

Question	Scheme		Marks	AOs
1(a)	Differentiate v w.r.t. t		M1	3.1a
	$a = \frac{dv}{dt} = 10 - 2t$ isw		A1	1.1b
			(2)	
1(b)	Solve problem using $v = 0$ when $t = 6$		M1	3.1a
	$0 = 10t - t^2 - 24$		A1	1.1b
	Solve quadratic oe to find other value of t		M1	1.1b
	$t = 4$		A1	1.1b
			(4)	
1(c)	Integrate v or $-v$ w.r.t. t		M1	3.1a
	$5t^2 - \frac{1}{3}t^3 - 24t$		A1	1.1b
	Total distance = $-\left[5t^2 - \frac{1}{3}t^3 - 24t\right]_0^4 + \left[5t^2 - \frac{1}{3}t^3 - 24t\right]_4^6$		M1	2.1
	$\frac{116}{3}$ (m)		A1	1.1b
			(4)	
(10 marks)				
Notes:				
1a	M1	Differentiate, with both powers decreasing by 1		
	A1	Correct expression		
1b	M1	Put $t = 6$ OR use $(t-6)(t-x) = t^2 - 10t + k$ oe		
	A1	Correct expression (unsimplified) for v OR $v = (t-6)(t-4)$		
	M1	Put $v = 0$ to give quadratic in t and solve for other value of t		
	A1	$t = 4$		
1c	M1	Integrate, with at least two powers increasing by 1 (allow if only two terms integrated)		
	A1	Correct expression		
	M1	Complete method to find the total distance		
	A1	Accept 39(m) or better		

Question	Scheme		Marks	AOs
2(a)	Differentiate s wrt t		M1	3.1a
	$(v \Rightarrow) t^2 - 5t + 6$		A1	1.1b
	Equate their v to 0 and solve		M1	1.1b
	$t = 2$ or 3		A1	1.1b
	$(a \Rightarrow) 2t - 5$		B1ft	2.1
	$a = 1$ and -1 (m s^{-2}) isw (A0 if extras)		A1	1.1b
			(6)	
(b)	Attempt to find values of s for $t = 2, 3$ and 4 oe Correct values are $\left(s_2 = \frac{14}{3}, s_3 = \frac{9}{2} \text{ and } s_4 = \frac{16}{3} \right)$ Could be implied by correct values for: $s_2, (s_3 - s_2)$ and $(s_4 - s_3)$ which are $\frac{14}{3}, \left(-\frac{1}{6}\right)$ and $\frac{5}{6}$		DM1	1.1b
	Total distance travelled $= s_2 + (s_2 - s_3) + s_4 - s_3$ OR $s_2 - (s_3 - s_2) + s_4 - s_3$ OR $\left[\frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t \right]_0^2 - \left[\frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t \right]_2^3 + \left[\frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t \right]_3^4$ OR $\frac{14}{3} - \left(-\frac{1}{6}\right) + \frac{5}{6}$ OR $s_2 + 2(s_2 - s_3) + s_4 - s_2$ $(= 2s_2 - 2s_3 + s_4)$ oe		M1	2.1
	$5\frac{2}{3}$ oe (m) Accept 5.7 or better		A1	1.1b
				(3)
(9 marks)				
Notes:				
2a	M1	Differentiate, with at least 2 powers decreasing by 1		
	A1	Correct expression		
	M1	Must have attempted to differentiate s to find v and be solving a 3 term quadratic		
	A1	Both values needed		
	B1ft	Follow their v (must be differentiating)		

	A1	cao
2b	DM 1	This mark is dependent on the 2 nd M1 in part (a) and their t values are between 0 and 4. Clear attempt to find all three s values (may integrate their v incorrectly) N.B. No penalty for extra values.
	M1	Complete method using their s values Do NOT condone sign errors.
	A1	Any equivalent fraction, 5.7 or better.
		S.C. Correct answer, with no working, scores all 3 marks, since $\int_0^4 t^2 - 5t + 6 dt$ entered on a calculator will give $\frac{17}{3}$

