| Question number | Scheme | Marks |
|---|---|---|
| **10.** **(a)** | $a = \frac{\mathrm{d}v}{\mathrm{d}t} = 3t^2 - 8t + 5$ | M1A1 (2) |
| **(b)** | $3t^2 - 8t + 5 = 0 \Rightarrow (3t-5)(t-1) = 0 \Rightarrow t = \frac{5}{3}, 1$ | M1A1 (2) |
| **(c)** | $s = \int t^3 - 4t^2 + 5t + 1 = \frac{t^4}{4} - \frac{4t^3}{3} + \frac{5t^2}{2} + t + c$ | M1A1 |
| | When $t = 0, s = 3 \Rightarrow c = 3$ | B1 |
| | $s = \frac{t^4}{4} - \frac{4t^3}{3} + \frac{5t^2}{2} + t + 3$ | dM1 |
| | So $s = 8\frac{1}{3}$ m | A1 (5) |
| | **ALT** | |
| | $s = 3 + \int_0^2 t^3 - 4t^2 + 5t + 1 \, \mathrm{d}x = 3 + \left[\frac{t^4}{4} - \frac{4t^3}{3} + \frac{5t^2}{2} + t\right]_0^2 = 8\frac{1}{3}$ m | {M1A1B1 |
| | For correct substitution and evaluation | dM1A1} {(5)} **(9)** |

| Notes | | |
|---|---|---|
| (a) | M1 | For an attempt to differentiate the given $v$. See general guidance for the definition of an attempt |
| | A1 | For the correct $a = 3t^2 - 8t + 5$ |
| (b) | M1 | Sets their $a = 0$ **and** attempts to solve their 3TQ. They must achieve 2 values only for $t$ for the award of this mark. |
| | A1 | For $t = \frac{5}{3}, 1$ |
| **Please check the whole method in part (c) before you begin to award marks.** | | |
| (c) | M1 | Attempts to integrate the given $v$. See general guidance for the definition of an attempt. Award this mark if the constant of integration is not seen. |
| | A1 | For the correct integrated expression for $s$, which **must** include $+c$. |
| | B1 | For $c = 3$ (Or any other letter given for the constant of integration) |
| | dM1 | For substituting the value of $t = 2$ into an **integrated** expression |
| | A1 | For $s = 8\frac{1}{3}$ |
| **ALT 1** | | |
| (c) | M1 | Attempts to integrate the given $v$. See general guidance for the definition of an attempt. The limits of integration not required for this mark |
| | A1 | For the correct integrated expression |
| | B1 | For +3 |
| | dM1 | For substituting their limits of integration. |
| | A1 | For $s = 8\frac{1}{3}$ Note: if their limits were the wrong way around they will achieve $s = -8\frac{1}{3}$. Even if they give the final answer as $s = 8\frac{1}{3}$ this is A0. |
| **ALT 2 Only apply this scheme when see they have added the additional displacement of 3m at $t = 0$** | | |
| | M1 | Attempts to integrate the given $v$. See general guidance for the definition of an attempt. The limits of integration not required for this mark |
| | A1 | For the correct integrated expression $+c$ not required |
| | dM1 | For substituting the value of $t = 2$ into an **integrated** expression |
| | A1 | For achieving $s = \frac{16}{3}$ |
| | B1 | For adding 3 to their $s$ to achieve $s = \frac{25}{3}$ oe |

| Question number | Scheme | Marks |
|---|---|---|
| **11.** **(a)** | Mark parts (i) and (ii) together<br>$f'(x) = p + 2qx = 0 \Rightarrow p + 2q(3) = 0 \Rightarrow p + 6q = 0$ | M1 |
| | $9 = p(3) + q(3)^2 \Rightarrow 9 = 3p + 9q \Rightarrow (3 = p + 3q)$ | M1A1 |
| | Solves simultaneous equations by substitution or elimination | |
| | (i) $[6p + q = 0] - [3 = p + 3q] = 3q = -3 \Rightarrow q = -1 \Rightarrow p = 6$ | M1A1 |
| | $q = -1$ | B1 |
| | (ii) $f''(x) = -2 \Rightarrow$ negative constant so point is a maximum | B1<br>(7) |
| **(b)** | $-x + 10 = 6x - x^2 \Rightarrow 0 = x^2 - 7x + 10 \Rightarrow (x-2)(x-5) = 0 \Rightarrow x = 2, 5$ | M1M1A1<br>(3) |
| **(c)** | Volume $= \pi \int_2^5 \left(-x^2 + 6x\right)^2 \mathrm{d}x - \pi \int_2^5 \left(-x + 10\right)^2 \mathrm{d}x$ | M1 |
| | Volume $= \pi \int_2^5 \left\{\left(x^4 - 12x^3 + 36x^2\right) - \left(x^2 - 20x + 100\right)\right\} \mathrm{d}x$ | |
| | $= \pi \left[\frac{x^5}{5} - 3x^4 + \frac{35}{3}x^3 + 10x^2 - 100x\right]_2^5$<br>(or integrate without simplification) | M1A1 |
| | $= \pi \left[625 - 3\times 625 + \frac{35\times 125}{3} + 250 - 500\right] - \left[\frac{32}{5} - 48 + \frac{35\times 8}{3} + 40 - 200\right]$ | M1 |
| | $V = \frac{333\pi}{5}$ | A1<br>(5)<br>**(15)** |

