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MATHEMATICS

MA03

(9660/MA03) Unit P2 Pure Mathematics

Mark scheme

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Key to mark scheme abbreviations

M	Mark is for method
m	Mark is dependent on one or more M marks and is for method
A	Mark is dependent on M or m marks and is for accuracy
B	Mark is independent of M or m marks and is for method and accuracy
E	Mark is for explanation
√ **or ft**	Follow through from previous incorrect result
CAO	Correct answer only
CSO	Correct solution only
AWFW	Anything which falls within
AWRT	Anything which rounds to
ACF	Any correct form
AG	Answer given
SC	Special case
oe	Or equivalent
A2, 1	2 or 1 (or 0) accuracy marks
–*x* EE	Deduct *x* marks for each error
NMS	No method shown
PI	Possibly implied
SCA	Substantially correct approach
sf	Significant figure(s)
dp	Decimal place(s)
ISW	Ignore subsequent working

Q	Answer	Marks	Comments
1(a)	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]-270x^5\left(2-5x^6\right)^8$	M1 A1	**M1**: $kx^5\left(2-5x^6\right)^8$ **A1**: **ACF** eg $9\times\left(-30x^5\right)\left(2-5x^6\right)^8$ is **M1 A1**
		2	

Q	Answer	Marks	Comments
1(b)	$\frac{\mathrm{d}y}{\mathrm{d}x}=x\times\frac{3}{3x-1}+\ln\left(3x-1\right)$	M1 A1	**M1**: $x\times\frac{k}{3x-1}+\ln\left(3x-1\right)$ **A1**: **ACF**
		2	

Q	Answer	Marks	Comments
1(c)	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]$ $\frac{\left(1-5x\right)\left(12x^2\right)-\left(-5\right)\left(4x^3\right)}{\left(1-5x\right)^2}$ $=\frac{4x^2\left(3-10x\right)}{\left(1-5x\right)^2}$	M1 A1 A1	**M1**: $\frac{\left(px^2\right)\left(1-5x\right)\ \pm5\left(4x^3\right)}{\left(1-5x\right)^2}$ OR $px^2\times\left(1-5x\right)^{-1}\pm4x^3\times\left(-1\right)\times\left(-5\right)\times\left(1-5x\right)^{-2}$ **A1**: **ACF,** such as $3\times4x^2\times\left(1-5x\right)^{-1}+4x^3\times\left(-1\right)\times\left(-5\right)\times\left(1-5x\right)^{-2}$
		3	

	Question 1 Total	**7**	

Q	Answer	Marks	Comments
2(a)	Stretch + either I or II Parallel to y-axis I Scale Factor 2 II Translation $\begin{bmatrix}1\\0\end{bmatrix}$	**M1** **A1** **M1** **A1**	Transformations in either order
		4	

