\alpha = \frac{1}{4}$	A1	1.1b
	Solve for α	M1	1.1b
	$\therefore \alpha = 14^0$ or better	A1	2.2a
		(9)	
(c)	The target will have dimensions so in practice there would be a range of possible values of α **Or** There will be air resistance **Or** The ball will have dimensions **Or** Wind effects **Or** Spin of the ball	B1	3.5b
		(1)	
(d)	Find U using their α e.g. $U = \sqrt{\frac{2g}{\sin^2\alpha}}$	M1	3.1b
	Use $20 = Ut\cos\alpha$ (or use vertical motion equation)	A1 **M1**	1.1b
	$t = \frac{5}{\sqrt{2g}}$ or 1.1 or 1.13	B1 **A1**	1.1b
		(3)	
(d)	**ALTERNATIVE**		

Question	Scheme	Marks	AO
	In this question mark parts (a) and (b) together.		
5(a)	Horizontal speed $= 20\cos 30°$	B1	3.4
	Vertical velocity <u>at $t = 2$</u>	M1	3.4
	$= 20\sin 30° - 2g$	A1	1.1b
	$\theta = \tan^{-1}\left(\pm\dfrac{9.6}{10\sqrt{3}}\right)$	M1	1.1b
	Speed $= \sqrt{100\times 3 + 9.6^2}$ or e.g. speed $= \dfrac{9.6}{\sin\theta}$	M1	1.1b
	19.8 or 20 $\left(\text{m s}^{-1}\right)$ at 29.0° or 29° to the horizontal oe	A1	2.2a
		(6)	
(b)	Using sum of horizontal distances $= 50$ at $t = 2$	M1	3.3
	$(u\cos\theta)\times 2 + (20\cos 30°)\times 2 = 50$ $(u\cos\theta = 25 - 20\cos 30°)$	A1	1.1b
	Vertical distances equal	M1	3.4
	$\Rightarrow (20\sin 30°)\times 2 - \dfrac{g}{2}\times 4 = (u\sin\theta)\times 2 - \dfrac{g}{2}\times 4$ $(20\sin 30° = u\sin\theta)$	A1	1.1b
	Solving for both θ and u	M1	3.1b
	$\theta = 52°$ or better (52.47756849….°) $u = 13$ or better (12.6085128…)	A1	2.2a
		(6)	
(c)	It does not take account of the fact that they are not particles (moving freely under gravity) It does not take account of the size(s) of the balls It does not take account of the spin of the balls It does not take account of the wind g is not exactly 9.8 m s^{-2} **N.B.** If they refer to the mass or weight of the balls give B0	B1	3.5b
		(1)	
		(13)	

Question	Scheme	Marks	AOs
5(a)	Using horizontal motion	M1	3.3
	$U\cos 45^\circ t = 100$	A1	1.1b
	Using vertical motion	M1	3.4
	$U\sin 45^\circ t - \frac{1}{2}gt^2 = -25$	A1	1.1b
	Solve problem by eliminating t and solving for U	M1	3.1b
	$U = 28$*	A1*	1.1b
		(6)	
5(b)	Using vertical motion	M1	3.4
	$0^2 = (28\sin 45^\circ)^2 - 2gh$	A1	1.1b
	Greatest height = 45 m	A1	1.1b
		(3)	
5(c)	New value > 28	B1	3.5a
		(1)	
5(d)	e.g. wind effects, more accurate value of g, spin of ball, include size of the ball, not model as a particle, shape of ball	B1	3.5c
		(1)	
			(11 marks)

Notes:

5a	M1	Complete method to give equation in U and t only, condone sin/cos confusion and sign errors
	A1	Correct equation
	M1	Complete method to give equation in U and t only, condone sin/cos confusion and sign errors
	A1	Correct equation (g does not need to be substituted)
	M1	Must have earned the previous two M marks. Eliminate t and solve for U. **N.B**. They may solve for t first ($100 - \frac{1}{2}gt^2 = -25$) and then use it to find U.
	A1*	Exact given answer correctly obtained with no wrong working (e.g. $g = 9.81$ used) or approximation seen.
5b	M1	Complete method to give equation in h only (allow if U not substituted), condone sin/cos confusion and sign errors

