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Q 2		mark		sub
	$(v =)12 - 3t^{2}$ $v = 0 \Rightarrow 12 - 3t^{2} = 0$ so $t^{2} = 4$ and $t = \pm 2$ $x = \pm 16$	M1 A1 M1 A1	Differentiating Allow confusion of notation, including $x =$ Dep on 1 st M1. Equating to zero. Accept one answer only but no extra answers. FT only if quadratic or higher degree. cao. Must have both and no extra answers.	
				5

Q 3		mark		sub
(i)	R = mg so 49 N	B1	Equating to weight. Accept 5 <i>g</i> (but not <i>mg</i>)	1
(ii)	R 40° 7 10 N F 49 N	B1	All except F correct (arrows and labels) (Accept mg, W etc and no angle). Accept cpts instead of 10N. No extra forces. F clearly marked and labelled	2
(iii)	$\uparrow R + 10\cos 40 - 49 = 0$	M1 B1	Resolve vertically. All forces present and 10N resolved Resolution correct and seen in an equation. (Accept $R = \pm 10\cos 40$ as an equation)	
	R = 41.339 so 41.3 N (3 s. f.) F = 10sin 40 = 6.4278 so 6.43 N (3 s. f.)	A1 B1	Allow –ve if consistent with the diagram.	4
				7

Q 4		mark		sub
(i)	20 16 60 20	D4		
	$4 20 + 16\cos 60 = 28$	B1		1
<i>(</i> ,,)				
(ii)	either → 16 sin 60	B1	Any form. May be seen in (i). Accept any	
			appropriate equivalent resolution.	
		M1	Use of Pythag with 2 distinct cpts (but not 16 and	
			± 20)	
	Mag $\sqrt{28^2 + 192} = 31.2409$ so 31.2 N (3 s.f.)	F1	Allow 34.788 only as FT	
	or	' '	·	
	Cos rule $mag^2 = 16^2 + 20^2 - 2 \times 16 \times 20 \times \cos 120$	M1	Must be used with 20 N, 16 N and 60° or 120°	
		A1 A1	Correct substitution	
				3
(iii)	Magnitude of accn is 15.620 m s ⁻²	B1	Award only for their F÷2	
	Magnitude of accn is 15.620 m s ⁻² so 15.6 m s ⁻² (3 s. f.)		·	
	angle with 20 N force is $\arctan\left(\frac{16\sin 60}{28}\right)$	M1	Or equiv. May use force or acceleration. Allow use	
	(20)		of sine or cosine rules. FT only $s \leftrightarrow c$ and sign	
	so 26.3295 so 26.3° (3 s. f.)	A1	errors. Accept reciprocal of the fraction.	
	50 20.3293 50 20.3 (3 5. 1.)	AI	cao	3
				•
				7
Q 5		mark		
Q 5 (i)			N2L. All forces attempted in one equation.	7
		mark M1	Allow	7
		M1	Allow sign errors. No extra forces. Don't condone $F = mga$.	7
	sphere $19.6 - T = 2a$ block $T - 14.8 = 4a$	M1	Allow sign errors. No extra forces. Don't condone $F =$	7
(i)	sphere $19.6 - T = 2a$ block $T - 14.8 = 4a$	M1	Allow sign errors. No extra forces. Don't condone $F = mga$.	7
	block $T-14.8=4a$	M1 A1 A1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6	7 sub
(i)	·	M1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6 Attempt to solve. Award only if two equations present both containing a and T . Either variable	7 sub
(i)	block $T-14.8=4a$	M1 A1 A1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6	7 sub
(i)	block $T-14.8 = 4a$ Solving	M1 A1 A1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6 Attempt to solve. Award only if two equations present both containing a and T . Either variable eliminated. Either found cao Other value. Allow wrong equation(s) and wrong	7 sub
(i)	block $T-14.8 = 4a$ Solving	M1 A1 A1 A1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6 Attempt to solve. Award only if two equations present both containing a and T . Either variable eliminated. Either found cao	7 sub
(i)	block $T-14.8 = 4a$ Solving	M1 A1 A1 A1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6 Attempt to solve. Award only if two equations present both containing a and T . Either variable eliminated. Either found cao Other value. Allow wrong equation(s) and wrong working for 1 st value [If combined equation used award: M1 as in (i) for	7 sub
(i)	block $T-14.8 = 4a$ Solving	M1 A1 A1 A1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6 Attempt to solve. Award only if two equations present both containing a and T . Either variable eliminated. Either found cao Other value. Allow wrong equation(s) and wrong working for 1 st value [If combined equation used award: M1 as in (i) for the equation with mass of 6 kg; A1 for $a = 0.8$; M1 as	7 sub
(i)	block $T-14.8 = 4a$ Solving	M1 A1 A1 A1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6 Attempt to solve. Award only if two equations present both containing a and T . Either variable eliminated. Either found cao Other value. Allow wrong equation(s) and wrong working for 1 st value [If combined equation used award: M1 as in (i) for the equation with mass of 6 kg; A1 for $a = 0.8$; M1 as in (i) for equation in T and a for either sphere or	7 sub
(i)	block $T-14.8 = 4a$ Solving	M1 A1 A1 A1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6 Attempt to solve. Award only if two equations present both containing a and T . Either variable eliminated. Either found cao Other value. Allow wrong equation(s) and wrong working for 1 st value [If combined equation used award: M1 as in (i) for the equation with mass of 6 kg; A1 for $a = 0.8$; M1 as	7 sub
(i)	block $T-14.8 = 4a$ Solving	M1 A1 A1 A1	Allow sign errors. No extra forces. Don't condone $F = mga$. Accept $2g$ for 19.6 Attempt to solve. Award only if two equations present both containing a and T . Either variable eliminated. Either found cao Other value. Allow wrong equation(s) and wrong working for 1^{st} value [If combined equation used award: M1 as in (i) for the equation with mass of 6 kg ; A1 for $a = 0.8$; M1 as in (i) for equation in T and a for either sphere or block; A1 equation correct; F1 for T , FT their a ;	7 sub

