Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	6	6	6	/	0	1	Signature	

Paper Reference(s)

6666/01

Edexcel GCE

Core Mathematics C4

Advanced

Monday 15 June 2009 – Afternoon

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
8	
Total	

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Orange or Green)	Nil

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initials and signature.
Check that you have the correct question paper.
Answer ALL the questions.
You must write your answer for each question in the space following the question.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 8 questions in this question paper. The total mark for this paper is 75.
There are 28 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You should show sufficient working to make your methods clear to the Examiner.
Answers without working may not gain full credit.

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1. $$\mathrm{f}(x)=\frac{1}{\sqrt{(4+x)}},\qquad |x|<4$$

Find the binomial expansion of $\mathrm{f}(x)$ in ascending powers of x, up to and including the term in x^3. Give each coefficient as a simplified fraction.

(6)

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June 2009
6666 Core Mathematics C4
Mark Scheme

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

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2.

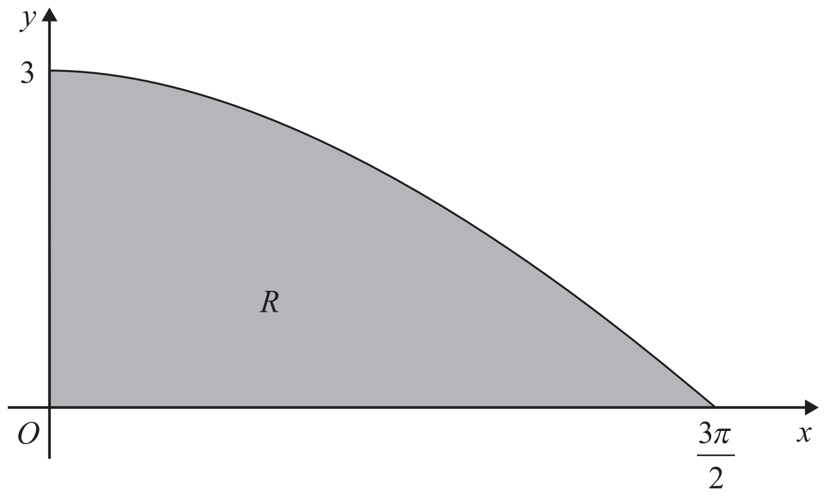

Figure 1

Figure 1 shows the finite region R bounded by the x-axis, the y-axis and the curve with equation $y = 3\cos\left(\dfrac{x}{3}\right)$, $0 \leqslant x \leqslant \dfrac{3\pi}{2}$.

The table shows corresponding values of x and y for $y = 3\cos\left(\dfrac{x}{3}\right)$.

x	0	$\frac{3\pi}{8}$	$\frac{3\pi}{4}$	$\frac{9\pi}{8}$	$\frac{3\pi}{2}$
y	3	2.77164	2.12132		0

(a) Complete the table above giving the missing value of y to 5 decimal places.
(1)

(b) Using the trapezium rule, with all the values of y from the completed table, find an approximation for the area of R, giving your answer to 3 decimal places.
(4)

(c) Use integration to find the exact area of R.
(3)

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Question Number	Scheme		Marks
Q2 (a)	1.14805	awrt 1.14805	B1 (1)
(b)	$A \approx \frac{1}{2} \times \frac{3\pi}{8}(\;...\;)$		B1
	$= \;...\; \left(3 + 2\left(2.77164 + 2.12132 + 1.14805\right) + 0\right)$	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
	$= \frac{3\pi}{16} \times 15.08202\;... \;= 8.884$	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]

Leave blank

3. $$\mathrm{f}(x) = \frac{4-2x}{(2x+1)(x+1)(x+3)} = \frac{A}{2x+1} + \frac{B}{x+1} + \frac{C}{x+3}$$

(a) Find the values of the constants A, B and C.

(4)

(b) (i) Hence find $\int \mathrm{f}(x)\,\mathrm{d}x$.

(3)

(ii) Find $\int_0^2 \mathrm{f}(x)\,\mathrm{d}x$ in the form $\ln k$, where k is a constant.

