Question	Scheme	Marks	AOs
1(a)	Differentiate v w.r.t. t	M1	3.1a
	$a=\frac{\mathrm{d}v}{\mathrm{d}t}=10-2t$ 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
	$(v=)\ t^2-5t+6$	A1	1.1b
	Equate their *v* to 0 and solve	M1	1.1b
	$t=2$ or 3	A1	1.1b
	$(a=)\ 2t-5$	B1**ft**	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 $\left(s_2=\frac{14}{3}, s_3=\frac{9}{2}\ \textit{and}\ s_4=\frac{16}{3}\right)$ Could be implied by correct values for: s_2 , (s_3-s_2) and (s_4-s_3) which are $\frac{14}{3}$, $(-\frac{1}{6})$ and $\frac{5}{6}$	**DM**1	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** $\frac{14}{3}\quad-\quad(-\frac{1}{6})\quad+\quad\frac{5}{6}$ **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
	B1**ft**	Follow their *v* (must be differentiating)

	A1	cao
2b	**DM** 1	This mark is dependent on the 2nd 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 $\int_0^4 \left\|t^2 - 5t + 6\right\| \, dt$ entered on a calculator will give $\frac{17}{3}$

Question	Scheme	Marks	AOs
3(a)	$15-3^2-2\times3=0$ *	B1*	1.1b
		(1)	
3(b)	Differentiate *v* wrt *t*	M1	2.1
	$-2t-2$	A1	1.1b
	8 ($\mathrm{m\,s^{-2}}$)	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
	$\frac{94}{3}$ (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 **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 **v** wrt t	M1	3.1a
	$\mathbf{r}=2t^{\frac{3}{2}}\mathbf{i}-t^2\mathbf{j}(+\mathbf{C})$	A1	1.1b
	$t = 1$, $\mathbf{r} = -\mathbf{j}$ => $\mathbf{C} = -2\mathbf{i}$ 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 **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	cso

Question	Scheme	Marks	AOs
5(a)	Put $t = 2$ in **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 **v** wrt t to obtain **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 **v** wrt t to obtain **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 **i**'s and/or **j**'s to go missing from their **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 **i** or **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 **i** or **j** is missing but allow recovery.
	A1	(**r** =) not required
	M1	Putting **r** = $(\mathbf{i} - 4\mathbf{j})$ and $t = 4$ into their displacement **vector** expression which must have **C** (allow *C*) to give an equation in **C** only, seen or implied. Must have attempted to integrate **v** for this mark to be available. **N.B**. **C** does not need to be found and this is a method mark, so allow slips.
	A1	cao

Question	Scheme	Marks	AOs
6(a)	7**i** – 3**j** seen or implied by Pythagoras	B1	1.1b
	Use Pythagoras: $\sqrt{7^2+(-3)^2}$	M1	3.1a
	$\sqrt{58}$, 7.6 or better ($\mathrm{m\,s^{-1}}$)	A1	1.1b
		(3)	
6(b)	$t^2-3t+7=2t^2-3$ **OR** $\dfrac{t^2-3t+7}{2t^2-3}=\dfrac{1}{1}$ = 1	M1	2.1
	t = 2 only	A1	1.1b
		(2)	
6(c)	Differentiate **v** wrt t 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 t = 0
	A1	cao. Must come from a correct **v**.
6b	M1	Equating **i** and **j** components of **v** or a ratio of 1:1 to obtain a quadratic in t only. If they use a constant, e.g. $t^2-3t+7=k$ and $2t^2-3=k$, k must be eliminated to earn this mark. **N.B.** M0 (since wrong working seen) if they write down $\mathbf{i}+\mathbf{j}=\left(t^2-3t+7\right)\mathbf{i}+\left(2t^2-3\right)\mathbf{j}$ **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 **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 **v)** = 0 **N.B**. M0 if they equate the derivative of both components of **v** to zero.
	A1	cao **N.B.** Correct answer, with no working, can score both marks.