Question	Answer	Marks	Guidance
2	Differentiate to obtain $2x + ax^{-2}$ or equivalent	**B1**	
	Equate first derivative to zero, substitute $x = -3$ and attempt value of a	**M1**	Must be an attempt at differentiation.
	Obtain $a = 54$	**A1**	
	Obtain $b = 27$	**A1**	
		4	

Question	Answer	Marks	Guidance
5(a)	Attempt correct process for solving 3-term quadratic equation in $\sqrt{x}$	M1	Accept $8y^2 - 6y - 9 \to (2y-3)(4y+3)$, if $y = \sqrt{x}$ specified.
	Obtain at least $2\sqrt{x} - 3 = 0$ or equivalent	A1	Ignore $4\sqrt{x} + 3 = 0$. **SC B1** for $\sqrt{x} = \frac{3}{2}$ with no method shown for solving the 3-term quadratic.
	Conclude $x = \frac{9}{4}$ ignore $\frac{9}{16}$	A1	**SC B1** if no method shown for solving the 3-term quadratic.
	Alternative Method for Q5(a)		
	$3\sqrt{x} = 4x - \frac{9}{2} \to 16x^2 - 45x + \frac{81}{4}$ o.e and attempt correct process to solve	M1	
	Obtain $x = \frac{9}{4}$ or $\frac{9}{16}$	A1	**SC B1** if no method shown for solving the 3-term quadratic.
	$x = \frac{9}{4}$ ignore $\frac{9}{16}$	A1	**SC B1** if no method shown for solving the 3-term quadratic.
		3	

Question	Answer	Marks	Guidance
5(b)	Integrate to obtain form $k_1x^2 + k_2x^{\frac{3}{2}} + k_3x$ where $k_1k_2k_3 \neq 0$	**M1**	
	Obtain correct $2x^2 - 2x^{\frac{3}{2}} + x$ or equivalent	**A1**	Allow unsimplified.
	Substitute $x = 4$ and $y = 11$ to attempt value of c	**M1**	Dependent on at least 2 correct terms involving x.
	Obtain $y = 2x^2 - 2x^{\frac{3}{2}} + x - 9$	**A1**	Must be simplified. Allow 'f(x) ='. Allow y missing if y appears previously.
		4	

Question	Answer	Marks	Guidance
7(a)	Differentiate to obtain form $k_1(2x+1)^{-\frac{4}{3}}$	**M1**	
	Obtain correct $-8(2x+1)^{-\frac{4}{3}}$ or unsimplified equivalent	**A1**	
	Attempt equation of tangent at $\left(\frac{7}{2}, 6\right)$ with numerical gradient	**M1**	Gradient must come from a differentiated expression.
	Obtain $y = -\frac{1}{2}x + \frac{31}{4}$ or equivalent of requested form	**A1**	
		4	

Question	Answer	Marks	Guidance
7(b)	Integrate to obtain form $k_2(2x+1)^{\frac{2}{3}}$	**M1**	
	Obtain correct $9(2x+1)^{\frac{2}{3}}$ or unsimplified equivalent	**A1**	
	Use correct limits correctly to find area	**M1**	Substitute correct limits into an integrated expression. 36 – 9 minimum working required.
	Obtain 27	**A1**	**SC B1** if M1 A1 M0 scored.
		4	

Question	Answer	Marks	Guidance
9(a)	Differentiate to obtain $5+12x-9x^2$	B1	
	Attempt to find two critical values by solving quadratic equation or inequality	M1	
	Obtain values $-\frac{1}{3}$ and $\frac{5}{3}$	A1	**SC B1** if no method for solving the quadratic.
	Conclude $x<-\frac{1}{3}$, $x>\frac{5}{3}$	A1FT	**SC B1** if no method for solving the quadratic.
		4	

Question	Answer	Marks	Guidance
9(b)	Equate first derivative to 9 and simplify to 3 term quadratic	*M1	
	Obtain $x = \dfrac{2}{3}$	A1	**SC B1** for solving $5+12x-9x^2 = 9$ without simplifying to a 3-term quadratic.
	Use x-value and corresponding y-value to determine value of k	DM1	
	Obtain $k = \dfrac{28}{9}$	A1	**SC B1** for $k = \dfrac{28}{9}$ from solving $5+12x-9x^2 = 9$ without simplifying to a 3-term quadratic.
		4	

Question	Answer	Marks	Guidance
3(a)	$\left[\mathrm{f}(2+h)=\right]\ 2(2+h)^2-3$	**B1**	SOI
	$\dfrac{\left(2(2+h)^2-3\right)-5}{(2+h)-2}\quad\left[=\dfrac{2h^2+8h}{h}\right]$	**M1**	$\dfrac{\left\{their\left(2(2+h)^2-3\right)\right\}-their5}{(2+h)-2}$ can be implied by the simplified expression or the correct answer. *Their* 5 must come from $2(2)^2-3$.
	$2h+8$ or $2(h+4)$	**A1**	
		3	
3(b)	$h\to 0$, or chord [AB] $\to$ tangent [at A]	**B1**	Either of these statements or any sight of $h=0$.
	8	**B1FT**	Could come from anywhere except wrong working. Either correct or FT their linear expression from **(a)**.
		2	