Question	Scheme	Marks	AOs
10(a)	Using the model and horizontal motion: $s = ut$	M1	3.4
	$36 = U t\cos\alpha$	A1	1.1b
	Using the model and vertical motion: $s = ut + \frac{1}{2}at^2$	M1	3.4
	$-18 = Ut\sin\alpha - \frac{1}{2}gt^2$	A1	1.1b
	Correct strategy for solving the problem by setting up two equations in t and U and solving for U	M1	3.1b
	$U = 15$	A1	1.1b
		(6)	
(b)	Using the model and horizontal motion: $U\cos\alpha$ (12)	B1	3.4
	Using the model and vertical motion: $v^2 = (U\sin\alpha)^2 + 2(-10)(-7.2)$	M1	3.4
	$v = 15$	A1	1.1b
	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	3.1b
	$\sqrt{369} = 19$ m s^{-1} (2sf)	A1 **ft**	1.1b
		(5)	
(c)	Possible improvement (see below in notes)	B1	3.5c
	Possible improvement (see below in notes)	B1	3.5c
		(2)	
			(13 marks)

Question Number	Scheme	Marks	Notes
7(a)	$\frac{1}{2}m\times v^2-\frac{1}{2}m\times 15^2=47.5mg$	M1	The Q tells them to use energy. Need all 3 terms. Condone sign errors Must be dimensionally correct.
		A1	Unsimplified equation with at most one error
		A1	Correct unsimplified equation
	$v=34$ m s^{-1}	A1	
		(4)	
(b)	$u=15\times\frac{3}{5}$ m s^{-1}, $a=-9.8$ m s^{-1}, $v=0$		
	$0=9^2-2\times 9.8s$	M1	Complete method using *suvat* to reach an equation in s.
	$s=4.1326...$	A1	
	ht above beach $=51.63...=52$ (m)	A1ft	Or 51.6(m). Their s + 47.5. Max 3 s.f.
		(3)	
(c)	least speed $=15\times\frac{4}{5}=12$ m s^{-1}	B1	
		(1)	
(d)	$u=-15\times\frac{3}{5}$ m s^{-1}, $a=9.8$ m s^{-1}, $s=47.5$		
	$47.5=-9t+\frac{1}{2}\times 9.8t^2$	M1	Complete method using *suvat* to reach an equation in t.
	$\left(4.9t^2-9t-47.5=0\right)$	A1	Correct equation (any form)
	$t=\frac{9\pm\sqrt{9^2+4\times 4.9\times 47.5}}{9.8}$	dM1	Solve for t. Dependent on preceding M
	$t=4.16448...$	A1	Only. –ve value must be rejected if seen.
	Horiz dist $=15\times\frac{4}{5}\times 4.16448...\left(=49.9738...\text{m}\right)$	M1	Complete method using *suvat* and their t to find distance. Independent
	$=50$ or 50.0 (m)	A1	Max 3 s.f.
		(6)	
		[14]	
	Alternative for first 4 marks in **(d)**		
	Complete method to find vertical component of the speed on impact with the ground	M1	Or use their $\sqrt{(a)^2-(c)^2}$ provided $(c)\neq 0$
	$v=\sqrt{1012}\left(=31.8....\right)$	A1	
	$\sqrt{1012}=-9+gt$	M1	Use *suvat* to find t. Condone sign error(s)
	$t=4.16448...$	A1	