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Q 6		mark		sub
(i)	$t = 2.5 \Rightarrow \mathbf{v} = \begin{pmatrix} -5\\10 \end{pmatrix} + 2.5 \begin{pmatrix} 6\\-8 \end{pmatrix} = \begin{pmatrix} 10\\-10 \end{pmatrix}$ 45°	B1 E1	Need not be in vector form	
	speed is $\sqrt{10^2 + 10^2} = 14.14$ so 14.1 m s ⁻¹ (3 s. f.)	F1	FT their v	3
(ii)	$\mathbf{s} = 2.5 \begin{pmatrix} -5 \\ 10 \end{pmatrix} + \frac{1}{2} \times 2.5^{2} \times \begin{pmatrix} 6 \\ -8 \end{pmatrix}$ $= \begin{pmatrix} 6.25 \\ 0 \end{pmatrix}$ $\mathbf{so } 090^{\circ}$	M1 A1 A1 A1	Consideration of s (const accn or integration) Correct sub into <i>uvast</i> with u and a . (If integration used it must be correct but allow no arb constant) cao. CWO.	4
				7

Q 7		mark		sub
(i)				
	acceleration is $\frac{24}{12}$ so 2 m s ⁻²	B1		
	12	-		
(ii)				1
(11)	24 15 12		Use of N2L. Both forces present. Must be $F =$	
	24 - 15 = 12a	M1	ma. No	
	$a = 0.75 \text{ m s}^{-2}$	A1	extra forces.	
	1^{st} distance is $0.5 \times 2 \times 16 = 16$	M1	Appropriate <i>uvast</i> applied at least once.	
	2^{nd} distance is $0.5 \times 0.75 \times 16 = 6$	A1	Need not evaluate. Both found. May be implied.	
	Difference is 10 m	A1	FT (i) cao	
	Difference is 10 fff		Cao	5
(iii)				
	$12g\sin 5 - 15 = 12a$	M1	Use of $F = ma$, allow 15 N missing or weight not	
			resolved. No extra forces. Allow use of 12 sin 5. Attempt at weight cpt. Allow sin ↔ cos. Accept	
		M1	seen	
			on diagram. Accept the use of 12 instead of 12g.	
		A1	Weight cpt correct. Accept seen on diagram. Allow not	
			used.	
	a = -0.39587			
	so -0.396 m s ⁻² (3 s. f.)	A1	Correct direction must be made clear	4
(iv)				7
,	time $0 = 1.5 + at \Rightarrow t = 3.789$	M1	Correct uvast. Use of 0, 1.5 and their a from (iii)	
		'''	or their s from (iv). Allow sign errors. Condone	
			$u \leftrightarrow v$.	
	so 3.79 s (3 s. f.)	A1		
	distance		Correct <i>uvast</i> . Use of 0, 1.5 and their <i>a</i> from (iii)	
	$s = 0.5 \times (1.5 + 0) \times 3.789$ (or)	M1	or	
			their t from (iv). Allow sign errors. Condone	
	giving s = 2.8418 so 2.84 m (3 s. f.)	A1	$u \leftrightarrow v$.	
	yiviiiy 5 = 2.0410 50 2.04 III (3 5. 1.)	^	The first A1 awarded for t or s has FT their a if	
			signs	
			correct; the second awarded is cao]	4
(v)				4
(*)	accn is given by	N 1 4	Lies of 0. 1.5 and 2.5 in correct	
	$0 = 1.5 + 3.5a \Rightarrow a = -\frac{3}{7} = -0.42857$	M1	Use of 0, 1.5 and 3.5 in correct <i>uvast</i> .	
		Λ 4	Condone $u \leftrightarrow v$.	
	10 5 . 10 . 0 40057	A1	Allow ± N2L. Must use their <i>new</i> accn. Allow only sign	
	$12g\sin 5 - R = 12 \times -0.42857$	M1	errors.	
	so <i>R</i> = 15.39 so 15.4 N (3 s. f.)	A1	cao	
		<u> </u>		18
				10

