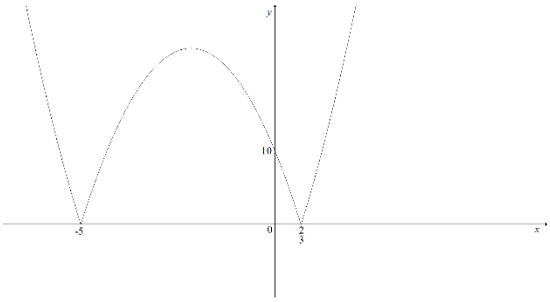
Question	Answer	Marks	Guidance
1	$a = 2$	**B1**	
	$b = 3$	**B1**	
	$c = –4$	**B1**	
2(a)		**4**	**B1** for a correct basic shape, allow ‘construction curve’ **Dep B1** for (0, 10) must have correct basic shape, must be convinced that this is the vertical intercept **B1** for (–5, 0) and $\left(\frac{2}{3}, 0\right)$ or (0.667, 0) or better **Dep B1** on all previous **B** marks for all correct with cusps and the correct shape for $x < –5$ and $x > \frac{2}{3}$
2(b)	Stationary point when $x = -\frac{13}{6}$ soi	**M1**	For differentiation or completing the square or use of symmetry
	$(-)\frac{289}{12}$ or $(-)24.1$ or better	**A1**	For *y*-value of stationary point, allow +ve or –ve value.
	$k > \frac{289}{12}$ or $k > 24.1$ or better	**A1**	
	$k = 0$	**B1**	
	Alternative		
	$3x^2 + 13x - (10 + k)$ Using discriminant, $169 + 12(10 + k)$	**(M1)**	Allow a sign error in $3x^2 + 13x - (10 + k)$, but must have a term in *k* not k^2
	Critical value $(-)\frac{289}{12}$ or $(-)24.1$ or better	**(A1)**	
	$k > \frac{289}{12}$ or $k > 24.1$ or better	**(A1)**	One solution only from correct work
	$k = 0$	**(B1)**	

Question	Answer	Marks	Guidance
3	$\frac{3}{8}p^{-2}q^{\frac{3}{2}}r^{-\frac{16}{5}}$	**4**	**B1** for $k=\frac{3}{8}$ or 0.375 **B1** for $a=-2$ **B1** for $b=\frac{3}{2}$ oe **B1** for $c=-\frac{16}{5}$, –3.2. $-3\frac{1}{5}$
4	$\tan\left(2x+\frac{\pi}{4}\right)=\frac{1}{\sqrt{3}}$ or $\sin^2\left(2x+\frac{\pi}{4}\right)=\frac{1}{4}$ or $\cos^2\left(2x+\frac{\pi}{4}\right)=\frac{3}{4}$	**B1**	Must be from correct working Allow if $\theta=2x+\frac{\pi}{4}$ oe
	$2x+\frac{\pi}{4}=\frac{\pi}{6},\ \frac{7\pi}{6},\frac{13\pi}{6}$ $x=-\frac{\pi}{24}$	**M1**	**Dep** on previous **B1** For attempt at the correct order of operations, may be implied by a correct solution or $x=-\frac{\pi}{24}$.
	$x=\frac{11\pi}{24}$ or $\frac{23\pi}{24}$ oe 0.458π or 0.958π 1.44 or 3.01	**2**	**Dep M1** for an attempt to find a solution within the given range. Must be working with $\frac{7\pi}{6}$ or $\frac{13\pi}{6}$ **A1** for either
	$x=\frac{11\pi}{24}$ or $\frac{23\pi}{24}$ oe 0.458π or 0.958π 1.44 or 3.01	**A1**	For a second solution within the given range with no extra solutions within the range.
5(a)	25	**B1**	soi
	$\begin{pmatrix}56\\-192\end{pmatrix}$ or $8\begin{pmatrix}7\\-24\end{pmatrix}$	**B1**	
5(b)	$\overrightarrow{AC}=\frac{1}{3}(\mathbf{b}-\mathbf{a})$ or $\overrightarrow{CB}=\frac{2}{3}(\mathbf{b}-\mathbf{a})$ oe	**B1**	
	$\overrightarrow{OC}=\mathbf{a}+\frac{1}{3}(\mathbf{b}-\mathbf{a})$ or $\mathbf{b}-\frac{2}{3}(\mathbf{b}-\mathbf{a})$ oe	**M1**	For using $\overrightarrow{OA}+their\,\overrightarrow{AC}$ or $\overrightarrow{OB}+their\,\overrightarrow{BC}$ oe
	$\frac{2}{3}\mathbf{a}+\frac{1}{3}\mathbf{b}$	**A1**	

