Question	Scheme	Marks	AOs
5(a)	Using horizontal motion, $s = ut$, with 35 resolved	M1	3.3
	$x = 35\cos\alpha \times t$	A1	1.1b
	Using vertical motion, $s = ut + \frac{1}{2}at^2$, with 35 resolved	M1	3.4
	$y = 35\sin\alpha \times t - \frac{1}{2}gt^2$	A1	1.1b
	Eliminate t : $y = 35\sin\alpha \times \frac{x}{35\cos\alpha} - \frac{1}{2}g\left(\frac{x}{35\cos\alpha}\right)^2$	DM1	3.1b
	$y = \frac{3}{4}x - \frac{1}{160}x^2$ *	A1*	1.1b
	N.B. No marks available if they just quote the equation of the path.		
	ALTERNATIVE: they do (b) and/or (c) first <u>using a suvat method</u> Assume $y = ax^2 + bx + c$ Use any three of (0,0), (120,0) from part (b), (60,22.5) from part (c) or $\frac{dy}{dx} = \frac{3}{4}$ at $x = 0$ to find a, b, and c. **M1A1, M1A1, DM1A1*** for finding each of a, b and c and stating final answer in correct form. **N.B.** If they realise that $c = 0$, and just use $y = ax^2 + bx$, that could score M1A1. Enter marks on ePEN in the order in which a, b and c are found: e.g. $x = 0, y = 0 \Rightarrow c = 0$ M1A1 $x = 0$, $\frac{dy}{dx} = 2ax + b = \frac{3}{4} \Rightarrow b = \frac{3}{4}$ M1 A1 $x = 120, y = 0 \Rightarrow 0 = 120^2 a + 120 \times \frac{3}{4} \Rightarrow a = \frac{-1}{160}$ DM1 so, $y = \frac{3}{4}x - \frac{1}{160}x^2$ A1*		
		(6)	
5(b)	**ALT 1** $0 = \frac{3}{4}x - \frac{1}{160}x^2$ and solve for x **ALT 2** $\frac{dy}{dx} = \frac{3}{4} - \frac{x}{80} = 0 \Rightarrow x = 60$ **and** $OA = 2 \times 60$ **ALT 3**	M1	3.1b

	A complete *suvat* method to find *OA*: e.g. $0 = 35\sin\alpha \times t - \frac{1}{2}gt^2$ or $0 = 35\sin\alpha - g\frac{t}{2}$ or $-35\sin\alpha = 35\sin\alpha - gt$ to find t $\left(= \frac{70\sin\alpha}{g} = \frac{30}{7}\right)$ **AND** $(OA =) 35\cos\alpha \times t = 35\cos\alpha \times \frac{70\sin\alpha}{g}$ **N.B. OR** use the calculator to input the equation of the path which then gives y_{max} = 45/2 when x = 60 **with no working**, so $OA = 2 \times 60$		
	(OA =)120 (m)	A1	1.1b
		(2)	
5(c)	**ALT 1** $H = \frac{3}{4} \times 60 - \frac{1}{160} \times 60^2$ **ALT 2** $y = \frac{-1}{160}(x^2 - 120x) = 22.5 - \frac{1}{160}(x-60)^2$ so max y = 45/2 or 22.5 **ALT 3** $\frac{dy}{dx} = \frac{3}{4} - \frac{2x}{160} = 0 \Rightarrow x = 60$ then find y when x = 60 **ALT 4** A complete *suvat* method: e.g. $H = \frac{(35\sin\alpha)^2}{2g}$ **or** $0 = 35\sin\alpha - gt$ to find the time to top, $t = \frac{35\sin\alpha}{g}$, or use half their time they found in (b) **AND** $H = 35\sin\alpha \times \frac{35\sin\alpha}{g} - \frac{1}{2}g\left(\frac{35\sin\alpha}{g}\right)^2$ or $\left(\frac{35\sin\alpha + 0}{2}\right) \times \frac{35\sin\alpha}{g}$ **N.B. OR** use the calculator to input the equation of the path which then gives y_{max} = 45/2 (when x = 60) with no working.	M1	3.1b
	(H =) 22.5 Accept 23	A1	1.1b

		(2)	
5(d)	*H* is greater (or *K* is smaller), as air resistance would slow the particle down oe.	B1	3.5a
		(1)	
5(e)	e.g. the inaccuracy of using 9.8 m s^{-2} for *g*	B1	3.5b
		(1)	
			(12 marks)

Notes:

5a	M1	Correct terms but condone sin/cos confusion and sign errors Available if they use *s* instead of *x*
	A1	Correct equation in *x* and *t* **N.B.** they may have the wrong value for $\cos\alpha$
	M1	Correct terms but condone sin/cos confusion and sign errors Available if they use a different letter for *y* provided it's not the same as they've used for *x*. **N.B.** M0 if they subsequently use a value for *y* e.g. 0
	A1	Correct equation in *y* and *t* **N.B.** they may have the wrong value for $\sin\alpha$ They may have *t* in terms of *x*, from their first equation.
	DM 1	Dependent on the two previous M marks for eliminating *t* to give an equation in *y* and *x* only.
	A1*	Given answer correctly obtained, with at least one further line of working with trig ratios and *g* = 9.8 explicitly seen or 4.9 oe used for 0.5g.. Allow $y = \frac{3x}{4} - \frac{x^2}{160}$ and with *y* on the RHS
5b	M1	**ALT 1:** Use of *y* = 0 in equation of path and solve for *x*. **ALT 2** : Use calculus to find the *x*-coordinate of the max point and double it **ALT 3** : Any other complete *suvat* method to find *OA*, condone sin/cos confusion and sign errors
	A1	cao
5c	M1	**ALT 1:** Use of $x = \left(\frac{1}{2} \times \text{their } OA\right)$ in equation of path **ALT 2:** Complete the square for the equation of the path **and** deduce maximum value of *y*: Need to see $p - q(x-r)^2$ with *p* as the answer **ALT 3:** Use $\frac{dy}{dx} = 0$ to find the *x*-coordinate of the max point and then use the path equation to find the *y*-coordinate **ALT 4:** Any complete *suvat* method to find *H*, condone sin/cos confusion and sign errors

	A1	A0 for $\frac{45}{2}$
5d	B1	Possible justifications for *H* greater (or *K* smaller): air resistance will provide an extra force acting against the stone or opposing the motion air resistance would take away energy from the stone work would be done against air resistance air resistance will mean the acceleration will be less (or deceleration greater) air resistance would reduce the velocity/speed Allow 'it' for air resistance B0 if no justification given. B0 for air resistance would reduce the **initial** velocity of the stone B0 for air resistance will limit the vertical height (not a reason) or oppose the vertical force. Ignore extras.
5e	B1	Any single correct answer. **Acceptable** answer: the inaccuracy of using 9.8 m s^{-2} for *g* **or** wind or weather effects **or** the spin of the stone **or** the size (or shape or surface area) of the stone oe **or** the stone is still modelled as a particle **N.B.** Allow if the stone is referred to as e.g. a ball B0 if any incorrect extras **Unacceptable** answers: The model (it) does not take account of: the mass or weight of the stone air resistance. The ground may not be horizontal. B0 for consequences of air resistance being included e.g. the path won't be a parabola the path won't be symmetrical