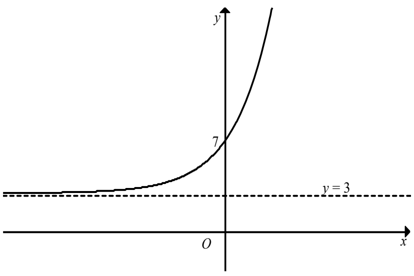
Question	Answer	Marks	Partial Marks
1	$[y=]\frac{6+\sqrt{6}}{3+\sqrt{6}}\times\frac{3-\sqrt{6}}{3-\sqrt{6}}$ oe, soi	**M1**	
	Correctly multiplies out correct expression: $[y=]\frac{18-6\sqrt{6}+3\sqrt{6}-6}{9-6}$ oe	**M1**	
	$[y=]\ 4-\sqrt{6}$	**A1**	not from wrong working
2	$f(x)=-2x+5$ or $g(x)=x-1$ soi	**B1**	
	Uses correct f(*x*) and g(*x*) to find the critical value 2 soi	**B1**	
	Valid method to find other CV e.g. $2x-5*x-1$ oe seen, where * is = or any inequality sign	**M1**	**FT** *their* equations of form $y = mx + c$, for non-zero *m* and *c*; **dep** on first **B1**
	Correct critical value 4 soi	**A1**	
	$2 \leqslant x \leqslant 4$ mark final answer	**A1**	
	Alternative method 1 $f(x)= 2x-5$ or $g(x)=x-1$ soi	**(B1)**	
	Uses correct f(*x*) and g(*x*) to find the critical value 4 soi	**(B1)**	
	Valid method to find other CV e.g. $-2x+5*x-1$ oe seen, where * is = or any inequality sign	**(M1)**	**FT** *their* equations of form $y = mx + c$, for non-zero *m* and *c*; **dep** on first **B1**
	Correct critical value 2 soi	**(A1)**	
	$2 \leqslant x \leqslant 4$ mark final answer	**(A1)**	
	Alternative method 2 $f(x) = -2x + 5$ or $2x - 5$ OR $g(x) = x - 1$ soi	**(B1)**	
	Squares, equates, simplifies correct f(*x*) and g(*x*): $3x^2-18x+24[*0]$	**(B1)**	where * is = or any inequality sign
	Attempts to solve or factorise	**(M1)**	FT *their* 3-term quadratic from $(ax + b)^2 = (cx + d)^2$ for non-zero *a, b, c* and *d*; **dep** on first **B1**
	Correct critical values 2, 4	**(A1)**	
	$2 \leqslant x \leqslant 4$ mark final answer	**(A1)**	

Question	Answer	Marks	Partial Marks
3	Uses $b^2 - 4ac$ oe: $(k+5)^2 - 4k(-4)$ [* 0, where * could be = or any inequality sign]	**M1**	
	Forms a correct 3-term expression: $k^2 + 26k + 25$	**A1**	
	Factorises $k^2 + 26k + 25$ or solves $k^2 + 26k + 25 = 0$ oe	**M1**	**dep** on first **M1**, **FT** *their* 3-term quadratic in k
	Correct critical values $-1, \quad -25$ soi	**A1**	
	$k \leqslant -25$, $k \geqslant -1$	**A1**	mark final answer
4	Substitutes $y = 4$ and rearranges to correct 3-term quadratic $3x^2 - 2x - 1 = 0$ oe	**B1**	
	Solves *their* 3-term quadratic in x as far as $x = \ldots$	**M1**	
	$\frac{dy}{dx} = -2x^{-2} - 2x^{-3}$ oe, isw	**B1**	
	$\frac{0.01}{\delta x} = their\left(\left.\frac{dy}{dx}\right\|_{x = their\ 1}\right)$ or better	**M1**	**FT** *their* derivative and *their x,* providing *their* $x > 0$ and *their* $x \neq 4$ unless 4 is a genuine solution of *their* 3-term quadratic; must see a power decrease for attempted differentiation in two out of the three terms
	$-\frac{1}{400}$ oe as the only solution	**A1**	**dep** on all previous marks being awarded