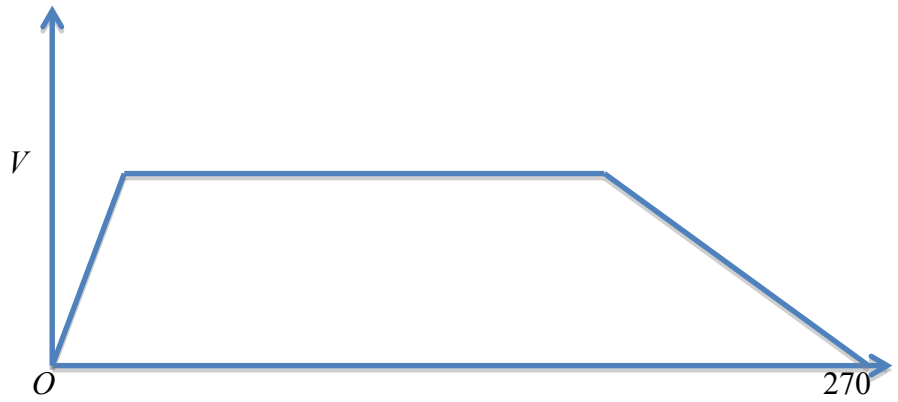
Q	Scheme	Marks	Notes
7(a)	Horizontal distance in terms of U, t and α	M1	
	$x = Ut\cos\alpha$	A1	Correct unsimplified equation
	Vertical distance in terms of U, t and α	M1	Condone sign error
	$y = Ut\sin\alpha - \frac{1}{2}gt^2$	A1	Correct unsimplified equation
	$y = U\sin\alpha\frac{x}{U\cos\alpha} - \frac{1}{2}g(\frac{x}{U\cos\alpha})^2$	DM1	Substitute for t Dependent on the first 2 M marks
	$y = x\tan\alpha - \frac{gx^2\sec^2\alpha}{2U^2}$	DM1	Simplify the trig. and use Pythagoras Dependent on the first 2 M marks
	$y = x\tan\alpha - \frac{gx^2(1+\tan^2\alpha)}{2U^2}$ given answer	A1	Obtain **given answer** from correct working
		(7)	
(b)	$(\rightarrow)\ v_H = U$	B1	Horizontal component in U, g, T
	$(\downarrow)\ v_V = gT$	B1	Vertical component in U, g, T. Accept $\pm$
	Use of Pythagoras	M1	
	$v = \sqrt{U^2 + g^2T^2}$	A1	Or equivalent. Allow t for T
		(4)	
(b) alt	$-h = d\tan 0 - \frac{gd^2}{2U^2}(1+\tan^2 0)$	B1	$\left(h = \frac{gd^2}{2U^2}\right)$
	$d = UT\ \left(\Rightarrow h = \frac{gT^2}{2}\right)$	B1	
	$\frac{1}{2}mv^2 - \frac{1}{2}mU^2 = mgh$	M1	Energy equation
	$v^2 = U^2 + 2gh = U^2 + g^2T^2$, $v = \sqrt{U^2 + g^2T^2}$	A1	
		(4)	
(c)	$d = UT$	B1	Horizontal distance
	$-h = d\tan\alpha - \frac{gd^2(1+\tan^2\alpha)}{2U^2}$	M1	Substitute for x and y in given equation. Condone sign error
	$h = \frac{1}{2}gT^2$	B1	Vertical distance
	$-\frac{1}{2}gT^2 = d\tan\alpha - \frac{g(UT)^2(1+\tan^2\alpha)}{2U^2}$	M1	Substitute to eliminate U from the equation
	$0 = d\tan\alpha - \frac{gT^2}{2}\tan^2\alpha$	A1	Correct equation in T and d
	$d = \frac{1}{2}gT^2\tan\alpha$ **given answer**	A1	Obtain given answer from correct working
		(6)	
		[17]	

Question Number	Scheme	Marks	Notes
8(a)	Vertical motion : Use of $v = u + at$	M1	Correct equation in U, t
	$(\uparrow)$: $-U = U - gt$	A1	
	Horizontal motion: Use of $s = ut$	M1	Second equation in U and their t e.g. $\frac{U^2}{2g} = U \times \frac{20}{U} - \frac{g}{2}\left(\frac{20}{U}\right)^2$
	$(\rightarrow)$: $3Ut = 120$	A1ft	Follow their t provided it matches the value of s used.
	$\Rightarrow U = 14$	A1	***Answer Given*** Need to see supporting evidence e.g. correct linear equation or solution of quadratic in U^2 giving $U^2 = 20g$
		(5)	
(b)	$v = \sqrt{U^2 + (3U)^2}$	M1	Correct use of Pythagoras' theorem and $U = 14$
	$v = 14\sqrt{10} = 44$ or 44.3 m s^{-1}	A1	Max 3 s.f.
		(2)	
(c)	$\tan\alpha = \frac{1}{4} \Rightarrow \frac{V}{3U} = \frac{1}{4}$	M1	Use angle to find vertical component
	$\Rightarrow V = \frac{3}{4}U$	A1	$\left(10.5\ \left(\text{m s}^{-1}\right)\right)$
	Use of $v = u + at$ $(\uparrow)$: $\pm\frac{3}{4}U = U - gt$	M1	Condone without $\pm$ Accept complete alternative routes via suvat.
		A1	Correct unsimplified (including $\pm$)
	$t_1 = \frac{U}{4g} = 0.36\text{s}$, $t_2 = \frac{7U}{4g} = 2.5\text{s}$	A1	One value correct Accept $\frac{7}{2g}$ and $\frac{49}{2g}$, but not $\frac{5}{14}$ decimals to max 3 s.f.
		A1	Both values correct Apply accuracy penalty only once
		(6)	
		13	

NB a candidate who misreads horizontal and vertical components gets $t = 4.64\left(\frac{13u}{4g}\right)$ and $t = 3.93\left(\frac{11u}{4g}\right)$.

