Mark Scheme (Results)
Summer 2009

GCE

GCE Mathematics (6666/01)

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June 2009
6666 Core Mathematics C4
Mark Scheme

Question Number	Scheme	Marks
Q1	$\mathrm{f}(x) = \dfrac{1}{\sqrt{(4+x)}} = (4+x)^{-\frac{1}{2}}$	M1
	$= (4)^{-\frac{1}{2}}(1+\ \ldots\ )^{\ldots}$ $\qquad \dfrac{1}{2}(1+\ \ldots\ )^{\ldots}$ or $\dfrac{1}{2\sqrt{(1+\ldots)}}$	B1
	$= \ \ldots \left(1 + \left(-\tfrac{1}{2}\right)\left(\dfrac{x}{4}\right) + \dfrac{\left(-\frac{1}{2}\right)\left(-\frac{3}{2}\right)}{2}\left(\dfrac{x}{4}\right)^2 + \dfrac{\left(-\frac{1}{2}\right)\left(-\frac{3}{2}\right)\left(-\frac{5}{2}\right)}{3!}\left(\dfrac{x}{4}\right)^3 + \ \ldots\right)$	M1 A1ft
	ft their $\left(\dfrac{x}{4}\right)$	
	$= \dfrac{1}{2} - \dfrac{1}{16}x, + \dfrac{3}{256}x^2 - \dfrac{5}{2048}x^3 + \ \ldots$	A1, A1 (6)
		[6]
	Alternative	
	$\mathrm{f}(x) = \dfrac{1}{\sqrt{(4+x)}} = (4+x)^{-\frac{1}{2}}$	M1
	$= \underline{4^{-\frac{1}{2}}} + \left(-\tfrac{1}{2}\right)4^{-\frac{3}{2}}x + \dfrac{\left(-\frac{1}{2}\right)\left(-\frac{3}{2}\right)}{1.2}4^{-\frac{5}{2}}x^2 + \dfrac{\left(-\frac{1}{2}\right)\left(-\frac{3}{2}\right)\left(-\frac{5}{2}\right)}{1.2.3}4^{-\frac{7}{2}}x^3 + \ \ldots$	<u>B1</u> M1 A1
	$= \dfrac{1}{2} - \dfrac{1}{16}x, + \dfrac{3}{256}x^2 - \dfrac{5}{2048}x^3 + \ \ldots$	A1, A1 (6)

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Question Number	Scheme		Marks
Q2 (a)	1.14805	awrt 1.14805	B1 (1)
(b)	$A \approx \frac{1}{2} \times \frac{3\pi}{8}(\ \dots\ )$		B1
	$= \ \dots \ \left(3 + 2\left(2.77164 + 2.12132 + 1.14805\right) + 0\right)$	0 can be implied	M1
	$= \ \frac{3\pi}{16}\left(3 + 2\left(2.77164 + 2.12132 + 1.14805\right)\right)$	ft their (a)	A1ft
	$= \frac{3\pi}{16} \times 15.08202\ \dots \ = 8.884$	cao	A1 (4)
(c)	$\int 3\cos\left(\frac{x}{3}\right)\mathrm{d}x = \frac{3\sin\left(\frac{x}{3}\right)}{\frac{1}{3}}$		M1 A1
	$= 9\sin\left(\frac{x}{3}\right)$		
	$A = \left[9\sin\left(\frac{x}{3}\right)\right]_0^{\frac{3\pi}{2}} = 9 - 0 = 9$	cao	A1 (3)
			[8]