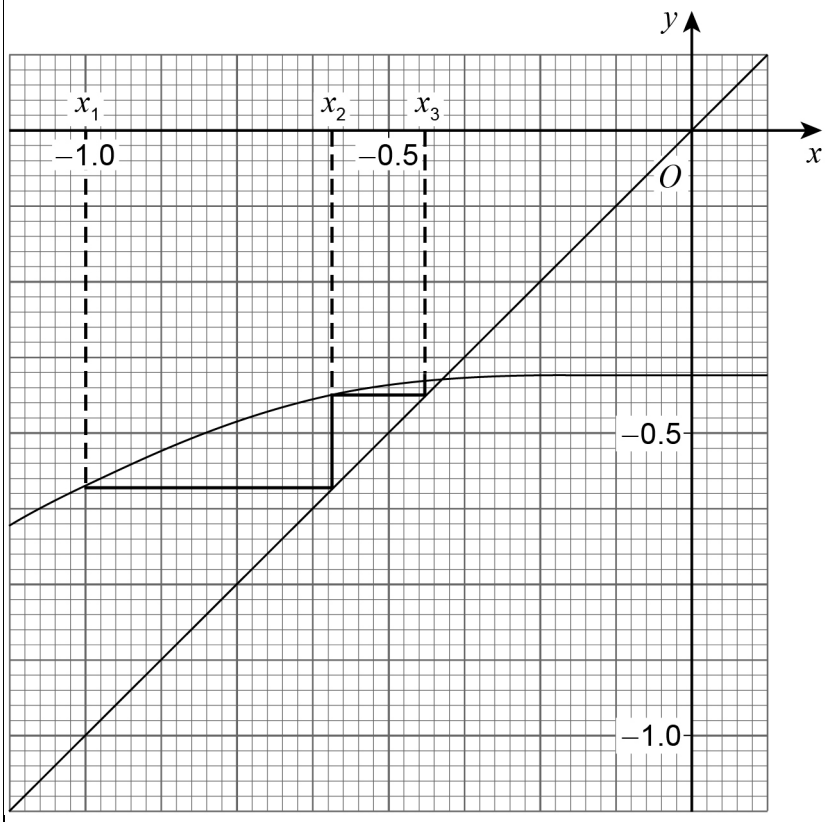
Q	Answer	Marks	Comments
2(b)	$(-1, 12)$	**B1B1**	**B1:** $(-1, k)$ **B1:** $(k, 12)$
		2	

	Question 2 Total	**6**	

Q	Answer	Marks	Comments
3(a)(i)	$f(x) = e^{(-x)} + 0.3x^3 - 1.5$ $f(-1) = 0.918$ $f(-0.1) = -0.395$	M1	Or reverse Both values rounded or truncated to at least 1 sf
	Change of sign, $-1 < \alpha < -0.1$	A1	Must have both statement and interval in words or symbols **or** comparing 2 sides: at -1, $e^1 > 1.5 - 0.3(-1)^3$, $2.7 > 1.8$ at -0.1, $e^{0.1} < 1.5 - 0.3 \times (-0.1)^3$, $1.1 < 1.5$ **(M1)** Conclusion as before **(A1)**
		2	

Q	Answer	Marks	Comments
3(a)(ii)	$e^{-x} = 1.5 - 0.3x^3$ $-x = \ln(1.5 - 0.3x^3)$ $x = -\ln(1.5 - 0.3x^3)$	B1	**AG** Must be convincingly shown
		1	

2Q	Answer	Marks	Comments
3(a)(iii)	$x_2 = -0.588$	B1	**CAO**
	$x_3 = -0.445$	B1	**CAO**
		2	

Q	Answer	Marks	Comments
3(b)		**M1** **A1**	Lines indicating a staircase in approx. correct position x_2 and x_3 in correct position (approx.)
		2	

	Question 3 Total	**7**	

Q	Answer	Marks	Comments
4(a)	$12\left(-\frac{1}{2}\right)^3+k\left(-\frac{1}{2}\right)+1=R$ $12+k+1=4R$ $13+k=4\left(-\frac{1}{2}-\frac{1}{2}k\right)$ $k=-5$	**M1** **A1** **A1**	One correct equation Both correct **AG** Must be convincingly shown
		3	

Q	Answer	Marks	Comments
4(b)	$12\left(\frac{1}{2}\right)^3-5\left(\frac{1}{2}\right)+1=1.5-2.5+1=0$ $(2x-1)$ is a factor of $\mathrm{p}(x)$	 **B1**	 **AG** Must be convincingly shown
		1	

Q	Answer	Marks	Comments
4(c)	$12x^3-5x+1=(2x-1)(6x^2+3x-1)$ $\left[6x^2+3x-1=0\right]\Rightarrow x=\frac{-3\pm\sqrt{33}}{12}$ $(6x^2+3x-1)$ has no rational solutions $\mathrm{p}(x)=0$ has only one rational root	**B1** **E1**	 **AG** Must be convincingly shown
		2	

