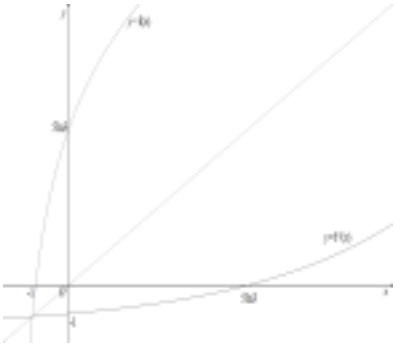
Question	Answer	Marks	Guidance
1	$y = \pm 3(x+2)(x+1)(x-4)$	**3**	**B1** for 3 **B1** for $(x+2)(x+1)(x-4)$ **B1** for $\pm$
2(a)	4	**B1**	
2(b)	1080° or 6π	**B1**	
2(c)		**3**	**B1** for shape, it must be symmetrical about the *y*-axis. **B1**for *y*-intercept of 5 **B1** for $(\pm 180^{\circ}, 3)$
3(a)	$a = \frac{3}{2}$ or $p^{\frac{3}{2}}$	**B1**	
	$b = \frac{10}{3}$ or $q^{\frac{10}{3}}$	**B1**	
	$c = -\frac{7}{3}$ or $r^{-\frac{7}{3}}$	**B1**	
3(b)	$\left(3x^{\frac{1}{3}} - 1\right)\left(2x^{\frac{1}{3}} - 1\right) = 0$	**M1**	For recognising as a quadratic in $x^{\frac{1}{3}}$ and attempt to solve to obtain $x^{\frac{1}{3}} = k$
	$x^{\frac{1}{3}} = \frac{1}{3}$, $x^{\frac{1}{3}} = \frac{1}{2}$ leading to $x = \frac{1}{27}$ or 0.0370 $x = \frac{1}{8}$ or 0.125	**2**	**Dep M1** for a valid method of solving $x^{\frac{1}{3}} = k$ where $k > 0$ **A1** for both
4(a)	$\frac{dy}{dx} = \frac{\sin x \times 3\sec^2 3x - \tan 3x \cos x}{\sin^2 x}$	**3**	**B1** for $3\sec^2 3x$ **M1** for differentiation of a quotient or equivalent product **A1** for all other terms apart from $3\sec^2 3x$ correct
	When $x = \frac{\pi}{3}$ $\frac{dy}{dx} = 2\sqrt{3}$	**A1**	
4(b)	$2\sqrt{3}h$	**B1**	**FT** on *their* answer to **(a)**

Question	Answer	Marks	Guidance
4(c)	$\frac{dy}{dx}\times\frac{dx}{dt}=\frac{dy}{dt}$ $2\sqrt{3}\times 3=\frac{dy}{dt}$	**M1**	For correct use of rates of change using *their* answer to **(a)**
	$\frac{dy}{dt}=6\sqrt{3}$	**A1**	
5(a)(i)	360	**B1**	
5(a)(ii)	Starts with 6: $1\times4\times3\times1\ \ =12$	**B1**	
	Starts with 7 or 9 : $=2\times4\times3\times2$ $=48$	**B1**	
	Total = 60	**B1**	
	Alternative		
	Ending in 4: $\frac{1}{6}\times360\times\frac{3}{5}=36$	**(B1)**	Allow unsimplified
	Ending in 6: $\frac{1}{6}\times360\times\frac{2}{5}=24$	**(B1)**	Allow unsimplified
	Total = 60	**(B1)**	
5(b)(i)	1287	**B1**	
5(b)(ii)	$1287-{}^{7}C_{5}$ or 1 doctor: 210 2 doctors: 525 3 doctors: 420 4 doctors: 105 5 doctors: 1	**M1**	For *their* **(b)(i)** $-{}^{7}C_{5}$ or listing all the other separate cases which must be evaluated, allow 1 error
	1266	**A1**	
5(b)(iii)	45	**B1**	
6(a)	Velocity vector = $\begin{pmatrix}-8\\6\end{pmatrix}$	**2**	**M1** for obtaining 5
	$\begin{pmatrix}30\\10\end{pmatrix}+\begin{pmatrix}-8\\6\end{pmatrix}t$	**B1**	**FT** for $\begin{pmatrix}30\\10\end{pmatrix}+(\textit{their}\text{ velocity vector})t$
6(b)	13	**B1**	

