1		Mark	Comment	
(i)	Hor $21t = 60$ so $\frac{20}{7}$ s (2.8571…) **either** $0 = u - 9.8 \times \frac{20}{7}$ **or** $-u = u - 9.8 \times \left(\frac{40}{7}\right)$ **or** $40 = u \times \frac{20}{7} - 4.9\left(\frac{20}{7}\right)^2$ so u = 28 so 28 m s^{-1}	M1 A1 M1 E1	Use of horizontal components and a = 0 or $s = vt - 0.5at^2$ with v = 0. Any form acceptable. Allow M1 A1 for answer seen WW. [If $s = ut + 0.5at^2$ and u = 0 used without justification award M1 A0] [If u = 28 *assumed* to find time then award SC1] Use of $v = u + at$ (or $v^2 = u^2 + 2as$) with v = 0. **or** Use of $v = u + at$ with $v = -u$ and appropriate t. **or** Use of $s = ut + 0.5at^2$ with s = 40 and appropriate t Condone sign errors and, where appropriate, $u \leftrightarrow v$. Accept signs not clear but not errors. Enough working must be given for 28 to be properly shown. [NB u = 28 may be found first and used to find time]	4
(ii)	$y = 28t - 0.5 \times 9.8t^2$	E1	*Clear & convincing* use of g = – 9.8 in $s = ut + 0.5at^2$ or $s = vt - 0.5at^2$ **NB: AG**	1
(iii)	Start from same height with same (zero) vertical speed at same time, same acceleration Distance apart is $0.75 \times 21t = 15.75t$	E1 M1 A1	For two of these reasons 0.75×21t seen **or** 21t and 5.25t both seen with intention to subtract. Need simplification - LHS alone insufficient. CWO.	3
(iv) (A)	**either** Time is $\frac{20}{7}$ s by symmetry so $15.75 \times \frac{20}{7} = 45$ so 45 m **or** Hit ground at same time. By symmetry one travels 60 m so the other travels 15 m in this time ($\frac{1}{4}$ speed) so 45 m.	B1 B1 B1 B1	Symmetr or *uvast* FT their (iii) with $t = \frac{20}{7}$ [SC1 if 90 m seen]	2
(B)	see next page			

1	continued			
(B)	**either** Time to fall is $40-10=0.5\times9.8\times t^2$ t = 2.47435… need $15.75\times2.47435..=38.971..$ so 39.0 (3sf) **or** Need time so $10=28t-4.9t^2$ $4.9t^2-28t+10=0$ so $t=\frac{28\pm\sqrt{28^2-4\times4\,9\times10}}{9\,8}$ so 0.382784… or 5.33150… Time required is 5.33150… $-\frac{20}{7}$ = 2.47435.. need $15.75\times2.47435..=38.971..$ so 39.0 (3sf)	 M1 A1 A1 A1 F1 M1 M1* A1 M1 F1	[SC1 if **either** and **or** methods mixed to give $\pm30=28t-4.9t^2$ or $\pm10=4.9t^2$] Considering time from explosion with u = 0. Condone sign errors. LHS. Allow ±30 All correct cao FT **their** (iii) only. Equating $28t-4.9t^2=\pm10$ Dep. Attempt to solve quadratic by a method that could give two roots. Larger root correct to at least 2 s. f. Both method marks may be implied from two correct roots alone (to at least 1 s. f.). [SC1 for either root seen WW] FT **their** (iii) only.	5
(v)	Horiz $(x=)\ 21t$ Elim t between $x=21t$ and $y=28t-4.9t^2$ so $y=28\left(\frac{x}{21}\right)-4.9\left(\frac{x}{21}\right)^2$ so $y=\frac{4x}{3}-\frac{0\,1x^2}{9}=\frac{1}{90}\left(120x-x^2\right)$	B1 M1 A1 E1	 Intention must be clear, with some attempt made. t completely and correctly eliminated from their expression for x and correct y. Only accept wrong notation if subsequently explicitly given correct value e.g $\frac{x^2}{21}$ *seen* as $\frac{x^2}{441}$. Some simplification must be shown. [SC2 for 3 points shown to be on the curve. Award more only if it is made clear that (a) trajectory is a parabola (b) 3 points define a parabola]	4
		19		

2		mark		sub
(i)	Using $s = ut + 0.5at^2$ with u = 10 and a = -10	E1	Must be clear evidence of derivation of – 5. Accept one calculation and no statement about the other.	1
(ii)	**either** s = 0 gives $10t - 5t^2 = 0$ so $5t(2-t) = 0$ so t = 0 or 2. Clearly need t = 2 **or** Time to highest point is given by 0 = 10 – 10t Time of flight is 2×1 = 2 s horizontal range is 40 m as 40 < 70, hits the ground	 B1 M1 A1 M1 M1 A1 B1 E1	 Factorising Award 3 marks for t = 2 seen WWW Dep on 1st M1. Doubling **their** t. Properly obtained FT $20 \times$ **their** t Must be clear. FT **their** range.	5
(iii)	need $10t - 5t^2 = -15$ Solving $t^2 - 2t - 3 = 0$ so $(t-3)(t+1) = 0$ and t = 3 range is 60 m	 M1 M1 A1 M1 A1	[May divide flight into two parts] Equate s = -15 or equivalent. Allow use of ± 15. Method leading to solution of a quadratic. Equivalent form will do. Obtaining t = 3. Allow no reference to the other root. [Award SC3 if t = 3 seen WWW] Range is $20 \times$ **their** t (provided t > 0) cao. CWO.	5
(iv)	Using (ii) & (iii), since 40 + 60 > 70, paths cross (For $0 < t \leq 2$) both have same vertical motion so B is always 15 m above A	E1 E1	Must be convincing. Accept sketches. Do not accept evaluation at one or more points alone. That B is *always* above A must be clear.	2
(v)	Need x components summing to 70 $20 \times 0.75 + 20 \times 2.75 = 15 + 55 = 70$ so true Need y components the same $10 \times 2.75 - 5 \times 2.75^2 + 15 = 4.6875$ $10 \times 0.75 - 5 \times 0.75^2 = 4.6875$	M1 E1 M1 B1 E1	May be implied. Or correct derivation of 0.75 s or 2.75 s Attempt to use 0.75 and 2.75 in two vertical height equations (accept same one or wrong one) 0.75 and 2.75 each substituted in the appropriate equn Both values correct. [Using cartesian equation: B1, B1 each equation: M1 solving: A1 correct point of intersection: E1 Verify times]	5
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