(3)

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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) $\displaystyle\int\left(\frac{4}{2x+1}-\frac{3}{x+1}+\frac{1}{x+3}\right)\mathrm{d}x$	
	$=\frac{4}{2}\ln(2x+1)-3\ln(x+1)+\ln(x+3)+C$ 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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4. The curve C has the equation $ye^{-2x} = 2x + y^2$.

(a) Find $\frac{dy}{dx}$ in terms of x and y.

(5)

The point P on C has coordinates $(0, 1)$.

(b) Find the equation of the normal to C at P, giving your answer in the form $ax + by + c = 0$, where a, b and c are integers.

(4)

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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5.

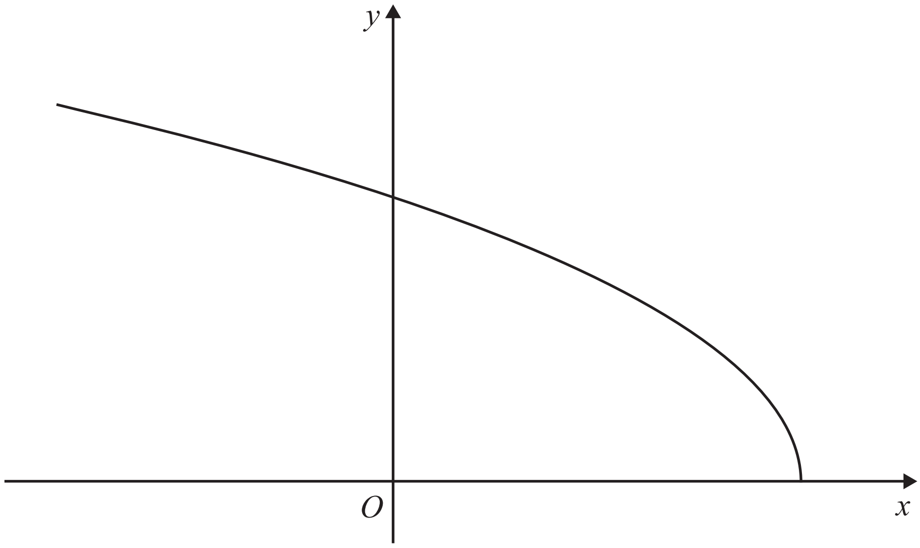

Figure 2

Figure 2 shows a sketch of the curve with parametric equations

$$x = 2\cos 2t, \qquad y = 6\sin t, \qquad 0 \leqslant t \leqslant \frac{\pi}{2}$$

(a) Find the gradient of the curve at the point where $t = \dfrac{\pi}{3}$.

(4)

(b) Find a cartesian equation of the curve in the form

$$y = \mathrm{f}(x), \quad -k \leqslant x \leqslant k,$$

stating the value of the constant k.

(4)

(c) Write down the range of $\mathrm{f}(x)$.

(2)

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Question Number	Scheme	Marks
Q5 (a)	$\frac{dx}{dt} = -4\sin 2t$, $\frac{dy}{dt} = 6\cos t$	B1, B1
	$\frac{dy}{dx} = -\frac{6\cos t}{4\sin 2t} \quad \left(= -\frac{3}{4\sin t}\right)$	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)

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6. (a) Find $\int \sqrt{(5-x)}\,\mathrm{d}x$.

(2)

