S.G.H.S. Extn 1 Task 2 2008

Question 1 (15 marks)

Marks

a) Evaluate :

i. $3\lim_{x\to 0}\frac{\tan x}{x}$ 1

ii. $\lim_{x\to 0}\frac{\sin 5x}{4x}$ 2

b) Find, correct to the nearest degree, the acute angle between the lines 4

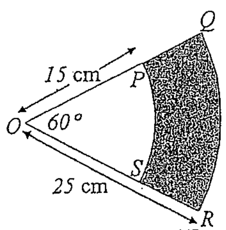
$x + y - 4 = 0$ and $y = 2x + 1$

c) Differentiate with respect to θ

i. $y = 4\cos^3\theta - 3\cos\theta$ 2

ii. $y = \sec\theta - \cot\theta$ 2

d)



NOT TO SCALE

PS and QR are arcs of concentric circles with O as centre. 4

Calculate in terms of π, the perimeter of the shaded region PQRS.

Question 2 (15 marks) (Start a new page)

Marks

a) Find the exact value of $\tan\frac{5\pi}{6}$, expressing your answer in surd form with a rational denominator. 2

b)

i. Write out the expansion of $\sin(x+y)$ 1

ii. Hence show that $\sin(x+\frac{\pi}{2}) = \cos x$ 1

c) Find:

i. $\int_0^{\frac{\pi}{4}}\cos 3x\,dx$ 2

ii. $\int_0^{\frac{\pi}{4}}\sin^2 2x.dx$ 2

d)

i. Express $\sqrt{3}\sin x + \cos x$ in the form $C\sin(x+\alpha)$ where $C > 0$ and $0 \le \alpha \le \frac{\pi}{2}$ 2

ii. Hence or otherwise, solve the equation $\sqrt{3}\sin x + \cos x = 1$ for $0 \le x \le 2\pi$ 2

e) Prove the identity $\frac{\cos 2\theta}{\sin\theta + \cos\theta} = \cos\theta - \sin\theta$. 3

Question 3 **(15 marks)** (Start a new page) Marks

a) (i) Express $\tan(\alpha - \beta)$ in terms of $\tan\alpha$ and $\tan\beta$. 1

(ii) Use the result from (i) to find the exact value of $\tan 15°$ 3

b) Let $t = \tan\frac{\theta}{2}$ and starting with $\tan\theta = \tan(\frac{\theta}{2} + \frac{\theta}{2})$, show that $\tan\theta = \frac{2t}{1-t^2}$. 3

c) Use the 't' results to solve $3\cos\theta + 4\sin\theta = -3$ for $0° \le \theta \le 360°$ giving your answer correct to the nearest minute. 4

d) Find the exact value of the volume of solid of revolution formed when the region bounded by curve y = sinx, the x-axis and the line $x = \frac{\pi}{4}$ is rotated about the x-axis. 4

Question 4 **(15 marks)** (Start a new page) Marks

a) Find the equation of the tangent to the curve $y = \frac{1}{2}\cos 4x$ at the point where $x = \frac{\pi}{8}$. 3

b) A sector of a circle has an area of 24 cm^2. Find the radius if the angle at the centre of the circle is 3 radians. 2

c) Solve the equation $\tan^2 2x = 1$ for $0 \le x \le \pi$. 3

d) Solve the equation $2\cos^2 x - \sin x - 1 = 0$ for $0 \le x \le 2\pi$. 3

e) (i) Draw a neat sketch of $y = \frac{1}{2}\sin 2x + 2$ for $0 \le x \le \pi$ showing all important features. 2

(ii) On the same graph sketch $y = 1$. 1

(iii) How many solution of $\frac{1}{2}\sin 2x + 1 = 0$ are there for $0 \le x \le \pi$? 1

End of Paper

S.G.H.S. Ext (1) - Task (2) March 2008

Question 1 (15 marks)

A ✓ E ✓
B ✓ F ✓
C ✓ G ✓
D ✓ H ✓

a) i) $3\lim_{x\to 0}\frac{\tan x}{x} = 3\times 1$

$= 3$ (1)

(ii) $\lim_{x\to 0}\frac{\sin 5x}{4x} = \frac{5}{4}\lim_{x\to 0}\frac{\sin 5x}{5x}$

$= \frac{5}{4}$ (2)

b) $x+y-4=0$ $\quad y = 2x+1$

$y = -x+4$ $\quad m_2 = 2$ 1

$m_1 = -1$ 1

$\tan\theta = \left|\frac{m_1-m_2}{1+m_1m_2}\right|$

$= \left|\frac{-1-2}{1+(-1\times 2)}\right|$ 1

$= \left|\frac{-3}{1-2}\right|$

$\tan\theta = 3$ (4)