Question	Answer	Marks	Partial Marks
4	**Alternative method**		
	$x = \frac{1}{\sqrt{y}-1}$ or $x = \frac{1+\sqrt{y}}{y-1}$ or $x = \frac{-1-\sqrt{y}}{1-y}$ oe	**(B2)**	**B1** for $y = \frac{(x+1)^2}{x^2}$ or better or for $x = \frac{2+\sqrt{4-4(y-1)(-1)}}{2(y-1)}$ or for $x = \frac{-2-\sqrt{4-4(1-y)}}{2(1-y)}$
	$\frac{dx}{dy} = -\left(\sqrt{y}-1\right)^{-2}\left(\frac{1}{2}y^{-\frac{1}{2}}\right)$ oe isw or $\frac{dx}{dy} = \frac{(y-1)\left(\frac{1}{2}y^{-\frac{1}{2}}\right)-(1+\sqrt{y})}{(y-1)^2}$ oe	**(M1)**	or $\frac{dx}{dy} = \frac{(1-y)\left(-\frac{1}{2}y^{-\frac{1}{2}}\right)-(-1-\sqrt{y})(-1)}{(1-y)^2}$ oe
	$\frac{\delta x}{0.01} = their\left(\left.\frac{dx}{dy}\right\|_{y=4}\right)$ or better	**(M1)**	**FT** *their* derivative ; must have attempted derivative
	$-\frac{1}{400}$ oe as the only solution	**(A1)**	**dep** on all previous marks being awarded

Question	Answer	Marks	Partial Marks
5(a)	$\frac{(5^4)^{\frac{x^3-1}{2}}}{(5^3)^{x^3}} = 5$ oe or $\frac{(25^2)^{\frac{x^3-1}{2}}}{\left(25^{\frac{3}{2}}\right)^{x^3}} = 25^{\frac{1}{2}}$ or $\frac{(\sqrt{625})^{x^3} \times 625^{-\frac{1}{2}}}{125^{x^3}} = 5$ or $\log 625^{\frac{x^3-1}{2}} - \log 125^{x^3} = \log 5$ oe	**B1**	converts the terms given to powers of 5 or 25 or separates the power in the numerator correctly or applies a correct log law
	$5^{2x^3-2-3x^3} = 5^1$ oe $\Rightarrow -x^3 - 2 = 1$ oe or $25^{x^3-1-1.5x^3} = 25^{\frac{1}{2}}$ oe $\Rightarrow -0.5x^3 - 1 = 0.5$ oe or $\left(\frac{1}{5}\right)^{x^3} \times \frac{1}{25} = 5$ oe $\Rightarrow x^3 \log\frac{1}{5} = \log 125$ oe or $\frac{x^3-1}{2}\log 625 - x^3 \log 125 = \log 5$ oe	**M1**	**FT** *their* exponential equation in the same base or *their* logarithmic equation with any consistent base, **providing** *their* exponential or logarithmic equation has at most one sign or arithmetic error
	$[x =]\ \sqrt[3]{-3}$ oe or –1.442249... rot to 3 or more figs.	**A1**	mark final answer; not from wrong working
5(b)		**B2**	**B1** for correct shape; tending to $y = 3$ **B1** for shape with correct curvature and correct intercept of 7 marked or (0, 7) indicated

Question	Answer	Marks	Partial Marks
6(a)	4cos75**i** + 4sin75**j** or 4sin15**i** + 4cos15**j** or 4sin15**i** + 4sin75**j** or 4cos75**i** + 4cos15**j** oe, isw	**B2**	**B1** for $x = 4\cos 75$ or $x = 4\sin 15$ oe, soi or $y = 4\sin 75$ or $y = 4\cos 15$ oe, soi or **B1** for a correct pair of implicit statements for *x* and *y* e.g. **both** $\frac{x}{4} = \sin 15$ **and** $\frac{y}{4} = \cos 15$ oe or **both** $\frac{x}{4} = \cos 75$ **and** $\frac{y}{4} = \sin 75$ oe If 0 scored, **SC1** for a correct expression with missing brackets such as $\sqrt{6} - \sqrt{2}\mathbf{i} + \sqrt{6} + \sqrt{2}\mathbf{j}$ or for $\begin{pmatrix} 1.04 \\ 3.86 \end{pmatrix}$ oe