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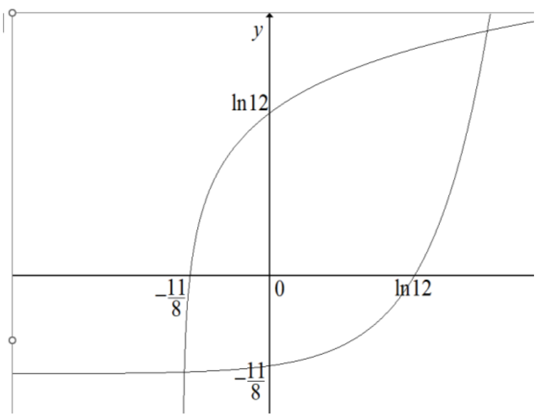
Question	Answer	Marks	Guidance
5(c)	$2p+2q=-5p+5$ or $p+4q=5p+5q$	**M1**	For equating like vectors to obtain at least one equation
	$p=-5,\ \ q=20$	**2**	**Dep M** mark for attempt to solve *their* equations to obtain both p and q **A1** for both
6	1144	**3**	**B1** With the brothers: 220 or ${}^{12}C_3$ **B1** Without the brothers: 924 or ${}^{12}C_6$
7(a)	2.8 oe	**B1**	
7(b)	$(BC=AC=)\ 10\tan 1.4$ or $\dfrac{10\sin 1.4}{\sin 0.1708}$	**M1**	
	Perimeter = $10(\textit{their }\ 2.8)+2(\textit{their }\ AC \text{ or } BC)$	**M1**	
	144	**A1**	
7(c)	Area of triangle *AOC* or *BOC* = $\dfrac{1}{2}\textit{their}(AC \text{ or } BC)\times 10$ or $\dfrac{1}{2}\textit{their }\ OC\times 10\sin 1.4$ soi	**M1**	Allow premature approximation for *OC*
	Area of minor sector *AOB* = 140	**B1**	**FT** on 50 × *their* 2.8
	Shaded area = 439 to 440	**A1**	Must have 579 ⩽ kite area ⩽ 580
8(a)	–1.5	**B1**	
8(b)	$\mathrm{f}\in\mathbb{R}$	**B1**	Allow $y\in\mathbb{R}$, $\mathbb{R}$, $-\infty<\mathrm{f}(x)<\infty$ oe, $\mathrm{f}(x)\in\mathbb{R}$

Question	Answer	Marks	Guidance
8(c)	$\ln(8x+12)$ or $\ln(4(2x+3))$	B1	May be implied
	$f^{-1}(x) = \frac{e^x - 12}{8}$ oe	2	**M1** for attempt to find the inverse, allow one sign error **A1** allow *y* = …
	Range: $f^{-1} > \textit{their}(-1.5)$	B1	Must be correct notation, follow through on *their* **(a)** $f^{-1}(x) > \textit{their}(-1.5)$, $y > \textit{their}(-1.5)$
	Alternative		
	$f^{-1}(x) = \frac{e^{x-\ln 4} - 3}{2}$ oe	(3)	**B1** for $e^{x-\ln 4}$ or $e^{y-\ln 4}$ **M1** for attempt to find the inverse, allow one sign error **A1** allow *y* = …
	Range: $f^{-1} > \textit{their}(-1.5)$	(B1)	Must be correct notation, follow through on *their* **(a)** $f^{-1}(x) > \textit{their}(-1.5)$, $y > \textit{their}(-1.5)$
8(d)		4	**B1** for correct shape of $f(x)$ in quadrants 1, 2 and 3, with asymptotic behaviour **B1** for $\ln 12$ and $-\frac{11}{8}$ or -1.375 in correct position, must have a correct shape. **B1** for correct shape of $f^{-1}(x)$ in quadrants 1, 3 and 4, with asymptotic behaviour **B1** for $\ln 12$ and $-\frac{11}{8}$ or -1.375 in correct position, must have a correct shape and intersect at least once with $y = f(x)$
9(a)	$\frac{(4x-1)(2x+1)-(4x-1)+4(2x+1)^2}{(2x+1)^2(4x-1)}$	M1	For attempt to obtain a single fraction An extra term of $(2x+1)$ throughout must be dealt with correctly before awarding **M1**
	$\frac{24x^2+14x+4}{(2x+1)^2(4x-1)}$	A1	Must see sufficient detail of expansion and collecting terms cso as **AG**