They can score 11/13. Deduct the first 2 A marks for the misread penalty.

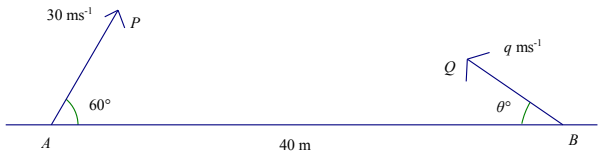
Question Number	Scheme	Marks
	First A1 for TWO correct equations (allow 4.12 or better) Second M1, independent, for solving a 'correct sine formula' for θ or ϕ **OR** independent for solving two equations, with correct structure, for α Second A1 for $\theta =$ AWRT 29^o or $\phi =$ AWRT 121^o **OR** $\alpha =$ AWRT 59^o	
	Third A1 for Bearing is 149^o (nearest degree)	
	N.B. First M1A1 Could use cos rule to find an angle	
	N.B. If the resolving method is used and there are no (i) or (ii) labels, only award M1A1 in both cases when an answer is reached.	
5a	$0 = 14.7^2 - 2 \times 9.8h$	M1A1
	$h = 11.025$	A1
	max ht $= 13.5$ or 14 (m)	A1 (4)
5b	$-1.5 = 14.7t - 4.9t^2$	M1A1
	$4.9t^2 - 14.7t - 1.5 = 0$	
	$t = \dfrac{14.7 \pm \sqrt{14.7^2 + 6 \times 4.9}}{9.8}$	**DM**1
	$t = 3.1$ or 3.10 (s)	A1 (4)
5c	$v^2 = 14.7^2 + 2 \times (-9.8) \times (-2.5)$	M1 A1
	$v = 16.3$ or 16 (m s^{-1})	A1 (3)
		11
	Notes	
5a	**N.B.** If they use $g = 9.81$, lose first A mark (once for whole question) but all other A marks can be scored. First M1 for a complete method to find the height (Could involve two *suvat* equations) condone sign errors. First A1 for a correct equation (or equations) Second A1 for $h = 11$ (may be unsimplified) or better (For other methods, give this A1 for any correct (may be unsimplified) intermediate answer) Third A1 for 13.5 or 14 (m)	
5b	First M1 for a complete method to find the required time (they may find the time up (1.5 s) and then add on the time down. Condone sign errors First A1 for a correct equation or equations Second DM1, dependent, for solving to find required time Second A1 for 3.1 or 3.10 (s)	

Question Number	Scheme	Marks
5c	First M1 for a complete method to find the speed / velocity(Could involve two *suvat* equations) Condone sign errors but must have correct numbers in their equation(s) First A1 for a correct equation (or equations) Second A1 for 16 or 16.3 (m s^{-1}) Must be *positive (speed)*	
6a		B1 shape B1 270, V (2)
6b	$\frac{V}{0.6}=\frac{5V}{3}$ **Given answer**	M1A1 (2)
6c	Time decelerating is $5V$	B1
	$\frac{1}{2}V\frac{5V}{3}+(270-5V-\frac{5V}{3})V+\frac{1}{2}V.5V=1500$ **OR:** $\frac{1}{2}(270+270-5V-\frac{5V}{3})V=1500$	M1 A2
	$V^2-81V+450=0$ **Given answer**	**DM1**A1 (6)
6d	$V^2-81V+450=0$ $(V-6)(V-75)=0$ or $V=\frac{81\pm\sqrt{81^2-4\times450}}{2}$	M1 solving
	$V=6$ or 75	A1 A1
	$V=6$ since $(5\times75)>270$ or $V=75$ unrealistic	**B**1 (4)
		14
	Notes	
6a	First B1 for a trapezium with line starting at the origin Second B1 for 270 and V correctly marked	
6b	M1 for $(t=)\frac{V}{0.6}$; **N.B.** M1A0 for V=0.6t then answer Must see division or intermediate step from V=0.6t e.g. Changing 0.6 into 3/5. A1 for $t=\frac{5V}{3}$ **Given answer**	

