Follow through between parts of Question 1 should be allowed for the value of *a* found in part (i) into parts (ii) and (iii).						
1	**(i)**		$v^2 - u^2 = 2as$ $31^2 - 12^2 = 2 \times 215 \times a$ $a = 1.9$ so $1.9\ \text{m s}^{-2}$	**M1** **A1** **[2]**	Selection and use of appropriate equation(s)	
	(ii)		$v = u + at$ $31 = 12 + 1.9t$ $t = 10$ so 10 s	**M1** **A1** **[2]**	Selection and use of appropriate equation(s) FT from their value of *a* from part (i).	

	(iii)		$s = ut + \frac{1}{2}at^2$ $\frac{215}{2} = 12t + \frac{1}{2} \times 1.9 \times t^2$ $\left(t = \frac{-12 \pm \sqrt{12^2 + 4 \times 0.95 \times 107.5}}{1.9} \right)$ $t = 6.055$ (or -18.69)	**M1** **M1** **A1** **[3]**	Selection and use of $s = ut + \frac{1}{2}at^2$, oe. Correct elements but condone minor arithmetic errors. Use of quadratic formula (may be implied by answer), oe. FT their *a* only.	
			Alternative: Finding a 2-stage method $v^2 - u^2 = 2as$ and $s = \frac{(u+v)}{2}t$ $v = \pm\sqrt{12^2 + 2 \times 1.9 \times 107.5} = (\pm)23.505...$ $s = \frac{(u+v)}{2}t \Rightarrow t = \frac{2 \times 107.5}{(12 + 23.505...)}$ $\left(\text{or } t = \frac{2 \times 107.5}{(12 - 23.505...)} \right)$ $t = 6.055$ (or 18.69)	 **M1** **M1** **A1**	 Selection and use of a complete valid 2-stage method Using the output from the first stage to find *t* FT their *a* only.	

	(iv)		Because it is accelerating, it travels less fast in the first half of the distance and so takes more time.	**B1** **[1]**	The answer must refer to the two parts of the distance (or "the same distance") so no credit is given to answers like "Because it is accelerating" and "Because its speed is not uniform". Most successful answers will refer to the times to cover AM and MB but this may be implicit. So B1 should be given for an answer like "It is travelling faster between M and B than it is between A and M" Notice that the fact that the acceleration is uniform is irrelevant.	

2	**(i)**		Initial speed is 25 m s^{-1}	B1 **[1]**	

2	**(ii)**		Vertical motion: $y = 20t - 4.9t^2$	M1	Forming an equation or expression for vertical motion
			When $y = 0$,	M1	Finding t when the height is 0
			$T = (0 \text{ or }) \dfrac{20}{4.9} = 4.08 \text{ s}$	A1	
			$R = 15 \times 4.08... = 61.22$	F1	Allow $15\times$ their T Note If horizontal and vertical components of the initial velocity are interchanged treat it as a misread; if no other errors are present this gives 3 marks.
				[4]	
			Alternative Using time to maximum height		
			Vertical motion: $v = 20 - 9.8t$	M1	Forming an equation or expression for vertical motion
			Flight time = 2 × Time to top	M1	Using flight time is twice time to maximum height or equivalent for range.
			$T = 2 \times \dfrac{20}{9.8} = 4.08 \text{ s}$	A1	
			$R = 15 \times 4.08... = 61.22$	F1	Allow $15\times$ their T
			Alternative Using formulae		
			Finding angle of projection $\alpha = \arctan\left(\dfrac{20}{15}\right) = 53.1°$	M1	Only award this mark if there is a clear intention to use this method
			$R = \dfrac{2u^2 \sin\alpha\cos\alpha}{g} = \dfrac{2 \times 25^2 \times \sin 53.1° \times \cos 53.1°}{9.8}$	M1	Allow the alternative form $R = \dfrac{u^2 \sin 2\alpha}{g}$ with substitution
			$R = 61.2$	A1	
			$T = \dfrac{2u\sin\alpha}{g} = 4.08$	A1	

Question			er	Marks	Guidance
2	**(iii)**	(*A*)	Flight time $= \frac{15}{4.9}$ Range $= 20 \times \frac{15}{4.9} = 61.22$	 B1 **[1]**	 Allow FT from part (ii) for a correct argument that they should be the same
2	**(iii)**	(*B*)	No eg angle of projection 45^o	M1 A1 **[2]**	Attempt at disproof or counter-example. There must be some reference to the angle. Complete argument