Question	Answer	Marks	Partial Marks
6(b)	$(-6\cos30-2\cos40)\mathbf{i}+(6\sin30-2\sin40)\mathbf{j}$ or $(-6\sin60-2\sin50)\mathbf{i}+(6\sin30-2\sin40)\mathbf{j}$ or $(-6\cos30-2\cos40)\mathbf{i}+(6\cos60-2\cos50)\mathbf{j}$ or $(-3\sqrt{3}-1.532...)\mathbf{i}+(3-1.285...)\mathbf{j}$ oe, soi	**B1**	
	$\left[r^2=\right](-6.7282...)^2+(1.7144...)^2$	**M1**	**FT** *their* (–6.728… **i** + 1.714…**j**)
	[r =] 6.94 or 6.9432329... rot to 4 or more sf	**A1**	**dep** on **B1**
	$\alpha=\tan^{-1}\left(\frac{6.7282...}{1.7144...}\right)$ or awrt 75.7 or $\beta=\tan^{-1}\left(\frac{1.7144...}{6.7282...}\right)$ or awrt 14.3	**M1**	**FT** *their* (–6.728… **i** + 1.714…**j**)
	284 or 284.2[95…] rot to 4 or more sf	**A1**	**dep** on **B1**
	Alternative method $[r^2=]\,2^2+6^2-2\times2\times6\times\cos(\textit{their}110)$	**(M1)**	
	[r =] 6.94 or 6.9432329... rot to 4 or more sf	**(A1)**	
	$\frac{\sin\theta}{2}=\frac{\sin(\textit{their}110)}{\textit{their}6.943...}$ oe or $\frac{\sin\phi}{6}=\frac{\sin(\textit{their}110)}{\textit{their}6.943...}$ oe	**(M1)**	$\cos\theta=\frac{2^2-\textit{their}6.943...^2-6^2}{-2(\textit{their}6.943...)(6)}$ or $\cos\phi=\frac{6^2-\textit{their}6.943...^2-2^2}{-2(\textit{their}6.943...)(2)}$
	$[\theta=]$ awrt 15.7 oe or $[\phi=]$ awrt 54.3	**(A1)**	
	284 or 284.2[95…] rot to 4 or more sf	**(A1)**	

Question	Answer	Marks	Partial Marks
7	$\frac{d}{dx}(e^{4x}) = 4e^{4x}$ soi	B1	
	$4e^{4x}\tan x + e^{4x}\sec^2 x$	M1	**FT** *their* $4e^{4x}$
	$\frac{(\ln x)(4e^{4x}\tan x + e^{4x}\sec^2 x) - \frac{1}{x}e^{4x}\tan x}{(\ln x)^2}$	M1	**FT** *their* $4e^{4x}\tan x + e^{4x}\sec^2 x$
	Fully correct derivative, isw	A1	
	Alternative method for final two marks Applies correct product rule to $y = (e^{4x}\tan x)(\ln x)^{-1}$ $\left(4e^{4x}\tan x + e^{4x}\sec^2 x\right)(\ln x)^{-1}$ $+\left(-(\ln x)^{-2}\left(\frac{1}{x}\right)\right)\left(e^{4x}\tan x\right)$	(M1)	**FT** *their* $4e^{4x}\tan x + e^{4x}\sec^2 x$
	Fully correct derivative, isw	(A1)	
8(a)	$3(2\sin x\cos x) - (-2\sin x)\quad [=0]$ or better	B2	**B1** for the correct derivative for either term; may be unsimplified
	Factors out $\sin x$ and equates to 0: $[2](\sin x)(3\cos x + 1) = 0$ oe	B1	**FT** an expression of the form $a\sin x\cos x + b\sin x$ for non-zero constants a and b
	$\sin x = 0 \quad [\textit{their } a\cos x = -\textit{their } b]$	M1	**FT** an expression of the form $a\sin x\cos x + b\sin x$ for non-zero constants a and b; **dep** on previous **B1**
	$x = \pi$ as only solution	A1	**dep** on all previous marks awarded If **B2 B0 M0** then **SC1** for dividing by $\sin x$ and using $\cos^{-1}\left(-\frac{1}{3}\right)$ to find x = 1.91 and 4.37 and clearly reject them.