Question Number	Scheme	Marks
Q3 (a)	$\mathrm{f}(x) = \dfrac{4-2x}{(2x+1)(x+1)(x+3)} = \dfrac{A}{2x+1} + \dfrac{B}{x+1} + \dfrac{C}{x+3}$	
	$4-2x = A(x+1)(x+3) + B(2x+1)(x+3) + C(2x+1)(x+1)$	M1
	A method for evaluating one constant	M1
	$x \to -\frac{1}{2}, \quad 5 = A\left(\frac{1}{2}\right)\left(\frac{5}{2}\right) \Rightarrow A = 4$ any one correct constant	A1
	$x \to -1, \quad 6 = B(-1)(2) \Rightarrow B = -3$	
	$x \to -3, \quad 10 = C(-5)(-2) \Rightarrow C = 1$ all three constants correct	A1 (4)
(b)	(i) $\displaystyle\int \left(\frac{4}{2x+1} - \frac{3}{x+1} + \frac{1}{x+3} \right) \mathrm{d}x$	
	$= \dfrac{4}{2}\ln(2x+1) - 3\ln(x+1) + \ln(x+3) + C$ A1 two ln terms correct	M1 A1ft
	All three ln terms correct and "$+C$" ; ft constants	A1ft (3)
	(ii) $\left[2\ln(2x+1) - 3\ln(x+1) + \ln(x+3)\right]_0^2$	
	$= (2\ln 5 - 3\ln 3 + \ln 5) - (2\ln 1 - 3\ln 1 + \ln 3)$	M1
	$= 3\ln 5 - 4\ln 3$	
	$= \ln\left(\dfrac{5^3}{3^4}\right)$	M1
	$= \ln\left(\dfrac{125}{81}\right)$	A1 (3)
		[10]

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Question Number	Scheme	Marks
Q4 (a)	$e^{-2x}\dfrac{dy}{dx}-2ye^{-2x}=2+2y\dfrac{dy}{dx}$ A1 correct RHS	M1 A1
	$\dfrac{d}{dx}\left(ye^{-2x}\right)=e^{-2x}\dfrac{dy}{dx}-2ye^{-2x}$	B1
	$\left(e^{-2x}-2y\right)\dfrac{dy}{dx}=2+2ye^{-2x}$	M1
	$\dfrac{dy}{dx}=\dfrac{2+2ye^{-2x}}{e^{-2x}-2y}$	A1 (5)
(b)	At P , $\dfrac{dy}{dx}=\dfrac{2+2e^{0}}{e^{0}-2}=-4$	M1
	Using $mm'=-1$	
	$m'=\dfrac{1}{4}$	M1
	$y-1=\dfrac{1}{4}(x-0)$	M1
	$x-4y+4=0$ or any integer multiple	A1 (4)
		[9]
	Alternative for (a) *differentiating implicitly with respect to y.*	
	$e^{-2x}-2ye^{-2x}\dfrac{dx}{dy}=2\dfrac{dx}{dy}+2y$ A1 correct RHS	M1 A1
	$\dfrac{d}{dy}\left(ye^{-2x}\right)=e^{-2x}-2ye^{-2x}\dfrac{dx}{dy}$	B1
	$\left(2+2ye^{-2x}\right)\dfrac{dx}{dy}=e^{-2x}-2y$	M1
	$\dfrac{dx}{dy}=\dfrac{e^{-2x}-2y}{2+2ye^{-2x}}$	
	$\dfrac{dy}{dx}=\dfrac{2+2ye^{-2x}}{e^{-2x}-2y}$	A1 (5)

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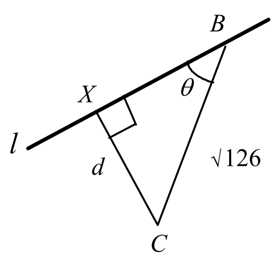
Question Number	Scheme	Marks
Q5 (a)	$\frac{dx}{dt} = -4\sin 2t$, $\frac{dy}{dt} = 6\cos t$	B1, B1
	$\frac{dy}{dx} = -\frac{6\cos t}{4\sin 2t}$ $\left(= -\frac{3}{4\sin t}\right)$	M1
	At $t = \frac{\pi}{3}$, $m = -\frac{3}{4 \times \frac{\sqrt{3}}{2}} = -\frac{\sqrt{3}}{2}$ accept equivalents, awrt -0.87	A1 (4)
(b)	Use of $\cos 2t = 1 - 2\sin^2 t$	M1
	$\cos 2t = \frac{x}{2}$, $\sin t = \frac{y}{6}$	
	$\frac{x}{2} = 1 - 2\left(\frac{y}{6}\right)^2$	M1
	Leading to $y = \sqrt{(18-9x)}$ $\left(= 3\sqrt{(2-x)}\right)$ cao	A1
	$-2 \le x \le 2$ $k = 2$	B1 (4)
(c)	$0 \le f(x) \le 6$ either $0 \le f(x)$ or $f(x) \le 6$	B1
	Fully correct. Accept $0 \le y \le 6$, $[0, 6]$	B1 (2)
		[10]
	Alternatives to (a) *where the parameter is eliminated*	
	① $y = (18-9x)^{\frac{1}{2}}$	
	$\frac{dy}{dx} = \frac{1}{2}(18-9x)^{-\frac{1}{2}} \times (-9)$	B1
	At $t = \frac{\pi}{3}$, $x = \cos\frac{2\pi}{3} = -1$	B1
	$\frac{dy}{dx} = \frac{1}{2} \times \frac{1}{\sqrt{(27)}} \times -9 = -\frac{\sqrt{3}}{2}$	M1 A1 (4)
	② $y^2 = 18 - 9x$	
	$2y\frac{dy}{dx} = -9$	B1
	At $t = \frac{\pi}{3}$, $y = 6\sin\frac{\pi}{3} = 3\sqrt{3}$	B1
	$\frac{dy}{dx} = -\frac{9}{2 \times 3\sqrt{3}} = -\frac{\sqrt{3}}{2}$	M1 A1 (4)

