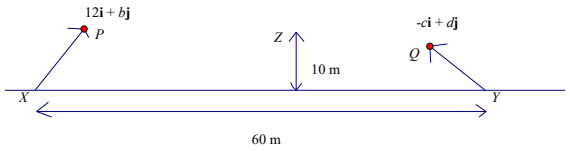
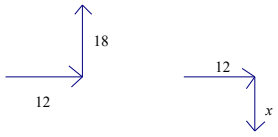
8a			
	P and Q collide $\Rightarrow$ at same vertical height $\Rightarrow bt - \frac{1}{2}gt^2 = dt - \frac{1}{2}gt^2$ $\Rightarrow bt = dt,\ b = d$	B1	Obtain **given result** correctly No incorrect statements seen
		(1)	
8b	$10 = 3d - \frac{9}{2}g$	M1	Complete method using *suvat* to form an equation in d e.g.use of $s = ut + \frac{1}{2}at^2$ with correct values substituted but condone sign error
	$\Rightarrow d = 18\ \ (18.0)$	A1	Follows use of 9.8. Not $\frac{541}{30}$ Must be a scalar
		(2)	
8c	$t = 3$, vertical speed $v = d - 3g\ (= -11.4)$	M1	Condone sign errors
	$-11.4 = 11.4 - gt$	M1	Using symmetry with their 11.4
	$t = 2.3\ \ (2.32)$(s)	A1	Not $\frac{341}{147}$
		(3)	
8calt1	Vertical distance $10 = dt - \frac{g}{2}t^2$	M1	Condone sign errors
	Solve for t and subtract $\left(3,\ \frac{200}{3\times 98}\right)$	M1	
	$t = 2.3\ \ (2.32)$(s)	A1	
		(3)	
8calt2	Time to top: $0 = d - gt,\ \ (t = 1.84)$	M1	Condone sign errors
	Solve for required time: $T = 2(3 - 1.84)$	M1	
	$= 2.3$ (s)	A1	
		(3)	
8d	Horizontal distance: $60 = 12\times 3 + 3c$	M1	Allow if seen earlier and used here
	$(\ c = 8)$	A1	Correct unsimplified **equation** for horizontal distance. Allow $c = -8$ if used correctly later
	$\mathbf{v} = -8\mathbf{i} - 11.4\mathbf{j}$	M1	For their 8 and 11.4
	Direction $\tan^{-1}\frac{11.4}{8}$	DM1	Use of trig to find a relevant angle Dependent on the previous M1

	Downwards at $54.9°$ to the horizontal $(55°)$ $(35.1°$ to the vertical)	A1	Or equivalent. Direction must be stated or clearly implied by a diagram. 0.959 rads (0.96 rads) Max 3 sf
		(5)	
8dalt	Horizontal distance: $60 = 12\times 3 + 3c$	M1	Allow if seen earlier and used here
	$(c = 8)$	A1	Correct unsimplified **equation** for horizontal distance. Allow $c = -8$ if used correctly later
	$\mathbf{v} = -8\mathbf{i} + 18.0\mathbf{j}$ and conservation of energy $\frac{1}{2}mv^2 - \frac{1}{2}m\left(8^2 + 18^2\right) = -mg\times 10$ $(v = 13.9)$	M1	For their 8 and 18.0
	Direction $\cos^{-1}\frac{8}{13.9}$	DM1	Use of trig to find a relevant angle Dependent on the previous M1
	Downwards at $54.9°$ to the horizontal $(55°)$ $(35.1°$ to the vertical)	A1	Or equivalent. Direction must be stated or clearly implied by a diagram. 0.959 rads (0.96 rads) Max 3 sf
		(5)	
8e			
	$\frac{-x}{12}\times\frac{18}{12} = -1$, $\left(\frac{-x}{12}\times\frac{d}{12} = -1\right)$	M1	Complete method (with their d) using velocity to find x Could be in scalar product format
	$x = 8$	A1	7.99 or better Allow +/-
	$-8 = 18 - 9.8T$, $(-x = d - 9.8T)$	DM1	Form equation in T. Signs correct Dependent on the previous M1
	$T = 2.7$ (2.65)	A1	Follows use of 9.8
		(4)	
8e alt	$\tan\alpha = \frac{d}{12}$, $\beta = 90 - \alpha$	M1	Complete method (with their d) to find the direction of motion
	$= 33.64°$	A1	
	$-\tan\beta = \frac{d - 9.8T}{12}$	DM1	Form equation in T. Signs correct. Dependent on the previous M1
	$T = 2.7$ (2.65)	A1	CSO – need to be convinced by any changes of sign. Follows use of 9.8
		(4)	
		[15]	

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