	Question 4 Total	**6**	

Q	Answer	Marks	Comments
5(a)	$m = P\mathrm{e}^{-\frac{t}{30}}$ $0.75P = P\mathrm{e}^{-\frac{t}{30}}$ $\mathrm{e}^{-\frac{t}{30}} = 0.75$ $-\frac{t}{30} = \ln 0.75$ $\frac{t}{30} = \ln\left(\frac{4}{3}\right)$ $t = 30\ln\left(\frac{4}{3}\right) = 8.6$	**B1** **M1** **A1**	**PI** $-kt = \ln B$
		3	

Q	Answer	Marks	Comments
5(b)	$m = Pe^{-\frac{24}{30}} = Pe^{-\frac{4}{5}}$ $= 0.449P$ Change in mass $= = [\pm]55.1\%$	**M1** **A1**	
		2	

	Question 5 Total	**5**	

Q	Answer	Marks	Comments
6(a)	$g(x) \geq -1$	B1	
		1	

Q	Answer	Marks	Comments
6(b)(i)	$\left[fg(x) =\right] \ \dfrac{8}{4x^2-5}$	B1	Allow $\dfrac{8}{4(x^2-1)-1}$
		1	

Q	Answer	Marks	Comments
6(b)(ii)	[All real values of] $x \neq \pm\dfrac{\sqrt{5}}{2}$	B1	
		1	

Q	Answer	Marks	Comments
6(b)(iii)	$\left[\dfrac{8}{4x^2-5}=8\right] \quad 4x^2-5=1$ $x=\pm\sqrt{\dfrac{3}{2}}$	M1 A1	**PI** by one correct answer **ACF** eg $x=\pm\dfrac{\sqrt{6}}{2}$
		2	

Q	Answer	Marks	Comments
6(c)(i)	$x=\dfrac{8}{4y-1}$ $4y-1=\dfrac{8}{x}$ $f^{-1}(x)=\dfrac{1}{4}\left(\dfrac{8}{x}+1\right) \ =\dfrac{2}{x}+\dfrac{1}{4} \ =\dfrac{8+x}{4x}$	M1 M1 A1	Swap x, y Attempt to isolate y **ACF**
		3	

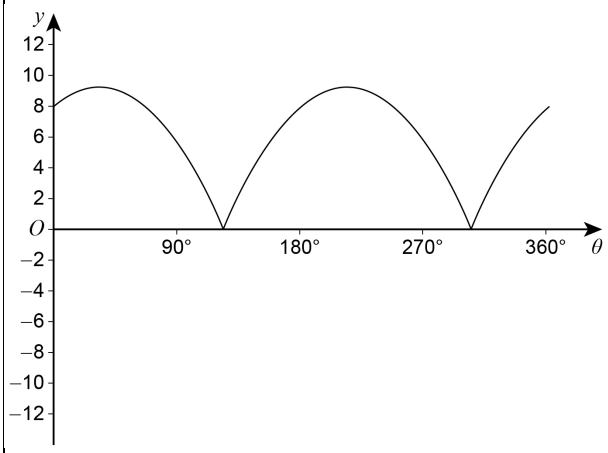
Q	Answer	Marks	Comments
6(c)(ii)	$\frac{8}{4x-1} = \frac{8+x}{4x}$ $32x = 4x^2 + 31x - 8$ $4x^2 - x - 8 = 0$ $x = \frac{1 \pm \sqrt{129}}{8}$	**M1** **A1** **A1**	Equating their correct expressions Correct 3-term quadratic equation
		3	