$\therefore \theta = 71°34'$

$\doteqdot 72°$ 1

c) i) $y = 4\cos^3\theta - 3\cos\theta$

$\frac{dy}{dx} = 4.3\cos^2\theta.-\sin\theta + 3\sin\theta$

$= 3\sin\theta - 12\sin\theta\cos^2\theta$ (2)

(ii) $y = \sec\theta - \cot\theta$

$= \frac{1}{\cos\theta} - \frac{\cos\theta}{\sin\theta}$

c) (ii) $y = (\cos\theta)^{-1} - (\tan\theta)^{-1}$

$\frac{dy}{dx} = -1(\cos\theta)^{-2}.-\sin\theta + 1(\tan\theta)^{-2}\times\sec^2\theta.$

$= \frac{\sin\theta}{\cos^2\theta} + \frac{\sec^2\theta}{\tan^2\theta}.$

$= \frac{\sin\theta}{\cos^2\theta} + \frac{\cos^2\theta}{\sin^2\theta.\cos^2\theta}$

$= \frac{\sin\theta}{\cos^2\theta} + \frac{1}{\sin^2\theta}$ (2)

$= \tan\theta.\sec\theta + \mathrm{cosec}^2\theta$

d) $\theta = 60°$

$= \frac{\pi}{3}$

length of arc $PS = r\theta$

$= 15\times\frac{\pi}{3}$

$= 5\pi$ cm 1

length of arc $QR = r\theta$

$= 25\times\frac{\pi}{3}$

$= \frac{25\pi}{3}$ 1

$PQ = SR = 25-15$

$= 10$ cm 1

$\therefore$ Perimeter of Shaded Region $= 5\pi + \frac{25\pi}{3} + 20$

$= \frac{40\pi}{3} + 20$ cm. 1

(4)

Q2 a) $\tan\left(\frac{5\pi}{6}\right) = \tan\left(\pi - \frac{\pi}{6}\right)$

$= -\tan\frac{\pi}{6}$

$= \frac{-1}{\sqrt{3}}$ ($1\frac{1}{2}$ marks)

$= \frac{-\sqrt{3}}{3}$ (2 marks)

b) i) $\sin(x+y) = \sin x \cos y + \cos x \sin y$ (1 mark)

ii) $\sin\left(x+\frac{\pi}{2}\right) = \sin x \cos\frac{\pi}{2} + \cos x \sin\frac{\pi}{2}$

$= \sin x \times 0 + \cos x \times 1$

$= \cos x$ (1 mark)

c) i) $\int_0^{\pi/4} \cos 3x \, dx = \left[\frac{1}{3}\sin 3x\right]_0^{\pi/4}$

$= \frac{1}{3}\sin\frac{3\pi}{4} - 0$

$= \frac{1}{3} \times \frac{1}{\sqrt{2}}$

$= \frac{1}{3\sqrt{2}}$ ($1\frac{1}{2}$ marks)

$= \frac{\sqrt{2}}{6}$ (2 marks)

ii) $\int_0^{\pi/2} \sin^2 2x \, dx = \frac{1}{2}\int_0^{\pi/2}(1-\cos 4x)\,dx$

$= \frac{1}{2}\left[x - \frac{1}{4}\sin 4x\right]_0^{\pi/2}$ (1 mark)

$= \frac{1}{2}\left[\frac{\pi}{2} - 0\right] - [0]$

$= \frac{\pi}{4}$ (2 marks)

d) I) $C\sin(x+\alpha) = C(\sin x\cos\alpha + \cos x \sin\alpha)$

$\sqrt{3}\sin x + \cos x = C.\cos\alpha\sin x + C\sin\alpha\cos x$

$\therefore C\cos\alpha = \sqrt{3}$ ---- (1)

$C\sin\alpha = 1$ ---- (2)

$C^2(\sin^2\alpha + \cos^2\alpha) = 3+1$

$C^2 = 4$

$C = 2$ $\quad C > 0$

$\tan\alpha = \frac{1}{\sqrt{3}}$, $\alpha = \frac{\pi}{6}$

$\sqrt{3}\sin x + \cos x = 2\sin\left(x+\frac{\pi}{6}\right)$ (2 marks)