Question Number	Scheme	Marks
Q6 (a)	$\int \sqrt{(5-x)}\,dx = \int (5-x)^{\frac{1}{2}}\,dx = \dfrac{(5-x)^{\frac{3}{2}}}{-\frac{3}{2}} \quad (+C)$	M1 A1 (2)
	$\left(= -\dfrac{2}{3}(5-x)^{\frac{3}{2}} + C\right)$	
(b)	(i) $\int (x-1)\sqrt{(5-x)}\,dx = -\dfrac{2}{3}(x-1)(5-x)^{\frac{3}{2}} + \dfrac{2}{3}\int (5-x)^{\frac{3}{2}}\,dx$	M1 A1ft
	$= \quad \ldots \quad + \dfrac{2}{3} \times \dfrac{(5-x)^{\frac{5}{2}}}{-\frac{5}{2}} \quad (+C)$	M1
	$= -\dfrac{2}{3}(x-1)(5-x)^{\frac{3}{2}} - \dfrac{4}{15}(5-x)^{\frac{5}{2}} \quad (+C)$	A1 (4)
	(ii) $\left[-\dfrac{2}{3}(x-1)(5-x)^{\frac{3}{2}} - \dfrac{4}{15}(5-x)^{\frac{5}{2}}\right]_1^5 = (0-0) - \left(0 - \dfrac{4}{15} \times 4^{\frac{5}{2}}\right)$	
	$= \dfrac{128}{15}\left(= 8\dfrac{8}{15} \approx 8.53\right)$ awrt 8.53	M1 A1 (2)
		[8]
	Alternatives for (b) *and* (c)	
	(b) $u^2 = 5 - x \Rightarrow 2u\dfrac{du}{dx} = -1 \quad \left(\Rightarrow \dfrac{dx}{du} = -2u\right)$	
	$\int (x-1)\sqrt{(5-x)}\,dx = \int (4-u^2)u\dfrac{dx}{du}\,du = \int (4-u^2)u(-2u)\,du$	M1 A1
	$= \int (2u^4 - 8u^2)\,du = \dfrac{2}{5}u^5 - \dfrac{8}{3}u^3 \quad (+C)$	M1
	$= \dfrac{2}{5}(5-x)^{\frac{5}{2}} - \dfrac{8}{3}(5-x)^{\frac{3}{2}} \quad (+C)$	A1
	(c) $x = 1 \Rightarrow u = 2, \quad x = 5 \Rightarrow u = 0$	
	$\left[\dfrac{2}{5}u^5 - \dfrac{8}{3}u^3\right]_2^0 = (0-0) - \left(\dfrac{64}{5} - \dfrac{64}{3}\right)$	M1
	$= \dfrac{128}{15}\left(= 8\dfrac{8}{15} \approx 8.53\right)$ awrt 8.53	A1 (2)