3(a)	$5.5 = \frac{1}{2}a.2^2$	M1	Complete method using *suvat* equations to form an equation in *a* only
	$\Rightarrow a = 2.75$	A1	
		(2)	
(b)	$R = 30\sin\alpha + 2g\cos\alpha$	M1	Resolve perpendicular to the plane to find an expression for *R*. Must have all terms. Condone sign errors and sin/cos confusion.
		A2	-1 each error. All correct A1A1, one error A1A0, two or more errors A0A0 ($R = 33.68$)
	$-F + 30\cos\alpha - 2g\sin\alpha = 2\ a$	M1	Equation of motion parallel to the plane with *a* or their *a*. Must have all terms. Condone sign errors and sin/cos confusion.
		A2	-1 each error ($F = 6.74$)
	$\mu = \dfrac{30\cos\alpha - 2g\sin\alpha - 5.5}{30\sin\alpha + 2g\cos\alpha}$	DM1	Use $F = \mu R$ Dependent on the 2 previous M marks
	$= 0.200$ or 0.20	A1	Do not accept 0.2
		(8)	
		10	
4.		M1	Use $s = ut + \dfrac{1}{2}at^2$ or a complete *suvat* route to find h in terms of *t*
	$h = \frac{1}{2}gt^2$	A1	Or $h = \frac{1}{2}g(t+1)^2$. The expression for time used in the first equation defines the expression expected in the second equation.
	$h = 19.6(t-1) + \frac{1}{2}g(t-1)^2$	A1	Or $h = 19.6(t) + \frac{1}{2}g(t)^2$ or $h = 4.9 + \left(9.8t + \dfrac{1}{2}gt^2\right)$
	$\frac{1}{2}gt^2 = 19.6(t-1) + \frac{1}{2}g(t-1)^2$	M1	Equate the two expressions for *h*.
		DM1	Solve for *t*. Dependent on the previous M1.
	$t = 1.5$	A1	Using the "Or" approach gives $t = 0.5$
	$h = 11$ m or 11.0 m	A1	Accept 2 or 3 s.f. only
		7	

Question Number	Scheme	Marks	Notes
6. (a)	$0=(25\sin\alpha)^2-2gs$	M1	A complete method using *suvat* to find *s*
	$s=400\div19.6$ (20.4)	A1	Correct expression in *s* only
	Height above ground $=10+400\div19.6=30$ or 30.4 m	A1 (3)	30 or 30.4 only
(b)	$10=-25\times\frac{4}{5}t+\frac{1}{2}\times gt^2$	M1	A complete method using *suvat* to find the total time from *A* to *B*. Condone sign slips.
		A1	Correctly substituted equation in *t*
	$4.9t^2-20t-10=0$ $\quad t=\frac{20\pm\sqrt{400+4\times4.9\times10}}{2\times4.9}$	DM1	Dependent on the preceding M1. Solve for *t*
	$t=4.531...$ s	A1	
	Horiz distance $=25\cos\alpha t\,(=15t$ m$)$	M1	
	$=68$ m	A1 (6)	68 or 68.0 only
(c)	At *C* horiz speed $=15$ m s^{-1}		
	Vert speed $=\frac{15}{\tan\alpha}$	M1	Use similar triangles, or equivalent, to find vertical speed at C
	$=11.25$	A1	
	$11.25=-20+gt$	DM1	Use *suvat* to find time from *A* to *C*. Dependent on the preceding M1
	$t=\frac{20+11.25}{9.8}=3.2$ or 3.19	A1 (4)	3.2 or 3.19 only
		[13]	