Question	Scheme		Marks	AOs
3(a)	$15 - 3^2 - 2 \times 3 = 0^*$		B1*	1.1b
			(1)	
3(b)	Differentiate v wrt t		M1	2.1
	$-2t - 2$		A1	1.1b
	$8 \text{ (m s}^{-2}\text{)}$		A1	1.1b
			(3)	
3(c)	Integrate v w.r.t. t		M1	1.1b
	$15t - \frac{1}{3}t^3 - t^2$		A1	1.1b
	Total distance = $\left[15t - \frac{1}{3}t^3 - t^2 \right]_0^3 - \left[15t - \frac{1}{3}t^3 - t^2 \right]_3^4$ OR $s_3 + (s_3 - s_4)$ where s_3 means the value of their integral when $t = 3$. N.B. Allow the negative of this.		M1	3.1a
	$\frac{94}{3} \text{ (m)}$		A1	1.1b
			(4)	
(8 marks)				
Notes:				
3a	B1*	Correct expression, correctly evaluated to give 0 OR $0 = 15 - t^2 - 2t$ $t = 3$		
3b	M1	Differentiate v , with at least two powers decreasing by 1		
	A1	Correct expression		
	A1	cao (must be positive)		
		N.B. If they give 8 as their answer, without any working, this can score all 3 marks.		
3c	M1	Integrate v , with at least two powers increasing by 1 (allow if only two terms integrated) .		
	A1	Correct expression. Ignore (+ C)		
	M1	Complete method to find the total distance or displacement		
	A1	Accept 31(m) or better, must be positive		
		N.B. If the indefinite integral $(15t - \frac{1}{3}t^3 - t^2)$ is never seen, they score nothing, even if the correct answer appears, as this indicates they have used a calculator to do the whole question.		

Question	Scheme		Marks	AOs
	Allow column vectors throughout this question			
4(a)	Differentiate \mathbf{v} wrt t		M1	3.1a
	$\frac{3}{2}t^{-\frac{1}{2}}\mathbf{i} - 2\mathbf{j}$ isw		A1	1.1b
			(2)	
4(b)	$3t^{\frac{1}{2}} = 2t$		M1	2.1
	Solve for t		DM1	1.1b
	$t = \frac{9}{4}$		A1	1.1b
			(3)	
4(c)	Integrate \mathbf{v} wrt t		M1	3.1a
	$\mathbf{r} = 2t^{\frac{3}{2}}\mathbf{i} - t^2\mathbf{j} (+\mathbf{C})$		A1	1.1b
	$t = 1, \mathbf{r} = -\mathbf{j} \Rightarrow \mathbf{C} = -2\mathbf{i}$ so $\mathbf{r} = 2t^{\frac{3}{2}}\mathbf{i} - t^2\mathbf{j} - 2\mathbf{i}$		A1	2.2a
			(3)	
4(d)	$\sqrt{(3t^{\frac{1}{2}})^2 + (2t)^2} = 10$ or $(3t^{\frac{1}{2}})^2 + (2t)^2 = 10^2$		M1	2.1
	$9t + 4t^2 = 100$		M(A)1	1.1b
	$t = 4$		A1	1.1b
	$\mathbf{r} = 14\mathbf{i} - 16\mathbf{j}$		M1	1.1b
	$\sqrt{14^2 + (-16)^2}$		M1	3.1a
	$\sqrt{452} (2\sqrt{113})$ (m)		A1	1.1b
			(6)	
(14 marks)				
Notes:				
4a	M1	Both powers decreasing by 1 (M0 if vector(s) disappear but allow recovery)		
	A1	cao		
4b	M1	Complete method, using \mathbf{v} , to obtain an equation in t only, allow a sign error		
	DM1	Dependent on M1, solve for t		

	A1	cao
4c	M1	Both powers increasing by 1 (M0 if vectors disappear but allow recovery)
	A1	Correct expression without C
	A1	cao
4d	M1	Use of Pythagoras on v and 10 to set up equation in t
	M(A)1	Correct 3 term quadratic in t
	A1	cao
	M1	Substitute their numerical t value into their r
	M1	Use of Pythagoras to find the magnitude of their r
	A1	cs0