Question	Answer	Marks	Partial Marks
8(b)	For use of $\sin^2 x = 1 - \cos^2 x$ to write in terms of $\cos x$ only e.g. $3(1 - \cos^2 x) - 2\cos x = 1 - 3\cos x$	**M1**	
	Collects terms e.g. $3\cos^2 x - \cos x - 2 = 0$	**A1**	
	Factorises the left-hand side or solves: $(3\cos x + 2)(\cos x - 1) = 0$	**M1**	
	$x = 2.3[0]$, $x = 3.98$ and no extras	**A2**	not from wrong working **A1** for either; not from wrong working
9(a)	[area sector =] $2 \times \frac{1}{2}a^2\phi$ or $\frac{1}{2}a^2(2\phi)$ oe	**B1**	or [area kite =] $2a^2\phi$ or [area OPT =] $a^2\phi$ nfww
	[shaded area =] $\left[2 \times \frac{1}{2} \times\right]\frac{1}{2}a(a\tan\phi)$ oe or $a(a\tan\phi) - \frac{1}{2}a^2(2\phi)$ oe soi	**B1**	or [$a^2\phi = \frac{1}{2}a \times PT$ $\therefore$] $PT = 2a\phi$ **<u>and</u>** $PT = a\tan\phi$ oe, nfww
	Correct equation using correct areas e.g. $a^2\phi = \frac{1}{2}a(a\tan\phi)$ or $a(a\tan\phi) - a^2\phi = a^2\phi$ soi	**M1**	or equates expressions for PT
	Correct completion to given equation $\tan\phi = 2\phi$	**A1**	
	Alternative method [$\frac{1}{2}$ area sector =] $\frac{1}{2}a^2\phi$	**(B1)**	
	[$\frac{1}{2}$ shaded area =] $\frac{1}{2} \times \frac{1}{2}a(a\tan\phi)$ oe or $\frac{1}{2}a(a\tan\phi) - \frac{1}{2}a^2\phi$ oe soi	**(B1)**	
	Correct equation using correct areas e.g. $\frac{1}{2}a^2\phi = \frac{1}{4}a(a\tan\phi)$ or $\frac{1}{2}a^2\tan\phi - \frac{1}{2}a^2\phi = \frac{1}{2}a^2\phi$ soi	**(M1)**	
	Correct completion to given equation $\tan\phi = 2\phi$	**(A1)**	

Question	Answer	Marks	Partial Marks
9(b)	$2a + a(2\phi) = \frac{1}{2}(2a\tan\phi + a(2\phi))$ oe or $a\tan\phi = 2a + a\phi$	**M2**	**M1** for arc length = $2a\phi$ soi or for $PT = a\tan\phi$ **and** $PT = 2a + a\phi$
	$\tan\phi = 2 + \phi$	**A1**	
10(a)(i)	$ar = 8$ and $ar^2 + ar^3 = 160$ soi	**B2**	**B1** for each
	Correct unsimplified quadratic equation in r e.g. $\left[a = \frac{8}{r} \text{ and so}\right] \frac{8}{r} \times r^2 + \frac{8}{r} \times r^3 = 160$ oe	**M1**	
	Correct simplification to $r^2 + r - 20 = 0$	**A1**	
10(a)(ii)	Factorises or solves: $(r + 5)(r - 4) = 0$	**M1**	
	$r = 4$	**A1**	
	$a = 2$	**A1**	
	Alternative method $5a^2 - 2a - 16 = 0$ oe	**(B1)**	
	Factorises or solves *their* 3-term quadratic in a	**(M1)**	
	$a = 2$	**(A1)**	
10(b)	$p + 2(q - 1) = 14$ oe	**B1**	
	$\frac{q}{2}\{2p + 4(q-1)\} = 168$ oe	**B1**	
	Eliminates p or q e.g. $\frac{q}{2}\{2(14 - 2(q-1)) + 4(q-1)\} = 168$ OR simplifies S_q : $q\{p + 2(q-1)\} = 168$ and writes $q(14) = 168$	**M1**	condone one error in rearrangement of either equation before substituting
	Correctly solves *their* equation for *their* p or *their* q	**M1**	**dep** on previous **M1**
	$q = 12$ and $p = -8$	**A2**	**A1** for $q = 12$ or $p = -8$