Question	Answer	Marks	Guidance
6(c)	$P:\begin{pmatrix}-50\\70\end{pmatrix}$ $Q:\begin{pmatrix}-30\\210\end{pmatrix}$	**M1**	Using $t=10$ to find position vector of each particle
	$\sqrt{20^2+140^2}$	**M1**	**Dep** on previous M mark, for use of Pythagoras on difference of the 2 position vectors
	$100\sqrt{2}$	**A1**	
7(a)	$\mathrm{f}\in\mathbb{R}$	**B1**	Allow *y* but not *x*
7(b)	$x=5\ln(2y+3)$ $\mathrm{e}^{\frac{x}{5}}=2y+3$	**M1**	For a complete attempt to obtain inverse
	$\mathrm{f}^{-1}(x)=\dfrac{\mathrm{e}^{\frac{x}{5}}-3}{2}$	**A1**	Must be using correct notation
	Domain $x\in\mathbb{R}$	**B1**	**FT** on *their* **(a)**. Must be using correct notation
7(c)		**5**	**B1** for shape of $y=\mathrm{f}(x)$ **B1** for shape of $y=\mathrm{f}^{-1}(x)$ **B1** for $5\ln 3$ or 5.5 and -1 on both axes for $y=\mathrm{f}(x)$ **B1** for $5\ln 3$ or 5.5 and -1 on both axes for $y=\mathrm{f}^{-1}(x)$ **B1** All correct, with apparent symmetry which may be implied be previous 2 B marks or by inclusion of $y=x$, and implied asymptotes, may have one or two points of intersection
8(a)(i)	$\dfrac{1}{\left(1+\dfrac{1}{\sin\theta}\right)\left(\sin\theta-\sin^2\theta\right)}$	**B1**	For use of $\mathrm{cosec}\,\theta=\dfrac{1}{\sin\theta}$, may be implied
	$\dfrac{1}{\sin\theta+1-\sin\theta-\sin^2\theta}$	**M1**	For expansion of brackets
	$\dfrac{1}{\cos^2\theta}$	**M1**	For simplification and use of identity
	$\sec^2\theta$	**A1**	For final result, must see $\dfrac{1}{\cos^2\theta}$

Question	Answer	Marks	Guidance
8(a)(ii)	$\cos^2\theta = \frac{3}{4}$	**B1**	For relating to and making use of **(a)**
	$\cos\theta = \pm\frac{\sqrt{3}}{2}$	**M1**	For attempt to solve, may be implied by one correct solution
	$\theta = -150^\circ,\ -30^\circ,\ 30^\circ,\ 150^\circ$	**2**	**A1** for any correct pair **A1** for a second correct pair and no extra solutions within the range
8(b)	$\tan\left(3\phi + \frac{2\pi}{3}\right) = 1$	**B1**	
	$3\phi + \frac{2\pi}{3} = \frac{\pi}{4},\ \frac{5\pi}{4},\ \frac{9\pi}{4}$ $3\phi = \frac{7\pi}{12},\ \frac{19\pi}{12}$	**M1**	For correct order of operations
	$\phi = \frac{7\pi}{36}$	**A1**	
	$\phi = \frac{19\pi}{36}$	**A1**	
9(a)	$\left[\ln x - \frac{1}{2}\ln(2x+3)\right]_1^a$	**2**	**B1** for $\ln x$ **B1 f**or $\frac{1}{2}\ln(2x+3)$
	$\ln a - \frac{1}{2}\ln(2a+3) + \frac{1}{2}\ln 5$	**M1**	For correct application of limits, must have at least one **B1**
	$\ln a\sqrt{\frac{5}{2a+3}}$	**M1**	**Dep** on previous M mark, for application of log laws
	$5a^2 - 18a - 27 = 0$	**M1**	**Dep** on previous M mark for equating to $\ln 3$ and simplification to a 3 term quadratic = 0
	$a = \frac{9+6\sqrt{6}}{5}$	**A1**	Must have one solution only

Question	Answer	Marks	Guidance
9(b)	$-\frac{1}{2}\cos\left(2x+\frac{\pi}{3}\right)+\frac{1}{2}\sin 2x-x$	**3**	**B1** for $-\frac{1}{2}\cos\left(2x+\frac{\pi}{3}\right)$ **B1** for $+\frac{1}{2}\sin 2x$ **B1** for $-x$
	$\left(-\frac{1}{2}\cos\pi+\frac{1}{2}\sin\frac{2\pi}{3}-\frac{\pi}{3}\right)$ $-\left(-\frac{1}{2}\cos\frac{\pi}{3}\right)$	**M1**	For correct use of limits in *their* integral, must have at least one **B1** term
	$\frac{3}{4}+\frac{\sqrt{3}}{4}-\frac{\pi}{3}$	**A1**	
10(a)	$a+d=8$ $a+3d=18$	**2**	**B1** for both equations **M1** for attempt to solve *their* equations
	$a=3,\ \ d=5$	**A1**	For both
	$\frac{n}{2}\left(6+(n-1)5\right)>1560$	**M1**	For correct use of sum formula with *their a* and *d*, allow equality
	$5n^2+n-3120>0$	**M1**	For attempt to solve, allow equality, to obtain at least one critical value
	Positive critical value 24.9 25terms	**A1**	
10(b)(i)	$\frac{a}{1-r}=72$ and either $a+ar+ar^2=\frac{333}{8}$ or $\frac{a\left(1-r^3\right)}{1-r}=\frac{333}{8}$	**B1**	For both
	$a=72(1-r)$ and $a\left(1+r+r^2\right)=\frac{333}{8}$ oe $72(1-r)\left(1+r+r^2\right)=\frac{333}{8}$ or $72\left(1-r^3\right)=\frac{333}{8}$	**M1**	For attempt to obtain an equation in terms of *r* only
	$1-r^3=\frac{333}{576}$	**A1**	
	$r=0.75$	**2**	**M1** for attempt to solve *their* equation in *r*
10(b)(ii)	$a=18$	**B1**	**FT** on their r provided $\lvert r\rvert<1$