Question	Scheme		Marks	AOs
5(a)	Put $t = 2$ in \mathbf{v} and use Pythagoras: $\sqrt{12^2 + (-6\sqrt{2})^2}$		M1	3.1a
	$\sqrt{216}, 6\sqrt{6}$ or 15 or better (m s ⁻¹)		A1	1.1b
			(2)	
5(b)	Differentiate \mathbf{v} wrt t to obtain \mathbf{a}		M1	3.4
	$6t\mathbf{i} - 3t^{-\frac{1}{2}}\mathbf{j}$ oe (m s ⁻²) isw		A1	1.1b
			(2)	
5(c)	Integrate \mathbf{v} wrt t to obtain \mathbf{r}		M1	3.4
	$\mathbf{r} = t^3\mathbf{i} - 4t^{\frac{3}{2}}\mathbf{j} (+\mathbf{C})$		A1	1.1b
	$(\mathbf{i} - 4\mathbf{j}) = 4^3\mathbf{i} - 4 \times 4^{\frac{3}{2}}\mathbf{j} + \mathbf{C}$		M1	3.1a
	$(-62\mathbf{i} + 24\mathbf{j})$ (m) isw e.g. if they go on to find the distance.		A1	1.1b
			(4)	
(8 marks)				
Notes: Accept column vectors throughout apart from the answer to (b).				
5a	M1	Need square root but -ve sign not required. Allow \mathbf{i} 's and/or \mathbf{j} 's to go missing from their \mathbf{v} at $t = 2$, provided they have applied Pythagoras correctly.		
	A1	cao N.B. Correct answer with no working can score 2 marks.		
5b	M1	Both powers decreasing by 1. Allow a column vector. M0 if \mathbf{i} or \mathbf{j} is missing but allow recovery in (b).		
	A1	cao. Do not accept a column vector.		
5c	M1	Both powers increasing by 1 M0 if \mathbf{i} or \mathbf{j} is missing but allow recovery.		
	A1	$(\mathbf{r} =)$ not required		
	M1	Putting $\mathbf{r} = (\mathbf{i} - 4\mathbf{j})$ and $t = 4$ into their displacement vector expression which must have \mathbf{C} (allow C) to give an equation in \mathbf{C} only, seen or implied. Must have attempted to integrate \mathbf{v} for this mark to be available. N.B. \mathbf{C} does not need to be found and <u>this is a method mark, so allow slips.</u>		
	A1	cao		

Question	Scheme		Marks	AOs
6(a)	7i – 3j seen or implied by Pythagoras		B1	1.1b
	Use Pythagoras: $\sqrt{7^2 + (-3)^2}$		M1	3.1a
	$\sqrt{58}$, 7.6 or better (m s ⁻¹)		A1	1.1b
			(3)	
6(b)	$t^2 - 3t + 7 = 2t^2 - 3$ OR $\frac{t^2 - 3t + 7}{2t^2 - 3} = \frac{1}{1} = 1$		M1	2.1
	t = 2 only		A1	1.1b
			(2)	
6(c)	Differentiate v wrt <i>t</i> to give a vector.		M1	3.1a
	$(2t - 3)\mathbf{i} + 4t\mathbf{j}$		A1	1.1b
			(2)	
6(d)	2t – 3 = 0		M1	3.1a
	t = 1.5		A1	1.1b
			(2)	
(9 marks)				
Notes: Allow column vectors throughout.				
6a	B1	cao		
	M1	Use of Pythagoras, including the square root, on a velocity vector at <i>t</i> = 0		
	A1	cao. Must come from a <u>correct</u> v .		
6b	M1	Equating i and j components of v or a ratio of 1:1 to obtain a quadratic in <i>t</i> only. If they use a constant, e.g. $t^2 - 3t + 7 = k$ and $2t^2 - 3 = k$, <i>k</i> must be eliminated to earn this mark. N.B. M0 (since wrong working seen) if they write down $\mathbf{i} + \mathbf{j} = (t^2 - 3t + 7)\mathbf{i} + (2t^2 - 3)\mathbf{j}$ OR $\begin{pmatrix} 1 \\ 1 \end{pmatrix} = \begin{pmatrix} t^2 - 3t + 7 \\ 2t^2 - 3 \end{pmatrix}$ OR $t^2 - 3t + 7 = 1$ and $2t^2 - 3 = 1$		

		and then $t^2 - 3t + 7 = 2t^2 - 3$
	A1	$t = 2$
		N.B. Allow M1A1 for a correct trial and error method where they obtain $\mathbf{v} = 5\mathbf{i} + 5\mathbf{j}$ when $t = 2$ but M0 if they don't get $t = 2$
6c	M1	At least one power decreasing by 1 in each component in their \mathbf{v} (M0 if clearly dividing by t) Both i and j needed in their answer or a column vector Allow recovery if the i and j disappear and then reappear.
	A1	cao (must be a vector) isw e.g. if they find the magnitude or put $t = 0$ or differentiate again i's and j's do not need to be collected. N.B. Allow M1A0 for $2t - 3\mathbf{i} + 4t\mathbf{j}$
6d	M1	$2t - 3 = 0$ or (their derivative of the i -component of \mathbf{v}) = 0 N.B. M0 if they equate the derivative of both components of \mathbf{v} to zero.
	A1	cao N.B. Correct answer, with no working, can score both marks.