Question Number	Scheme	Marks
Q7 (a)	$\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA} = \begin{pmatrix}10\\14\\-4\end{pmatrix} - \begin{pmatrix}8\\13\\-2\end{pmatrix} = \begin{pmatrix}2\\1\\-2\end{pmatrix}$ or $\overrightarrow{BA} = \begin{pmatrix}-2\\-1\\2\end{pmatrix}$	M1
	$\mathbf{r} = \begin{pmatrix}8\\13\\-2\end{pmatrix} + \lambda\begin{pmatrix}2\\1\\-2\end{pmatrix}$ *or* $\mathbf{r} = \begin{pmatrix}10\\14\\-4\end{pmatrix} + \lambda\begin{pmatrix}2\\1\\-2\end{pmatrix}$ accept equivalents	M1 A1ft (3)
(b)	$\overrightarrow{CB} = \overrightarrow{OB} - \overrightarrow{OC} = \begin{pmatrix}10\\14\\-4\end{pmatrix} - \begin{pmatrix}9\\9\\6\end{pmatrix} = \begin{pmatrix}1\\5\\-10\end{pmatrix}$ or $\overrightarrow{BC} = \begin{pmatrix}-1\\-5\\10\end{pmatrix}$	
	$CB = \sqrt{\left(1^2 + 5^2 + (-10)^2\right)} = \sqrt{(126)} \quad (= 3\sqrt{14} \approx 11.2)$ awrt 11.2	M1 A1 (2)
(c)	$\overrightarrow{CB}.\overrightarrow{AB} = \lvert\overrightarrow{CB}\rvert\lvert\overrightarrow{AB}\rvert\cos\theta$	
	$(\pm)(2+5+20) = \sqrt{126}\sqrt{9}\cos\theta$	M1 A1
	$\cos\theta = \frac{3}{\sqrt{14}} \Rightarrow \theta \approx 36.7°$ awrt 36.7°	A1 (3)
(d)		
	$\frac{d}{\sqrt{126}} = \sin\theta$	M1 A1ft
	$d = 3\sqrt{5}(\approx 6.7)$ awrt 6.7	A1 (3)
(e)	$BX^2 = BC^2 - d^2 = 126 - 45 = 81$	M1
	$!\ CBX = \frac{1}{2} \times BX \times d = \frac{1}{2} \times 9 \times 3\sqrt{5} = \frac{27\sqrt{5}}{2}(\approx 30.2)$ awrt 30.1 or 30.2	M1 A1 (3)
		[14]
	Alternative for (e)	
	$!\ CBX = \frac{1}{2} \times d \times BC\sin\angle XCB$	M1
	$= \frac{1}{2} \times 3\sqrt{5} \times \sqrt{126}\sin(90 - 36.7)°$ sine of correct angle	M1
	≈ 30.2 $\quad \frac{27\sqrt{5}}{2}$, awrt 30.1 or 30.2	A1 (3)

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Question Number	Scheme	Marks
Q8 (a)	$\int \sin^2\theta \, d\theta = \frac{1}{2}\int (1-\cos 2\theta)\, d\theta = \frac{1}{2}\theta - \frac{1}{4}\sin 2\theta \quad (+C)$	M1 A1 (2)
(b)	$x = \tan\theta \Rightarrow \frac{dx}{d\theta} = \sec^2\theta$	
	$\pi\int y^2\, dx = \pi\int y^2 \frac{dx}{d\theta}\, d\theta = \pi\int (2\sin 2\theta)^2 \sec^2\theta\, d\theta$	M1 A1
	$= \pi\int \frac{(2\times 2\sin\theta\cos\theta)^2}{\cos^2\theta}\, d\theta$	M1
	$= 16\pi\int \sin^2\theta\, d\theta \qquad k = 16\pi$	A1
	$x = 0 \Rightarrow \tan\theta = 0 \Rightarrow \theta = 0, \quad x = \frac{1}{\sqrt{3}} \Rightarrow \tan\theta = \frac{1}{\sqrt{3}} \Rightarrow \theta = \frac{\pi}{6}$	B1 (5)
	$\left(V = 16\pi\int_0^{\frac{\pi}{6}} \sin^2\theta\, d\theta\right)$	
(c)	$V = 16\pi\left[\frac{1}{2}\theta - \frac{\sin 2\theta}{4}\right]_0^{\frac{\pi}{6}}$	M1
	$= 16\pi\left[\left(\frac{\pi}{12} - \frac{1}{4}\sin\frac{\pi}{3}\right) - (0-0)\right]$ Use of correct limits	M1
	$= 16\pi\left(\frac{\pi}{12} - \frac{\sqrt{3}}{8}\right) = \frac{4}{3}\pi^2 - 2\pi\sqrt{3} \qquad p = \frac{4}{3},\ q = -2$	A1 (3)
		[10]