	Question 6 Total	**11**	

Q	Answer	Marks	Comments
7	$\left[\text{Vol} =\right]\ \pi\int_0^{\frac{\pi}{4}}\left(\sqrt{x}\cos 2x\right)^2\,\mathrm{d}x$	**B1**	Correct volume statement
	$\left[\left(\sqrt{x}\cos 2x\right)^2 = x\cos^2 2x = \frac{1}{2}x\left(1+\cos 4x\right)\right]$	**B1**	Correct use of double angle
	$\left[\text{Vol} = \pi\right]\ \int\frac{1}{2}x\,\mathrm{d}x + \int\frac{1}{2}x\cos 4x\,\mathrm{d}x$		
	$u = x \quad \mathrm{d}v = \cos 4x$ $\mathrm{d}u = 1 \quad v = \frac{\sin 4x}{4}$ $\int x\cos 4x\,\mathrm{d}x = \frac{x\sin 4x}{4} - \int\frac{\sin 4x}{4}\,\mathrm{d}x$	**M1** **m1**	Attempt at integration by parts Correct substitution into integration by parts formula
	$\int x\cos 4x\,\mathrm{d}x = \frac{x\sin 4x}{4} + \frac{\cos 4x}{16}$		
	$\left[\text{Vol} = \pi\right]\ \int\frac{1}{2}x\,\mathrm{d}x + \int\frac{1}{2}x\cos 4x\,\mathrm{d}x$ $\left[= \pi\right]\ \frac{1}{4}x^2 + \frac{x\sin 4x}{8} + \frac{\cos 4x}{32}$	**A1**	Correct integration
	$\pi\int_0^{\frac{\pi}{4}}\left(\sqrt{x}\cos 2x\right)^2\,\mathrm{d}x = \left[\pi\right]\left(\frac{\pi^2}{64} + \frac{\pi}{32}\times 0 - \frac{1}{32} - \frac{1}{32}\right)$	**M1**	Correct substitution of limits into their integration of the form $ax^2 + bx\sin 4x + c\cos 4x$
	$= \frac{\pi}{64}\left(\pi^2 - 4\right)$	**A1**	**oe**

	Question 7 Total	**7**	

Q	Answer	Marks	Comments
8(a)(i)	$[8\cos\theta + 6\sin\theta =]$ $R\cos\theta\cos\alpha + R\ \sin\theta\sin\alpha$ $R = \sqrt{8^2 + 6^2}\ = 10$ $\tan\alpha = 0.75\ \Rightarrow \alpha = 37°$	 **B1** **B1**	 **AG** Must be convincingly shown **oe AG** Must be convincingly shown
		2	

Q	Answer	Marks	Comments
8(a)(ii)		**M1** **A1**	Modulus graph with exactly two maxima Correct graph, starting at (0, 8), maxima at $y = 10$, including cusps
		2	

Q	Answer	Marks	Comments
8(a)(iii)	15	**B1**	
		1	

Q	Answer	Marks	Comments
8(b)	$8\left(\sec^2 X - 1\right) = 2\sec X + 7$	M1	Correct use of trig identity, may be in terms of $\cos X$ (could be x, X, y, x–60 etc)
	$\left(4\sec X + 5\right)\left(2\sec X - 3\right) = 0$		
	$\sec X = -1.25,\ 1.5$	A1	Allow $\cos X = -0.8,\ \frac{2}{3}$
	$X = -143,\ -217,\ \pm 48$	B1	For 3 correct values
	$x = -83°, -157°, 12°, 108°$	B1B1	**B1:** At least one correct value **B1:** All four values correct and no others in the interval
		5	

Q	Answer	Marks	Comments
8(c)	$\frac{2}{\sin y} = \frac{1}{\cos\left(y + \frac{\pi}{6}\right)}$	B1	
	$2\cos\left(y + \frac{\pi}{6}\right) = \sin y$		
	$2\cos y \cos\frac{\pi}{6} - 2\sin y \sin\frac{\pi}{6} = \sin y$	M1	Correct expansion
	$\sqrt{3}\cos y - \sin y = \sin y$	A1	Correct simplification
	$2\sin y = \sqrt{3}\cos y$		
	$\cot y = \frac{2}{\sqrt{3}}$	A1	**ACF** eg $\cot y = \frac{2\sqrt{3}}{3}$
		4	