| Notes | | |
|---|---|---|
| (a) | M1 | Attempts to differentiate the given equation for curve $C$, equates to 0, **and** substitutes in $x = 3$ to form an equation in $p$ and $q$. |
| | M1 | Substitutes (3,9) into the given equation to form an equation in $p$ and $q$. |
| | A1 | For both correct equations; $p+6q=0$ and $3=p+3q$ or any equivalent to either equation. |
| | M1 | Attempts to solve the simultaneous equations by any method. |
| | A1 | For $p = 6$. This is a show so check that the method is correct. |
| | B1 | For $q=-1$ |
| | B1 | Finds the second derivate, substitutes the value of $q$ and finds $f''(x)=-2$ **with a conclusion** hence maximum. E.g. Minimally acceptable $-2$ hence maximum |
| | | **OR**<br>Completes the square to show that the maximum value of $y$ is 9 when $x = 3$<br>$y=-x^2+6=-\left(x^2-6\right)=-\left[\left(x-3\right)^2-9\right]=-\left(x-3\right)^2+9$<br>**with a conclusion** that the maximum value of $y=9$ occurs when $x = 3$ |
| (b) | M1 | Sets the equation of $l$ = equation of $c$ with their values of $p$ and $q$ and forms a 3TQ. |
| | M1 | Attempts to solve their 3TQ by any method, but must achieve **two** values of $x$. |
| | A1 | For $x=2,5$ |
| **Marks in part (c) are dependent on their method being dimensionally correct and complete** | | |
| (c) | **Method 1 (Combined integration)** | |
| | M1 | For a statement using the correct formula for the volume of rotation $V=\pi\int y^2\ \mathrm{d}x$, using the equation for $C$ with their value of $q$, minus the equation for line $l$ rearranged to make $y$ the subject. Ignore missing d$x$ and ignore limits for this mark. $\pi$ must be present and the equations must be squared. |
| | M1 | For integrating their statement for $V$. Their limits of integration found in (b) must be shown, the correct way around for the award of this mark.<br>The highest power of $x$ must be a term in $x^4$. Ignore missing $\pi$ for this mark. |
| | A1 | For the correct integrated expression for $V$, complete with limits. It need not be simplified for this mark and ignore missing $\pi$ for this mark. |
| | ddM1 | For substituting in both of their values from (b) and subtracting them. |
| | A1 | For the correct volume in terms of $\pi$ only of $V=\dfrac{333\pi}{5}$ or $66.6\pi$ oe.<br>isw erroneous attempts to simplify after $66.6\pi$ oe seen |

| | | |
|---|---|---|
| | **Method 2 (Integration of curve and volume of truncated cone)** | |
| | M1 | For a statement using the correct formula for the volume of rotation $V=\pi\int y^2\ \mathrm{d}x$, using the equation for *C* with their value of *q*. $\pi$ must be present and the equations must be squared. Evidence of an attempt to find the volume of a truncated cone must be seen for this mark. |
| | M1 | For integrating their statement for *V*. Their limits of integration found in (b) must be shown, the correct way around for the award of this mark, and substituted into their integrated expression. The highest power of *x* must be a term in $x^4$. Ignore missing $\pi$ for this mark. |
| | A1 | For the correct volume for *C* $\left(V=195.6\ (\pi)\right)$ |
| | ddM1 | For a correct method to find the volume of a truncated cone using their values of *x* from (b) to find *y* and substitute into the volume of a truncated cone. When $x=5, y=5$ and $x=2, y=8$ $V=\frac{1}{3}\times\pi\times'8'^2\times'8'-\frac{1}{3}\times\pi\times'5'^2\times'5'$ $(=129\pi)$ |
| | A1 | For the correct volume in terms of $\pi$ only of $V=\frac{333\pi}{5}$ or $66.6\pi$ oe. isw erroneous attempts to simplify after $66.6\pi$ oe seen |
| | **Method 3 (Integration of curve and line separately)** | |
| | M1 | For a statement using the correct formula for the volume of rotation $V=\pi\int y^2\ \mathrm{d}x$, using the equation for *C* with their value of *q*. Ignore missing d*x* and ignore limits for this mark. $\pi$ must be present and the equation must be squared. **AND** For a statement using the correct formula for the volume of rotation $V=\pi\int y^2\ \mathrm{d}x$, using the equation for *l* with their values of *p* and *q*. Ignore missing d*x* and ignore limits for this mark. $\pi$ must be present and the equation must be squared. |
| | M1 | For integrating their statements for *V*. Their limits of integration found in (b) must be shown, the correct way around for the award of this mark. The highest power of *x* in *C* must be a term in $x^4$, and $x^2$ in *l*. Ignore missing $\pi$ for this mark. |
| | A1 | For the correct integrated expressions for *C* and *l*, complete with limits. They need not be simplified for this mark and ignore missing $\pi$ for this mark. |
| | ddM1 | For substituting in their values from (b) and subtracting them. **AND** subtracting the volume of the truncated cone fromm the volume of the curve. |
| | A1 | For the correct volume in terms of $\pi$ only of $V=\frac{333\pi}{5}$ or $66.6\pi$ oe. isw erroneous attempts to simplify after $66.6\pi$ oe seen |
| **NOTE:** Volume of revolution of *C* = $195.6\pi$<br>Volume of truncated come = $129\pi$ | | |

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