Question	Answer	Marks	Partial Marks
11	Full, complete and actioned method to find the first area: A or $\frac{1}{2}A$ or B or $\frac{1}{2}B$	**5**	**B1 for** $[\mathrm{F}(x)=]\int(1+\cos x)\,\mathrm{d}x = x+\sin x$ oe **B1** for the area of an appropriate rectangle or rectangles soi **M1** for correct use of correct limits to find an appropriate area under the curve **A1** for the accurate area under the curve **B1** for area A or $\frac{1}{2}A$ or B or $\frac{1}{2}B$ OR **M1** for attempting to integrate sin$x$ or ±cos$x$ **M1** dep for using correct limits **A1** for a correctly integrated expression with correct limits **M1** for correct use of correct limits **A1** for exact value $A = 2$ OR equivalent correct plan
	Full, complete and actioned method to find the second, corresponding area	**3**	**B1** for Area($A + B$) or $\frac{1}{2}$Area($A + B$) oe **M1** for using Area($A + B$) to find A or B or for using $\frac{1}{2}$Area($A + B$) to find $\frac{1}{2}A$ or $\frac{1}{2}B$ oe **A1** for exact value OR **B1** for $4\pi - \left(2\int_0^{\frac{\pi}{2}}(1+\cos x)\mathrm{d}x + \left(\frac{3\pi}{2}-\frac{\pi}{2}\right)\right)$ oe **M1** for correct use of correct limits **A1** for exact value $B = 2\pi - 2$ OR equivalent correct plan
	$k = \pi - 1$ cao	**B1**	**dep** on all previous marks; allow $k = \frac{2\pi - 2}{2}$

Question	Answer	Marks	Partial Marks
12	$x^{\frac{1}{2}}+2+x^{-\frac{1}{2}}$	B2	**B1** for $(x^{\frac{1}{4}}+x^{-\frac{1}{4}})^2$ or $\frac{x+2\sqrt{x}+1}{\sqrt{x}}$ oe seen or for two terms correct in $x^{\frac{1}{2}}+2+x^{-\frac{1}{2}}$
	At least two terms correct in *their* $\left[\frac{dy}{dx}=\right]\frac{2}{3}x^{\frac{3}{2}}+2x+2x^{\frac{1}{2}}(+c)$	M1	**FT** *their* $x^{\frac{1}{2}}+2+x^{-\frac{1}{2}}$ providing at least two terms correct and no extra spurious terms
	$\frac{4}{3}=\frac{2}{3}\left[1^{\frac{3}{2}}\right]+2[1]+2\left[1^{\frac{1}{2}}\right]+c$	M1	**dep** on previous **M1** and having an arbitrary constant; condone one sign or arithmetic slip
	$\int\left(\frac{2}{3}x^{\frac{3}{2}}+2x+2x^{\frac{1}{2}}-\frac{10}{3}\right)dx$ $=\frac{4}{15}x^{\frac{5}{2}}+x^2+\frac{4}{3}x^{\frac{3}{2}}-\frac{10}{3}x+A$	A1	**FT** *their* $-\frac{10}{3}$
	$-1=\frac{4}{15}\left[1^{\frac{5}{2}}\right]+1^{[2]}+\frac{4}{3}\left[1^{\frac{3}{2}}\right]-\frac{10}{3}[1]+A$	M1	**dep** on previous **A1**; condone one sign or arithmetic slip
	$y=\frac{4}{15}x^{\frac{5}{2}}+x^2+\frac{4}{3}x^{\frac{3}{2}}-\frac{10}{3}x-\frac{4}{15}$ oe	A1	