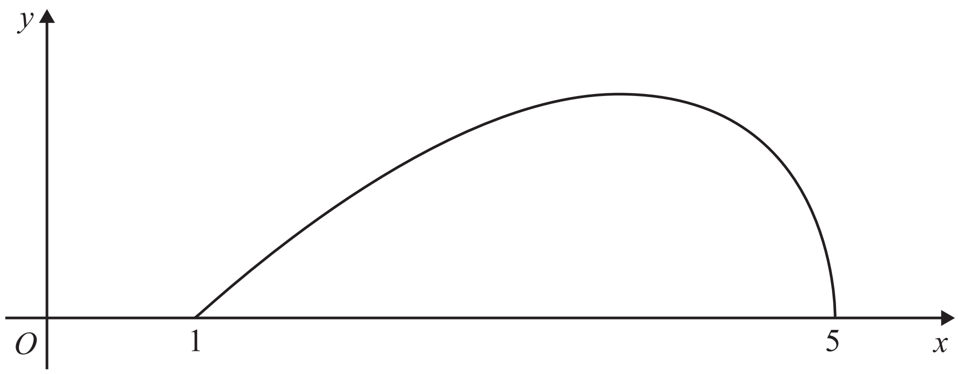

Figure 3

Figure 3 shows a sketch of the curve with equation

$$y = (x-1)\sqrt{(5-x)}, \qquad 1 \leqslant x \leqslant 5$$

(b) (i) Using integration by parts, or otherwise, find

$$\int (x-1)\sqrt{(5-x)}\,\mathrm{d}x$$

(4)

(ii) Hence find $\int_1^5 (x-1)\sqrt{(5-x)}\,\mathrm{d}x$.

(2)

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)

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7. Relative to a fixed origin O, the point A has position vector $(8\mathbf{i} + 13\mathbf{j} - 2\mathbf{k})$, the point B has position vector $(10\mathbf{i} + 14\mathbf{j} - 4\mathbf{k})$, and the point C has position vector $(9\mathbf{i} + 9\mathbf{j} + 6\mathbf{k})$.

The line l passes through the points A and B.

(a) Find a vector equation for the line l.
(3)

(b) Find $\left|\overrightarrow{CB}\right|$.
(2)

(c) Find the size of the acute angle between the line segment CB and the line l, giving your answer in degrees to 1 decimal place.
(3)

(d) Find the shortest distance from the point C to the line l.
(3)

The point X lies on l. Given that the vector $\overrightarrow{CX}$ is perpendicular to l,

(e) find the area of the triangle CXB, giving your answer to 3 significant figures.
(3)

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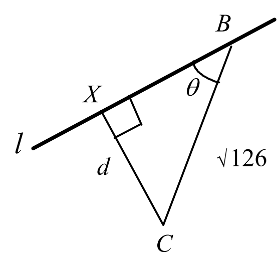
Question Number	Scheme	Marks
Q7 (a)	$\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA} = \begin{pmatrix}10\\14\\-4\end{pmatrix} - \begin{pmatrix}8\\13\\-2\end{pmatrix} = \begin{pmatrix}2\\1\\-2\end{pmatrix}$ or $\overrightarrow{BA} = \begin{pmatrix}-2\\-1\\2\end{pmatrix}$	M1
	$\mathbf{r} = \begin{pmatrix}8\\13\\-2\end{pmatrix} + \lambda\begin{pmatrix}2\\1\\-2\end{pmatrix}$ *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 $\frac{27\sqrt{5}}{2}$, awrt 30.1 or 30.2	A1 (3)

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8. (a) Using the identity $\cos 2\theta = 1 - 2\sin^2\theta$, find $\int \sin^2\theta \, d\theta$.

(2)

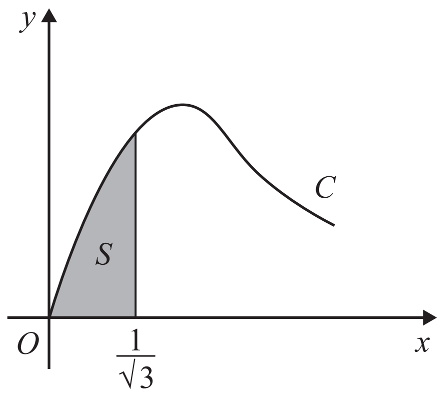

Figure 4

Figure 4 shows part of the curve C with parametric equations

$$x = \tan\theta, \qquad y = 2\sin 2\theta, \qquad 0 \leqslant \theta < \frac{\pi}{2}$$

The finite shaded region S shown in Figure 4 is bounded by C, the line $x = \frac{1}{\sqrt{3}}$ and the x-axis. This shaded region is rotated through 2π radians about the x-axis to form a solid of revolution.

(b) Show that the volume of the solid of revolution formed is given by the integral

$$k\int_0^{\frac{\pi}{6}} \sin^2\theta \, d\theta$$

where k is a constant.

(5)

(c) Hence find the exact value for this volume, giving your answer in the form $p\pi^2 + q\pi\sqrt{3}$, where p and q are constants.

(3)

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