Question	Answer	Marks	Guidance
10(a)	-18	**B1**	SOI
	$\frac{1}{18}$	**M1**	Use of $m_1 m_2 = -1$ from $f'(x)$ with $x = 1$.
	$\frac{y\ [-\ 0]}{x-1} = \frac{1}{18}$	**A1**	OE ISW
		3	

Question	Answer	Marks	Guidance
10(b)	$\left[\mathrm{f}(x)=\right]\left\{8(2x-3)^{\frac{4}{3}}.\frac{1}{2}.\frac{1}{\frac{4}{3}}\right\}\left\{-10x^{\frac{5}{3}}.\frac{1}{\frac{5}{3}}\right\}[+c]$ $\left[3(2x-3)^{\frac{4}{3}}-6x^{\frac{5}{3}}+c\right]$	B1B1	B1 for each unsimplified {}. Can be implied by equivalent simplified or partly simplified versions.
	$0=3(2(1)-3)^{\frac{4}{3}}-6(1)^{\frac{5}{3}}+c \quad [0=3-6+c]$	M1	Use of $x=1$ and $y=0$ in *their* integrated $f'(x)$, defined as an expression with at least one correct power, which must contain $+c$.
	$[f(x)\text{ or }y=]\ 3(2x-3)^{\frac{4}{3}}-6x^{\frac{5}{3}}+3$	A1	Only condone $c=3$ as their final answer if all coefficients have previously been simplified in a correct statement.
		4	
10(c)	$b^2-4ac=128^2-4\times125\times192$ and stating "<0" OR use of the quadratic formula and stating "No solutions" OR completing the square for the given quadratic and stating positive or >0. OR sketch of the given quadratic and stating positive.	M1*	$b^2-4ac=-79616$ can be accepted in place of working.
	No turning points [in the original function.]	DM1	
	Decreasing because $f'(\text{any positive }x\text{ value})<0$	A1	WWW e.g. $f'(1)=-18$.
		3	

Question	Answer	Marks	Guidance
11(a)	$\frac{dy}{dx} = \frac{1}{2}kx^{-\frac{1}{2}} - 8x$	**B1**	
	$\frac{d^2y}{dx^2} = -\frac{1}{4}kx^{-\frac{3}{2}} - 8$	**B1**	
		2	
11(b)	$x^{-\frac{1}{2}} - 8x = 0 \Rightarrow 1 - 8x^{\frac{3}{2}} = 0$ or $x^{-1} = 64x^2$ $\left[\Rightarrow x^3 = \frac{1}{64} \text{ or } 8x^{\frac{3}{2}} = 1\right]$ Setting their $\frac{dy}{dx}$ to zero and solving, providing their only error(s) are incorrect coefficients	**M1**	OE Award if working leads to $x = \frac{1}{4}$ WWW. Squaring $x^{-\frac{1}{2}} - 8x^2 = 0$ to $x^{-1} - 64x^2 = 0$ gets M0.
	$x = \frac{1}{4}$ only	**A1**	If $x = 0$ included, A0 and max of 3/4. **SC B1** only for $x = \frac{1}{4}$ only from squaring $x^{-\frac{1}{2}} - 8x^2 = 0$ directly to $x^{-1} - 64x^2 = 0$ (**SC B1** replacing the M1A1).
	$y = \frac{11}{4}$	**A1**	**SC B1** for $y = \frac{11}{4}$ from squaring $x^{-\frac{1}{2}} - 8x^2 = 0$ to $x^{-1} - 64x^2 = 0$.
	$\frac{d^2y}{dx^2} = -\frac{1}{2}x^{-\frac{3}{2}} - 8$ which is negative, so maximum	**B1 FT**	WWW FT *their* x-value and *their* $\frac{d^2y}{dx^2}$. No FT if $x = 0$ is the only solution.
		4	

Question	Answer	Marks	Guidance
11(c)	When $x=1$, attempting to find $y=k-2$ and gradient $=\frac{1}{2}k-8$	M1*	OE **SC B1** if both correct gradients only, or both correct y-coordinates only.
	Equation of tangent is $y-k+2=\left(\frac{1}{2}k-8\right)(x-1)$	A1	OE, e.g. $y=\left(\frac{k}{2}-8\right)x+\frac{k}{2}+6$ or $y=\frac{k}{2}x-8x+\frac{k}{2}+6$.
	When $x=\frac{1}{4}$,attempting to find $y=\frac{1}{2}k+1.75$ and gradient $=k-2$	M1*	OE
	Equation of tangent is $y-\frac{1}{2}k-1.75=(k-2)(x-0.25)$	A1	OE, e.g. $y=(k-2)x+\frac{k}{4}+\frac{9}{4}$ or $y=kx-2x+\frac{k}{4}+\frac{9}{4}$.
	Meet at $\left(\frac{1}{2}k-8\right)(0.6-1)+k-2=(k-2)(0.6-0.25)+\frac{1}{2}k+1.75$ Equate two tangent equations and substitute $x=0.6$	DM1	OE, e.g. $\left(\frac{k}{2}-8\right)0.6+\frac{k}{2}+6=(k-2)0.6+\frac{k}{4}+\frac{9}{4}$. M0 if constants in both equations are the same.
	$\Rightarrow [-0.2k+k+3.2-2=0.35k-0.7+0.5k+1.75]$ $\Rightarrow 0.05k=0.15$ $k=3$	A1	
		6	