	Question 8 Total	**14**	

Q	Answer	Marks	Comments
9(a)	$y = \mathrm{e}^{3x-2},\ \dfrac{\mathrm{d}y}{\mathrm{d}x} = 3\mathrm{e}^{3x-2}$	B1	
	$x = \dfrac{1}{2},\quad \dfrac{\mathrm{d}y}{\mathrm{d}x} = 3\mathrm{e}^{-0.5}$	B1	
	$y - \mathrm{e}^{-0.5} = 3\mathrm{e}^{-0.5}(x - \dfrac{1}{2})$	M1	Correct substitution of *their* gradient into tangent equation
	$y\sqrt{\mathrm{e}} = 3x - \dfrac{1}{2}$	A1	
		4	

Q	Answer	Marks	Comments
9(b)	$x = \dfrac{1}{2},\quad \dfrac{\mathrm{d}y}{\mathrm{d}x}(\text{normal}) = -\dfrac{1}{3\mathrm{e}^{-0.5}}$	B1	
	$y - \mathrm{e}^{-0.5} = -\dfrac{1}{3\mathrm{e}^{-0.5}}\left(x - \dfrac{1}{2}\right)$	M1	**ACF**
	$y - \dfrac{1}{\sqrt{\mathrm{e}}} = -\dfrac{\sqrt{\mathrm{e}}}{3}\left(x - \dfrac{1}{2}\right)$		
	$x = 0,\ y = \dfrac{1}{\sqrt{\mathrm{e}}} + \dfrac{\sqrt{\mathrm{e}}}{6}$	A1	Correct
	$y = 0,\ -\dfrac{1}{\sqrt{\mathrm{e}}} = -\dfrac{\sqrt{\mathrm{e}}}{3}\left(x - \dfrac{1}{2}\right)$		
	$3 = \mathrm{e}(x - \dfrac{1}{2}),\ x = \dfrac{3}{\mathrm{e}} + \dfrac{1}{2}$	A1	Correct
	$A = \dfrac{1}{2}\left(\dfrac{1}{\sqrt{\mathrm{e}}} + \dfrac{\sqrt{\mathrm{e}}}{6}\right)\left(\dfrac{3}{\mathrm{e}} + \dfrac{1}{2}\right)$	m1	Correct use of area of triangle
	$= \dfrac{(6+\mathrm{e})^2}{24\mathrm{e}^{1.5}}$	A1	
		6	

	Question 9 Total	**10**	

Q	Answer	Marks	Comments
10	$y = \dfrac{e^{-2x}}{\sin x}$		
	$\dfrac{dy}{dx} = \dfrac{\sin x \times -2e^{-2x} - e^{-2x}\cos x}{\sin^2 x} = \dfrac{-e^{-2x}(2\sin x + \cos x)}{\sin^2 x}$	**M1 A1**	**M1**: Attempt at differentiation **A1**: All correct
	$\dfrac{d^2y}{dx^2} = \dfrac{1}{\sin^4 x}\Big(\sin^2 x\left(2e^{-2x}(2\sin x + \cos x) - e^{-2x}(2\cos x - \sin x)\right)$ $-\left(-e^{-2x}(2\sin x + \cos x) \times 2\sin x\cos x\right)\Big)$	**m1 A1**	**m1**: Attempt at differentiation **A1**: All correct
	$= \dfrac{e^{-2x}(5\sin^2 x + 4\sin x\cos x + 2\cos^2 x)}{\sin^3 x}$		
	$\dfrac{d^2y}{dx^2} + 2\cot x\dfrac{dy}{dx} - 5y$ $= \dfrac{e^{-2x}(5\sin^2 x + 4\sin x\cos x + 2\cos^2 x)}{\sin^3 x}$ $+ 2\cot x\dfrac{-e^{-2x}(2\sin x + \cos x)}{\sin^2 x} - 5\dfrac{e^{-2x}}{\sin x}$		
	$= e^{-2x}\dfrac{(5\sin^2 x + 4\sin x\cos x + 2\cos^2 x) - 2\cos x(2\sin x + \cos x) - 5\sin^2 x}{\sin^3 x}$		
	$= e^{-2x}\dfrac{5\sin^2 x + 4\sin x\cos x + 2\cos^2 x - 4\sin x\cos x - 2\cos^2 x - 5\sin^2 x}{\sin^3 x}$		
	$= 0$	**A1**	**AG** Must be convincingly shown