Question Number	Scheme	Marks	Notes
6(a)	Considering energy: $\frac{1}{2}m\times14^2=\frac{1}{2}m\times10^2+mgh$ $h=\frac{48}{g}=4.90$	M1 A2 A1 (4)	All terms required. Terms need to be of the correct form but condone sign errors. -1 each error in the unsimplified equation Accept $\frac{48}{g}$. Maximum 3 s.f. if they go in to decimals.
alt(a)	Initial $v_y=14\sin\alpha$ Final $v_y=\sqrt{100-14^2\cos^2\alpha}$ $100-196\cos^2\alpha=196\sin^2\alpha-2gh$ $h=\frac{48}{g}=4.90$	M1A2 A1 (4)	Using $v^2=u^2+2as$ on the vertical components of speed. -1 each error in the unsimplified equation Accept in exact form. Maximum 3 s.f. if they go in to decimals.
NB	Using $v^2=u^2+2as$ with 10 and 14 is M0		
NB	In part (a) they must be solving the general case, not using 0.85. However, the marks in (b) are all available if they solve the specific case in (a).		
(b)	Vertical distance: $h=14\sin\alpha t-\frac{1}{2}\times9.8t^2$ $4.9t^2-11.9t+h=0$ $t=\frac{11.9\pm\sqrt{11.9^2-4\times4.9^2}}{9.8}$ $t=1.903.....$ Horizontal distance: $x=14\cos\alpha\times t$ =14.0 (m)	M1 A2 DM1 A1 M1 A1 A1 (8)	A complete method to find an equation in t. Must involve trig condone sin/cos confusion Correct in h or their h. -1 each error Solve a 3 term quadratic for t. Needs their value for h now. 1.9 or better Method for the horizontal distance. Condone consistent sin/cos confusion Correct for their positive t Accept 14

Q.	Scheme	Marks	Notes
6a			
	$30\cos 60\times 2+q\cos\theta\times 2=40$	M1	Equation for horizontal distance Need to be using the 40 m
		A1	Correct unsimplified
	$30\sin 60\times 2-4.9\times 4=q\sin\theta\times 2-4.9\times 4$ $30\sin 60=q\sin\theta$	M1	Equal vertical distance or initial vertical components of velocity
		A1	Correct unsimplified (no error seen)
	$q\cos\theta=\pm 5$ $q\sin\theta=15\sqrt{3}$		
	$\tan\theta=3\sqrt{3}$ $(\tan\theta=6\sin 60)$	DM1	Solve for q or θ Dependent on both preceding M marks
	$\theta=79.1$ (79)		(1.38 radians) or better
	$q=26.45...=26.5$	A1	(26 or better) $(10\sqrt{7})$ Both correct and no error seen
		(6)	
6b	Vertical component of speed =	M1	Must be working towards speed of P (or v^2) (condone if working on Q - they equal vertical components of velocity)
	$30\sin 60-2g\,(=6.38...)$	A1	Correct unsimplified. Accept ±
	speed $=\sqrt{(30\cos 60)^2+6.38^2}$	DM1	Use Pythagoras. Dependent on previous M Follow their vertical component.
		A1ft	Correct unsimplified equation in v or v^2.
	$=\sqrt{15^2+6.38^2}=16.3\,(\text{m s}^{-1})$	A1	or 16 2 or 3 sf only
		(5)	
6b alt	Vertical distance =	M1	Must be working towards speed of P
	$30\sin 60\times 2-4.9\times 4=32.36$	A1	Correct unsimplified
	Conservation of energy:	DM1	Dependent on previous M. Follow their vertical distance.
	$\frac{1}{2}mv^2+mg\times 32.36=\frac{1}{2}m\times 900$	A1ft	Correct unsimplified equation in v or v^2.
	$v=16.3$ (m s^{-1}) (16)	A1	
		(5)	
		[11]	

Question Number	Scheme	Marks	Notes
7. (a)	$(\rightarrow)\sqrt{27ag}\cos\theta.\, t = 9a$	M1	Horizontal motion. Condone trig confusion.
		A1	
	$(\uparrow)\sqrt{27ag}\sin\theta.\, t - \frac{1}{2}gt^2 = 6a$	M1	Vertical motion. Condone sign errors and trig confusion.
		A1	
	$(\uparrow)\sqrt{27ag}\sin\theta.\, \dfrac{9a}{\sqrt{27ag}\cos\theta} - \frac{1}{2}g\left(\dfrac{9a}{\sqrt{27ag}\cos\theta}\right)^2 = 6a$	DM1	Substitute for t (unsimplified). Dependent on both previous M marks
	$9a\tan\theta - \frac{1}{2}g.81a^2\dfrac{(1+\tan^2\theta)}{27ag} = 6a$	DM1	Express all trig terms in terms of tan. Dependent on preceding M.
	$\tan^2\theta - 6\tan\theta + 5 = 0$	A1 **(7)**	
(b)	$\tan^2\theta - 6\tan\theta + 5 = 0$		
	$(\tan\theta - 1)(\tan\theta - 5) = 0$	M1	Method to find one root of the quadratic
	$\tan\theta_2 = 1$ or $\tan\theta_1 = 5$	A1 A1 **(3)**	
(c)	$t = \dfrac{9a}{\sqrt{27ag}\cos\theta} = \dfrac{9a}{\sqrt{27ag}} \times \dfrac{\sqrt{26}}{1}$	M1 A1ft	Use $\tan\theta$ = their 5 to find t. Correct unsimplified. Correct $\cos\theta$ for their $\tan\theta$
	$= \sqrt{\dfrac{81a^2.26}{27a}} = \sqrt{\dfrac{78a}{g}}$ ***Answer given***	A1 **(3)**	Given answer →evidence of working is required