II) $2\sin\left(x+\frac{\pi}{6}\right) = 1$

$\sin\left(x+\frac{\pi}{6}\right) = \frac{1}{2}$ (1 mark)

$x + \frac{\pi}{6} = \frac{\pi}{6}, \ \pi - \frac{\pi}{6}, \ \frac{13\pi}{6}$

$x = 0, \ \frac{2\pi}{3}, \ 2\pi$ (2 mark)

e) $\frac{\cos 2\theta}{\sin\theta + \cos\theta}$

$= \frac{\cos^2\theta - \sin^2\theta}{\sin\theta + \cos\theta}$ ← (1 mark)

$= \frac{(\cos\theta + \sin\theta)(\cos\theta - \sin\theta)}{(\sin\theta + \cos\theta)}$ (2 marks)

$= \cos\theta - \sin\theta$ (3 marks)

Q3 a) i) $\tan(\alpha-\beta) = \dfrac{\tan\alpha - \tan\beta}{1+\tan\alpha\tan\beta}$

ii) $\tan 15^\circ = \tan(45^\circ - 30^\circ)$

$= \dfrac{\tan 45^\circ - \tan 30^\circ}{1+\tan 45^\circ \tan 30^\circ}$

Or: Use $(60^\circ - 45^\circ)$ etc.

$= \dfrac{1-\frac{1}{\sqrt3}}{1+1\times\frac{1}{\sqrt3}} \times \dfrac{\sqrt3}{\sqrt3}$

$= \dfrac{(\sqrt3-1)}{\sqrt3+1} \times \dfrac{(\sqrt3-1)}{(\sqrt3-1)}$

$= \dfrac{4-2\sqrt3}{2}$

$= 2-\sqrt3$

b) $\tan\theta = \tan\left(\frac{\theta}{2}+\frac{\theta}{2}\right)$

$= \dfrac{\tan\frac{\theta}{2}+\tan\frac{\theta}{2}}{1-\tan\frac{\theta}{2}\cdot\tan\frac{\theta}{2}}$

$= \dfrac{2\tan\frac{\theta}{2}}{1-\tan^2\frac{\theta}{2}}$

$= \dfrac{2t}{1-t^2}$

c) $3\cos\theta + 4\sin\theta = -3$ for $0 \le \theta \le 360^\circ$

$\sin\theta = \dfrac{2t}{1+t^2}$, $\cos\theta = \dfrac{1-t^2}{1+t^2}$

$\therefore 3\dfrac{(1-t^2)}{1+t^2} + \dfrac{4(2t)}{1+t^2} = -3$

$3(1-t^2) + 8t = -3(1+t^2)$

$3 - 3t^2 + 8t = -3 - 3t^2$

$8t = -6$

$t = -\frac{3}{4}$

$\therefore \tan\frac{\theta}{2} = -\frac{3}{4}$ for $0^\circ \le \frac{\theta}{2} \le 180^\circ$

$\therefore \frac{\theta}{2}$ is an obtuse angle

$\frac{\theta}{2} = \tan^{-1}\left(-\frac{3}{4}\right)$

$= -36^\circ 52'$

i.e. $\theta = 143^\circ 8'$ [partly cut off]

but test $\theta = 180^\circ$ as "t" method does not allow for such a solution.

When $\theta = 180^\circ$

LHS $= 3\cos 180^\circ + 4\sin 180^\circ$

$= 3\times -1 + 0$

$= -3$ $\therefore$ (True)

$=$ RHS

$\therefore$ Solutions are 180°, $286^\circ 16'$

d) $V = \pi\int_a^b y^2\,dx$

where $y = \sin x$

$\therefore y^2 = \sin^2 x$

$\therefore V = \pi\int_0^{\frac{\pi}{4}} \sin^2 x\,dx$

but $\sin^2 x = \frac{1}{2}(-\cos 2x + 1)$

$\therefore V = \pi \times \frac{1}{2}\int_0^{\frac{\pi}{4}} (-\cos 2x + 1)\,dx$

$= \frac{\pi}{2}\left[-\frac{1}{2}\sin 2x + x\right]_0^{\frac{\pi}{4}}$

$= \frac{\pi}{2} \times \left(\frac{1}{2}\sin\frac{\pi}{2} - \frac{\pi}{4}\right)$

$= \frac{\pi}{2}\left(\frac{1}{2} - \frac{\pi}{4}\right)$

$= -\frac{\pi}{4} + \frac{\pi^2}{8}$ (u^3)