	Question 10 Total	**5**	

Q	Answer	Marks	Comments
10 **ALT 1**	$y\sin x = e^{-2x}$ $y\cos x + \frac{\mathrm{d}y}{\mathrm{d}x}\sin x = -2\mathrm{e}^{-2x}$ $-y\sin x + \frac{\mathrm{d}y}{\mathrm{d}x}\cos x + \frac{\mathrm{d}y}{\mathrm{d}x}\cos x + \frac{\mathrm{d}^2y}{\mathrm{d}x^2}\sin x = 4\mathrm{e}^{-2x}$ $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}\sin x + 2\frac{\mathrm{d}y}{\mathrm{d}x}\cos x - y\sin x = 4y\sin x$ $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}\sin x + 2\frac{\mathrm{d}y}{\mathrm{d}x}\cos x - 5y\sin x = 0$ $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} + 2\cot x\frac{\mathrm{d}y}{\mathrm{d}x} - 5y = 0$	**M1A1** **m1A1** **A1**	**M1:** Attempt at differentiation **A1:** All correct **m1:** Attempt at differentiation **A1:** All correct **AG** Must be convincingly shown

	Question 10 Total	**5**	

Q	Answer	Marks	Comments
10 ALT 2	$y\sin x = \mathrm{e}^{-2x}$ $y\cos x + \dfrac{\mathrm{d}y}{\mathrm{d}x}\sin x = -2\,\mathrm{e}^{-2x} = -2y\sin x$	**M1 A1**	**M1**: Attempt at differentiation **A1**: All correct
	$\dfrac{\mathrm{d}y}{\mathrm{d}x}\sin x = -y\left(\cos x + 2\sin x\right) \Rightarrow \dfrac{\mathrm{d}y}{\mathrm{d}x} = -y\left(\cot x + 2\right)$		
	$\dfrac{\mathrm{d}^2y}{\mathrm{d}x^2} = -\dfrac{\mathrm{d}y}{\mathrm{d}x}\left(\cot x + 2\right) - y\left(-\mathrm{cosec}^2 x\right)$ $= -\dfrac{\mathrm{d}y}{\mathrm{d}x}\left(\cot x + 2\right) + y\left(1 + \cot^2 x\right)$	**m1 A1**	**m1**: Attempt at differentiation **A1**: All correct
	$\dfrac{\mathrm{d}^2y}{\mathrm{d}x^2} + 2\cot x\dfrac{\mathrm{d}y}{\mathrm{d}x} - 5y$ $= -\dfrac{\mathrm{d}y}{\mathrm{d}x}\left(\cot x + 2\right) + y\left(1 + \cot^2 x\right) + 2\cot x\dfrac{\mathrm{d}y}{\mathrm{d}x} - 5y$ $= \dfrac{\mathrm{d}y}{\mathrm{d}x}\left(\cot x - 2\right) + y\left(\cot^2 x - 4\right)$ $= -y\left(\cot x + 2\right)\left(\cot x - 2\right) + y\left(\cot x + 2\right)\left(\cot x - 2\right)$ $= 0$	**A1**	**AG** Must be convincingly shown