Question Number	Scheme	Marks	Notes
Question 7 continued...			
(d)	$\frac{1}{2}m(27ag - v^2) = mg6a$	M1 A1	Conservation of energy. Requires all 3 terms. Condone sign error Correct equation
	$v = \sqrt{15ag}$	A1 **(3)**	
Or (d)	$v^2 = \left(\sqrt{27ag}\cos\theta\right)^2 + \left(\sqrt{27ag}\sin\theta - g.\sqrt{\frac{78a}{g}}\right)^2$	M1	Horizontal and vertical components and Pythagoras. Condone trig confusion.
	$= \left(\frac{27ag}{26}\right) + \left(5\sqrt{\frac{27ag}{26}} - \sqrt{78ag}\right)^2 \left(= ag\left(\frac{27}{26} + \frac{363}{26}\right)\right)$	A1	Correctly substituted
	$v = \sqrt{15ag}$	A1 **(3)**	
		[16]	

Question Number	Scheme	Marks	
7 (a)	$0^2 = u_V{}^2 - 2 \times 9.8 \times 10$	M1	Complete method using *suvat* to form an equation in u_v.
		A1	Correct equation e.g. $0 = u^2 - 20g$
	$u_V = 14$ *	A1	*Answer given* requires equation and working, including 196, seen.
		(3)	
OR	conservation of energy:	M1	Initial KE = gain in GPE + final KE
	$\frac{1}{2}m\left(u_h{}^2 + u_v{}^2\right) = mg \times 10 + \frac{1}{2}mu_h{}^2 \,,\, \frac{1}{2}u_v{}^2 = 98$	A1	Correct equation
	$u_V = 14$ *	A1	*Answer given*
		(3)	
(b)		M1	Use the vertical distance travelled to find the total time taken.
	$(\uparrow),\ -52.5 = 14t - \frac{1}{2}gt^2$	A1	At most one error
		A1	Correct equation
	$49t^2 - 140t - 525 = 0$	DM1	Solve for t. Dependent on the preceding M mark
	$(t-5)(49t+105) = 0 \quad t = 5$	A1	only
	$(\rightarrow),\quad 50 = 5u_H$	M1	Use their time of flight to form an equation in u_H
	$u_H = 10$	A1	only
	$u = \sqrt{10^2 + 14^2}$	M1	Use of Pythagoras with two non-zero components, or solution of a pair of simultaneous equations in u and α.
	$= \sqrt{296}$; 17.2 m s^{-1}	A1	17.2 or 17 (method involves use of g = 9.8 so an exact surd answer is not acceptable)
		(9)	
			See next page for an alternative route to u, and (c).

OR			First 3 marks for the quadratic as above.
	$50 = u\cos\alpha t$ or $50 = u_H t$	M1	Used in their quadratic
	$49\left(\frac{50}{u_H}\right)^2 - 140\left(\frac{50}{u_H}\right) - 525 = 0$	A1	Correct quadratic in u_H
	$525(u_H)^2 + 140(u_H) - 122500 = 0$		
	Solve for u_H	DM1	Dependent on the M mark for setting up the initial quadratic equation in t.
	$u_H = 10$	A1	only
	etc.		Complete as above.
(c)	$\tan OBA = \frac{52.5}{50} = 1.05$	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. 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. For incorrect direction give A0 here.
	$t = 2.5$	A1	only
		(5)	
		17	