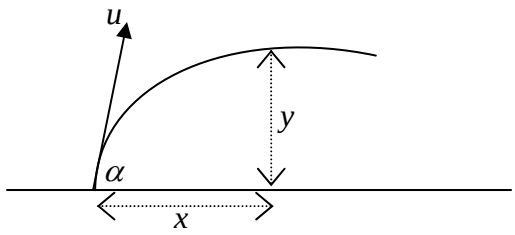
6. **(a)**	Using $s = ut + \frac{1}{2}at^2$ Method must be clear $\mathbf{r} = (3t)\mathbf{i} + (10 + 5t - 4.9t^2)\mathbf{j}$ Answer given	M1 A1 A1 (3)
(b)	**j** component $= 0$: $10 + 5t - 4.9t^2$ quadratic formula: $t = \frac{5 \pm \sqrt{25 + 196}}{9.8} = \frac{5 \pm \sqrt{221}}{9.8}$ $T = 2.03$(s),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

Question Number	Scheme	Marks
8. **(a)**		
	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
		(4)
(b)	$y = -7$: $-7 = \tan 45x - \frac{gx^2}{2\times 7^2\cos^2 45}$	M1 A1
	$-7 = x - \frac{9.8x^2}{7^2}$	
	$-7 = x - \frac{x^2}{5}$	M1
	$x^2 - 5x - 35 = 0$	
	$x = \frac{5 \pm \sqrt{25 + 4\times 35}}{2}$	M1
	$x = 8.92$ or 8.9	A1
		(5)
(c)	Time to travel 8.922 m horizontally $= \frac{8.922}{7\cos 45} = 1.802...$s	M1
	$v = \frac{8.922}{1.402}$	M1 A1 ft
	$= 6.36$ or 6.4 $\left(\text{m s}^{-1}\right)$	A1
		(4)
		13

Question Number	Scheme	Marks
7		
(a)	**i** → distance = $6t$	B1
	j ↑ distance = $12t - \frac{1}{2}gt^2$	M1 A1
	At B, $2\left(12t - \frac{1}{2}gt^2\right) = 6t$	M1 A1
	$(24-6)t = gt^2$	DM1
	$18 = gt$, $t = \frac{18}{g} (= 1.84\text{s})$	A1
		(7)
(b)	**i** → speed = 6	B1
	j ↑ velocity = $12 - gt = -6$	M1 A1
	$\therefore$ speed at A	
	$= \sqrt{6^2 + 6^2} = \sqrt{72} = 6\sqrt{2} (= 8.49) (\text{ms}^{-1})$	M1 A1
		(5)
(c)	↑ speed = $12 - gt = +6$	M1 A1 ft
	$t = \frac{6}{g} (= 0.61\text{s})$	A1
		(3)
		15

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)
	$v_V = 1.05$ 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	

Q.	Scheme	Marks	
6 (a)	$2 = -2u\sin\theta + \frac{1}{2}g \times 4$	M1	Vertical distance. Condone sign errors. Must have used $t = 2$, but could be using $u_y = u\sin\theta$
	$\left(-2 = u\sin\theta t - \frac{1}{2}gt^2\right)$ $u\sin\theta = g - 1$	A1	All correct
	$2u\cos\theta = 8 \quad (u\cos\theta = 4)$ $(u\cos\theta t = 8)$	B1	Horizontal distance. Accept $u_x = 4$ o.e.
	$\tan\theta = \frac{g-1}{4} = 2.2$ *	M1	Divide to obtain expression for $\tan\theta$
		A1	**Given answer** It is acceptable to quote and use the equation for the projectile path. Incorrect equation is 0/5.
(b)	$u\cos\theta = 4$	M1	Use the horizontal distance and θ to find u 9.67 or 9.7
	$u = \frac{4}{\cos\theta} = 9.66... = 9.7$ OR use components from (a) and Pythagoras.	A1	NB $\theta = 65.6°$ leading to 9.68 is an accuracy penalty.
(c)	$6 = (1-g)T + \frac{1}{2} \times 9.8T^2$	M1	Equation for vertical distance $= \pm 6$ to give a quadratic in T. Allow their u_y
	$4.9T^2 - 8.8T - 6 = 0$ $T = \frac{8.8 \pm \sqrt{\left[(-)8.8\right]^2 + 24 \times 4.9}}{9.8}$	DM1	Solve a 3 term quadratic
	$T = 2.323... = 2.32$ or 2.3	A1	2.3 or 2.32 only
(d)	$v^2 = 8.8^2 + 2g \times 6$ or v = -8.8+gT	M1	Use *suvat* to find vertical speed
		A1	Correct equation their u_y, T
	$v = 13.96...$ Horiz speed = 4 $\tan\alpha = \frac{v}{4}$	DM1	Correct trig. with their vertical speed to find the required angle.
		A1	Correct equation
	$\alpha = 74.01... = 74°$	A1	$74°$ or $74.0°$. Allow 106.
	Alternative: $\frac{1}{2}m(9.6664)^2 + 6mg = \frac{1}{2}mv^2$	M1	Conservation of energy to find speed
	$v = 14.52719...$	A1	
	$\cos\alpha = \frac{4}{14.5}$	DM1	Correct method for α
		A1	
	$\alpha = 74.01... = 74°$	A1	Allow 106

Question Number	Scheme	Marks	Notes
6a	Conservation of energy: $\frac{1}{2}mu^2 + mg \times 8 = \frac{1}{2}m\ \ 2u\ ^2$ $mu^2 + 16mg = 4mu^2$ $16mg = 3mu^2, \quad u = \sqrt{\frac{16g}{3}}$ $u = 7.2$	M1 A2 -1ee DM1 A1 [5]	Energy equation must contain the correct terms, but condone sign error. Correct unsimplified Solve for u Accept 7.23. Accept $\sqrt{\frac{16g}{3}}$
6b	Vertical distance: $-8 = u\sin\theta \times 2 - \frac{g}{2} \times 4$ $\sin\theta = \frac{2g-8}{2u} = 0.802...$ $\theta = 53.3°$	M1 A2 -1ee A1 [4]	Condone sign errors or trig error. u must be resolved. Correct equation for their u. or 53°
6c	Min speed at max height, i.e. $u\cos\theta$ $= 4.3$ (m s^{-1})	M1 A1 [2]	Condone consistent trig confusion with part (b) or 4.32 (ms^{-1})