	Question 10 Total	**5**	

Q	Answer	Marks	Comments
11	$u = x^2 - 8 \Rightarrow \mathrm{d}u = 2x\,\mathrm{d}x$	**B1**	**oe**
	$\int \frac{2x^3}{\sqrt{x^2-8}}\mathrm{d}x = \int \frac{2x^2\ x}{\sqrt{x^2-8}}\mathrm{d}x = \int \frac{(u+8)}{\sqrt{u}}\mathrm{d}u$	**M1**	All in terms of u
	$= \int \left(u^{0.5} + 8u^{-0.5}\right)\mathrm{d}u$	**A1**	
	$= \frac{2}{3}u^{1.5} + 16u^{0.5}$	**M1**	Integration $au^{1.5} + bu^{0.5}$
	$[u]_1^8 = \left[x^2 - 8\right]_3^4$	**B1**	Change of limits, or variable
	$\left[\frac{2}{3}u^{1.5} + 16u^{0.5}\right]_1^8 = \left[\frac{2}{3}\times 8^{\frac{3}{2}} + 16\times 8^{\frac{1}{2}}\right] - \left[\frac{2}{3} + 16\right]$	**m1**	Correct substitution of limits
	$= \frac{16\sqrt{8}}{3} + 16\times\sqrt{8} - 16\frac{2}{3}$		
	$= \frac{128\sqrt{2} - 50}{3} = \frac{2}{3}\left(64\sqrt{2} - 25\right)$	**A1**	**CAO**

	Question 11 Total	**7**	

Q	Answer	Marks	Comments
12(a)(i)	$(4+3x)^{-1} = \frac{1}{4}\left(1 + \frac{3}{4}x\right)^{-1}$	**M1**	
	$= \frac{1}{4}\left(1 - \frac{3}{4}x + \frac{9}{16}x^2\right) = \frac{1}{4} - \frac{3}{16}x + \frac{9}{64}x^2$	**A1**	
		2	

Q	Answer	Marks	Comments
12(a)(ii)	$-\frac{4}{3} < x < \frac{4}{3}$	**B1**	**oe**
		1	

Q	Answer	Marks	Comments
12(b)	$\mathrm{f}(x)=\dfrac{A}{(2-x)}+\dfrac{B}{(4-3x)}+\dfrac{C}{(4+3x)}$		
	$80=A(4+3x)(4-3x)+B(2-x)(4+3x)+C(2-x)(4-3x)$	**B1**	Correctly eliminating fractions
	$x=2,\ \ 80=-20A,\ \ A=-4$	**M1**	Attempt at finding one constant
	$x=\dfrac{4}{3},\ \ 80=\dfrac{16}{3}B,\ \ B=15$	**A1**	Two constants correct
	$x=-\dfrac{4}{3},\ \ 80=\dfrac{80}{3}C,\ \ C=3$	**A1**	All correct
	$\mathrm{f}(x)=\dfrac{-4}{(2-x)}+\dfrac{15}{(4-3x)}+\dfrac{3}{(4+3x)}$		
	$(2-x)^{-1}=\left(\dfrac{1}{2}\right)\left(1+\dfrac{x}{2}+\dfrac{x^2}{4}\right)$	**B1**	**oe**
	$(4-3x)^{-1}=\dfrac{1}{4}\left(1+\dfrac{3}{4}x+\dfrac{9}{16}x^2\right)$	**B1**	**oe**
	$\mathrm{f}(x)$:		
	$-4\left(\dfrac{1}{2}+\dfrac{x}{4}+\dfrac{x^2}{8}\right)+15\left(\dfrac{1}{4}+\dfrac{3x}{16}+\dfrac{9x^2}{64}\right)+3\left(\dfrac{1}{4}-\dfrac{3x}{16}+\dfrac{9x^2}{64}\right)$	**M1**	
	$=\left(-2+\dfrac{15}{4}+\dfrac{3}{4}\right)+\left(-1+\dfrac{45}{16}-\dfrac{9}{16}\right)x+\left(-\dfrac{1}{2}+\dfrac{135}{64}+\dfrac{27}{64}\right)x^2$	**A1**	Two terms correct (unsimplified)
	$=\dfrac{5}{2}+\dfrac{5x}{4}+\dfrac{65x^2}{32}$	**A1**	
		9	