$= \dfrac{\pi^2}{8} - \dfrac{\pi}{4}$

Question 4

a) $y = \frac{1}{2}\cos 4x$

$\frac{dy}{dx} = -2\sin 4x$ ✓

at $x = \frac{\pi}{8}$, $m = -2\sin\frac{\pi}{2}$
$= -2$ ✓

$y = \frac{1}{2}\cos\frac{\pi}{2}$
$= 0$ ✓

Eqn of tangent

$y - 0 = -2(x - \frac{\pi}{8})$

$y = -2x + \frac{\pi}{4}$ #

[3]

b) $A = \frac{1}{2}r^2\theta$ ✓, $A = 24$, $\theta = 3$

$24 = \frac{3}{2}r^2$

$r^2 = 16$

$r = 4$ cm ✓ #

[2]

c) $\tan^2 2x = 1$ $\quad 0 \le x \le \pi$

$\tan 2x = \pm 1$ ✓ $\quad 0 \le 2x \le 2\pi$

$2x = \frac{\pi}{4}, (\pi + \frac{\pi}{4}), (\pi - \frac{\pi}{4}), (2\pi - \frac{\pi}{4})$

$2x = \frac{\pi}{4}, \frac{5\pi}{4}, \frac{3\pi}{4}, \frac{7\pi}{4}$ ✓

$x = \frac{\pi}{8}, \frac{3\pi}{8}, \frac{5\pi}{8}, \frac{7\pi}{8}$ ✓ #

[3]

d) $2\cos^2 x - \sin x - 1 = 0$ $\quad 0 \le x \le 2\pi$

$2(1 - \sin^2 x) - \sin x - 1 = 0$ ✓

$2 - 2\sin^2 x - \sin x - 1 = 0$

$-2\sin^2 x - \sin x + 1 = 0$

$2\sin^2 x + \sin x - 1 = 0$

$(2\sin x - 1)(\sin x + 1) = 0$ ✓

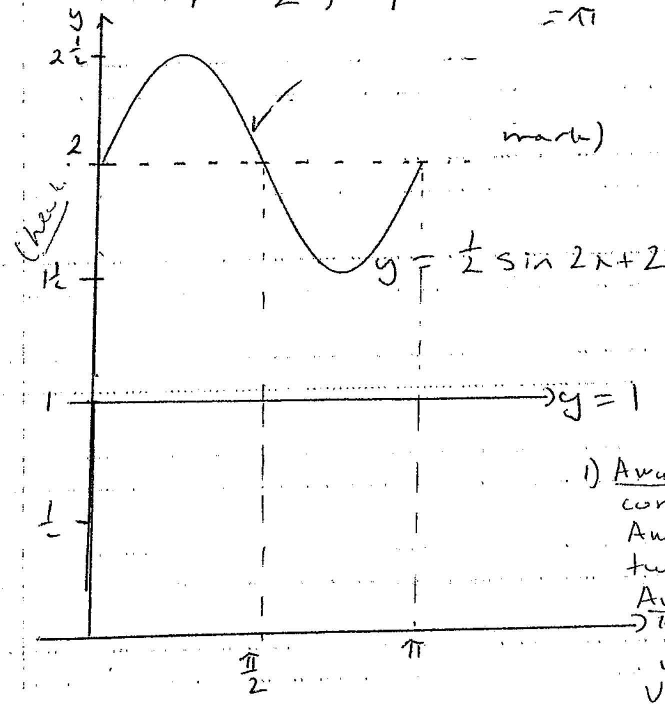
$\sin x = \frac{1}{2}$ or $\sin x = -1$ ✓

$x = \frac{\pi}{6}, \frac{5\pi}{6}, \frac{3\pi}{2}$ ✓ #

[3]

e) i) $y = \frac{1}{2}\sin 2x + 2$

amp $= \frac{1}{2}$, period $= \frac{2\pi}{2} = \pi$, Vertical shift $+2$ ✓



mark)

[2]

[1]

i) Award 1st mark for correct amp, period, Vshift. Award 1 mark for any two of above correct. Award second mark for correct sketch with correct amp, period, V. Shift. OR 1 mark for incorrect sketch (wrong period, ampl. etc of equivalent difficulty.

ii) as above

iii) $\frac{1}{2}\sin 2x + 1 = 0$

ie $\frac{1}{2}\sin 2x + 2 = 1$

this is solved by finding the intersection of $y = \frac{1}{2}\sin 2x + 2$ and $y = 1$.

As the two graphs do not intersect there are No solutions ✓

[No carry through, here as it changes the intent of the question]

[1]

Total [15]

A B C D E F G H