Question			Answer	Marks	Guidance
3	(i)		$v = \int (6t - 12)\,\mathrm{d}t$	M1	Attempt to integrate
			$v = 3t^2 - 12t + c$	A1	Condone no c if implied by subsequent working (eg adding 9 to the expression)
			$c = 9$	A1	
			$t = 3 \Rightarrow v = 3 \times 3^2 - 12 \times 3 + 9 = 0$	E1	Or by showing that $(t - 3)$ is a factor of $3t^2 - 12t + 9$
				[4]	
	(ii)		$s = \int (3t^2 - 12t + 9)\,\mathrm{d}t$	M1	Attempt to integrate Ft from part (i)
			$s = t^3 - 6t^2 + 9t - 2$	A1	A correct value of c is required. Ft from part (i).
			When $t = 2$, $s = 0$. (It is at the origin.)	B1	Cao
				[3]	

Question			Answer	Marks	Guidance
4	(i)		At C: $s = ut + \frac{1}{2}at^2$ $500 = 5 \times 20 + 0.5 \times a \times 20^2$ $a = 2$ (ms^{-2})	 M1 A1 **[2]**	 M1 for a method which if correctly applied would give a. Cao **Special case** If 800 is used for s instead of 500, giving $a = 3.5$, treat this as a misread. Annotate it as SC SC and give M1 A0 in this part
4	(ii)		At B: $v^2 - u^2 = 2as$ $v^2 - 5^2 = 2 \times 2 \times 300$ $v = 35$ Speed is 35 m s^{-1} At B: $v = u + at$ $35 = 5 + 2 \times t$ $t = 15$ Time is 15 s	M1 A1 A1 **[3]**	M1 for a method which if correctly applied would give either v or t Apply FT from incorrect a from part (i) for the M mark only Cao. No FT from part (i) except for SC1 for 46.2 following $a = 3.5$ after the use of $s = 800$. Cao. No FT from part (i) except for SC1 for 11.7 following $a = 3.5$ after the use of $s = 800$.

		mark	comment
5	**either** for u first: $8 = \frac{1}{2}(u + 2.25) \times 32$ $u = -1.75$ so 1.75m s^{-1} $2.25 = -1.75 + 32a$ $a = 0.125$ so 0.125 m s^{-2} Directions of u and a are defined	 M1 A1 M1 F1 F1 5	 Using $s = \frac{1}{2}(u + v)t$ Use of any appropriate *suvat* with **their** values and correct signs Sign must be consistent with their u, FT from their value of u Establish directions of both u and a in terms of A and B. May be shown by a diagram, eg showing A and B and a line between them together with an arrow to show the positive direction. Without a diagram, the wording must be absolutely clear: eg do not accept left/right, forwards/backwards without a diagram or more explanation. Dependent on both M marks.
	Or for a first: $8 = 2.25 \times 32 - \frac{1}{2} \times a \times 32^2$ $a = 0.125$ so 0.125 m s^{-2} $2.25 = u + 32 \times 0.125$ $u = -1.75$ so 1.75m s^{-1} Directions of u and a are defined	 M1 A1 M1 F1 F1 5	 Using $s = vt - \frac{1}{2}at^2$ Use of any appropriate *suvat* with **their** values and correct signs Sign must be consistent with their a, FT from their value of a Establish directions of both u and a in terms of A and B. May be shown by a diagram, eg showing A and B and a line between them together with an arrow to show the positive direction. Without a diagram, the wording must be absolutely clear: eg do not accept left/right, forwards/backwards without a diagram or more explanation. Dependent on both M marks.
	Or *using simultaneous equations* Set up one relevant equation with a and u. Set up second relevant equation with a and u. Solving to find $u = -1.75$ so 1.75m s^{-1} Solving to find $a = 0.125$ so 0.125 m s^{-2} Directions of u and a are defined	 M1 M1 A1 F1 F1 5	 Using **one** of $v = u + at$, $s = ut + \frac{1}{2}at^2$ and $v^2 = u^2 + 2as$ Using **another** of $v = u + at$, $s = ut + \frac{1}{2}at^2$ and $v^2 = u^2 + 2as$ FT from their value of u or a, whichever found first Establish directions of both u and a in terms of A and B. May be shown by a diagram, eg showing A and B and a line between them together with an arrow to show the positive direction. Without a diagram, the wording must be absolutely clear: eg do not accept left/right, forwards/backwards without a diagram or more explanation. Dependent on both M marks.
		5	

		mark	comment	sub
6(i)	The distance travelled by P is $0.5\times0.5\times t^2$ The distance travelled by Q is 10*t*	 B1 B1	 Accept 10*t* + 125 if used correctly below.	 2
(ii)	Meet when $0.25t^2 = 125+10t$ so $t^2 - 40t - 500 = 0$ Solving *t* = 50 (or -10) Distance is $0.25\times50^2 = 625$ m	M1 F1 A1 A1	All **their** wrong expressions for P and Q distances Allow ± 125 or 125 omitted Award for **their** expressions as long as one is quadratic and one linear. Must have 125 with correct sign. Accept any method that yields (smaller) + ve root of their 3 term quadratic cao Allow –ve root not mentioned cao [SC2 400 m seen]	 5
		7		