	Question 12 Total	**12**	

Q	Answer	Marks	Comments
13	$\left[2\left(x^2+1\right)\dfrac{\mathrm{d}y}{\mathrm{d}x}=x\left(y+3\right)\right]$		
	$\displaystyle\int\frac{2}{y+3}\mathrm{d}y=\int\frac{x}{x^2+1}\mathrm{d}x$	**B1**	
	$2\ln\left(y+3\right)=\dfrac{1}{2}\ln\left(x^2+1\right)+c$	**M1** **A1**	Attempt to integrate All correct
	At (1, 1) $2\ln 4=\dfrac{1}{2}\ln\left(2\right)+c$ or $4\ln 2-\dfrac{1}{2}\ln 2=c \quad c=\dfrac{7}{2}\ln 2$	**m1** **A1**	Attempt to find c **oe**
	$2\ln\left(y+3\right)=\dfrac{1}{2}\ln\left(x^2+1\right)+\dfrac{7}{2}\ln 2$		
	$4\ln\left(y+3\right)=\ln\left(x^2+1\right)+7\ln 2$		
	$\left(y+3\right)^4=128\left(x^2+1\right)$	**M1**	Eliminating ln
	$y+3=\left(128\left(x^2+1\right)\right)^{0.25}$	**m1**	Isolating y
	$y=\left(128\left(x^2+1\right)\right)^{0.25}-3$	**A1**	**ACF**

	Question 13 Total	**8**	

Q	Answer	Marks	Comments
14	P has coordinates $(4-3p,\ 11-4p,\ -9+5p)$	**B1**	**PI**
	$AP = \begin{bmatrix} 2-3p \\ 11-4p \\ -10+5p \end{bmatrix}$	**B1**	
	$\begin{bmatrix} 2-3p \\ 11-4p \\ -10+5p \end{bmatrix} \cdot \begin{bmatrix} -3 \\ -4 \\ 5 \end{bmatrix} = 0$	**M1**	Attempt at dot product
	$-6+9p-44+16p-50+25p=0$		
	$50p = 100$		
	$p = 2$	**A1**	
	P has coordinates $(-2,\ 3,\ 1)$		
	$\left\lvert\overrightarrow{AP}\right\rvert = \sqrt{\left(2-(-2)\right)^2+\left(0-(3)\right)^2+(1-1)^2}$	**m1**	Attempt at finding distance AP
	$\left\lvert\overrightarrow{AP}\right\rvert = \sqrt{25} = 5$	**A1**	

	Question 14 Total	**6**	

Q	Answer	Marks	Comments
15(a)	$t = \dfrac{y}{2a} \qquad x = a\left(\dfrac{y}{2a}\right)^2$ $y^2 = 4ax$	**M1** **A1**	
		2	

Q	Answer	Marks	Comments
15(b)	$\dfrac{\mathrm{d}x}{\mathrm{d}t} = 2at \qquad \dfrac{\mathrm{d}y}{\mathrm{d}t} = 2a$ $\dfrac{\mathrm{d}y}{\mathrm{d}x} = \dfrac{1}{t}$ When $t = p$, $\dfrac{\mathrm{d}y}{\mathrm{d}x}(\text{normal}) = -p$ $y - 2ap = -p\left(x - ap^2\right)$ $y + px = 2ap + ap^3$	**M1** **A1** **A1**	**AG** Must be convincingly shown
		3	

Q	Answer	Marks	Comments
15(c)(i)	$2q + pq^2 = 2p + p^3$ $2q - 2p = p^3 - pq^2$ $2(q - p) = p\left(p^2 - q^2\right)$ $-2 = p(p + q)$ $p^2 + pq + 2 = 0$	**M1** **A1**	**AG** Must be convincingly shown
		2	

Q	Answer	Marks	Comments
15(c)(ii)	$q = -\frac{2}{p} - p \Rightarrow \frac{\mathrm{d}q}{\mathrm{d}p} = \frac{2}{p^2} - 1$ $\left[\frac{\mathrm{d}q}{\mathrm{d}p} = \frac{2}{p^2} - 1 = 0 \Rightarrow\right] p^2 = 2$	**M1** **A1**	
		2	

	Question 15 Total	**9**	