B1 equations (accept same one or wrong one) $0.75 \text{ and } 2.75 \text{ each substituted in the appropriate}$ equations (accept same one or wrong one) $0.75 \text{ and } 2.75 \text{ each substituted in the appropriate}$ equations (accept same one or wrong one)	Q 8		mark		sub
either $s=0$ gives $10r-5r^2=0$ 81 81 so $5r(2-t)=0$ 81 81 so $5r(2-t)=0$ 81 81 82 so $5r(2-t)=0$ 81 81 82 so $5r(2-t)=0$ 82 so $t=0$ or	(i)		E1	Accept	1
Red $10t - 5t^2 = -15$ M1 Equate $s = -15$ or equivalent. Allow use of ± 15 . Solving $t^2 - 2t - 3 = 0$ M1 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 × their t (provided $t > 0$) cao. CWO. W1 Cao. CWO. Coo. CWO. E1 Coo. CWO. Coo. CWO. M1 Coo. CWO. M2 Coo. CWO. M2 Coo. CWO. M3 Coo. CWO. M4 Coo. CWO. M5 Coo. CWO. M6 Coo. CWO. M7 Coo. CWO. M6 Coo. CWO. M7 Coo. CWO. M7 Coo. CWO. M8 Coo. CWO. M9 Coo. CWO. M		$s = 0$ 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	M1 A1 M1 M1 A1 B1	Award 3 marks for $t = 2$ seen WWW Dep on 1 st M1. Doubling their t . Properly obtained FT 20 × their t	5
Using (ii) & (iii), since $40 + 60 > 70$, paths cross (For $0 < t \le 2$) both have same vertical motion so B is always 15 m above A E1 Do not accept evaluation at one or more points alone. That B is <i>always</i> above A must be clear. (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 Need y components the same $10 \times 2.75 - 5 \times 2.75^2 + 15 = 4.6875$ Must be convincing. Accept sketches. May be implied. Or correct derivation of 0.75 s or 0.75 and 0.75 in two vertical height equations (accept same one or wrong one) 0.75 and 0.75 each substituted in the appropriate equal	(iii)	Solving $t^2 - 2t - 3 = 0$ so $(t-3)(t+1) = 0$ and $t = 3$	M1 A1 M1	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 $t > 0$)	5
Need x components summing to 70 $20 \times 0.75 + 20 \times 2.75 = 15 + 55 = 70$ so true M1 May be implied. Or correct derivation of 0.75 s or 2.75 s Need y components the same $10 \times 2.75 - 5 \times 2.75^2 + 15 = 4.6875$ M1 Attempt to use 0.75 and 2.75 in two vertical height equations (accept same one or wrong one) $0.75 \text{ and } 2.75 \text{ each substituted in the appropriate}$ equa	(iv)	cross (For $0 < t \le 2$) both have same vertical		Do not accept evaluation at one or more points alone.	2
[Using cartesian equation: B1, B1 each equation: M1 solving: A1 correct point of intersection: E1 Verify times]	(v)	$20 \times 0.75 + 20 \times 2.75 = 15 + 55 = 70$ so true Need y components the same	E1 M1	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	5