Question	Answer	Marks	Guidance
9(b)	$\frac{1}{2}\ln(2x+1)$	**B1**	
	$\frac{1}{2(2x+1)}$	**B1**	Allow $\frac{-(2x+1)^{-1}}{-1\times 2}$ oe
	$\ln(4x-1)$	**B1**	
	$\left(\frac{1}{2}\ln 3+\frac{1}{6}+\ln 3\right)-\left(\frac{1}{2}\ln 2+\frac{1}{4}\right)$	**M1**	For correct application of limits, must have at least one log term. Must be using individual fractions from **(a)** Fractions and log terms must be bracketed correctly and manipulated correctly
	$\frac{1}{2}\ln\frac{27}{2}-\frac{1}{12}$	**3**	**M1** for application of log laws using $\frac{1}{2}\ln 3+\ln 3-\frac{1}{2}\ln 2$ to obtain the correct form **A1** for $\frac{1}{2}\ln\frac{27}{2}$ **B1** for $-\frac{1}{12}$
10(a)	Common difference = $4\lg x$	**B1**	
	Sum to n terms = $\frac{n}{2}(2\lg x+(n-1)(4\lg x))$	**M1**	For use of the sum formula with *their* common difference
	$n(2n-1)\lg x$	**2**	**Dep M1** for a correct attempt to rearrange to the required form **A1** cao
10(b)	$n(2n-1)=4950$	**M1**	For $n((\mathit{their}\ p)n-1)=4950$ together with an attempt to solve to obtain n
	50	**A1**	cao
10(c)	$50(99)\lg x=-14850$	**M1**	For use of *their* n and p in a complete method to find x or use of part **(b)**
	10^{-3} or equivalent	**A1**	

Question	Answer	Marks	Guidance
11(a)	$\dfrac{\left((t+1)\times\frac{3}{2}\times 2\times(2t+1)^{\frac{1}{2}}\right)-(2t+1)^{\frac{3}{2}}}{(t+1)^2}$	**3**	**B1** for $\frac{3}{2}\times 2\times(2t+1)^{\frac{1}{2}}$ **M1** for a correct attempt at a quotient or a product **A1** for all terms apart from $\frac{3}{2}\times 2\times(2t+1)^{\frac{1}{2}}$ correct
	$\dfrac{(2t+1)^{\frac{1}{2}}}{(t+1)^2}(t+2)$	**2**	**M1 dep** on previous M mark for attempt to obtain in the required form
	Alternative		
	$s=\dfrac{(2t+1)^{\frac{3}{2}}-t-1}{(t+1)}$ $\dfrac{\left((t+1)\times\left(3\times(2t+1)^{\frac{1}{2}}-1\right)\right)-\left((2t+1)^{\frac{3}{2}}-t-1\right)}{(t+1)^2}$	**(3)**	**B1** for $\frac{3}{2}\times 2\times(2t+1)^{\frac{1}{2}}$ **M1** for a correct attempt at a quotient or a product **A1** for all terms apart from $\frac{3}{2}\times 2\times(2t+1)^{\frac{1}{2}}$ correct
	$\dfrac{(2t+1)^{\frac{1}{2}}}{(t+1)^2}(t+2)$	**(2)**	**M1 dep** on previous M mark for attempt to obtain in the required form
11(b)	$(2t+1)^{\frac{1}{2}}(t+2)=0$ oe has no real positive solutions so velocity is never zero	**B1**	**FT** on *their* positive linear factor Reference needs to be made to both factors.

Question	Answer	Marks	Guidance
12	$a^5x^5 + 2a^4x^4 + \frac{8}{5}a^3x^3$	3	**B1** for each correct term, allow when first seen
	$1 - \frac{2b}{x} + \frac{b^2}{x^2}$	B1	
	$a = 2$	B1	
	$32 - 64b = -160$	M1	For using *their* expansions and *their* value for *a* to obtain two terms involving x^4
	$b = 3$	A1	
	$\frac{64}{5} - 192 + 288 = c$	M1	For using *their* expansions and *their* value for *a* to obtain three terms involving x^3
	$c = \frac{544}{5}$ oe	A1	
	Alternative		
	$a^5 \left(= 32\right)$	(B1)	
	$a = 2$	(B1)	
	$-2ba^5 + 2a^4 = -160$ soi $32 - 64b = -160$	(2)	**B1** for $2a^4$ soi **M1** For using *their* expansions and *their* value for *a* to obtain two terms involving x^4
	$b = 3$	(A1)	
	$\frac{8}{5}a^3 - 4a^4b + a^5b^2 = c$ $\frac{64}{5} - 192 + 288 = c$	(3)	**B2** for both $\frac{8}{5}a^3$ and a^5b^2 **B1** for either $\frac{8}{5}a^3$ or a^5b^2 if only one correct **M1** for using *their* expansions and *their* value for *a* to obtain three terms involving x^3
	$c = \frac{544}{5}$ oe	(A1)	