GCE Examinations

Advanced Subsidiary / Advanced Level

Further Pure Mathematics
Module FP2

Paper H

MARKING GUIDE

This guide is intended to be as helpful as possible to teachers by providing concise solutions and indicating how marks should be awarded. There are obviously alternative methods that would also gain full marks.

Method marks (M) are awarded for knowing and using a method.

Accuracy marks (A) can only be awarded when a correct method has been used.

(B) marks are independent of method marks.

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FP2 Paper H – Marking Guide

1. $2x^2 + y^2 = 4,\ \ 4x + 2y\frac{dy}{dx} = 0$ or $2x + y\frac{dy}{dx} = 0$ — M1 A1

$2 + y\frac{d^2y}{dx^2} + (\frac{dy}{dx})^2 = 0$ — M1 A1

at $(1, -\surd 2)$ $\quad 2 - \surd 2\frac{dy}{dx} = 0 \ \therefore\ \frac{dy}{dx} = \surd 2$ — A1

$2 - \surd 2\frac{d^2y}{dx^2} + 2 = 0 \ \therefore\ \frac{d^2y}{dx^2} = 2\surd 2$ — A1

$\rho = \frac{(1+(\sqrt{2})^2)^{\frac{3}{2}}}{2\sqrt{2}} = \frac{3\sqrt{3}}{2\sqrt{2}} = \frac{3\sqrt{6}}{4}$ — M1 A1 **(8)**

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2. *(a)* $f(x) = \cosh x = \frac{1}{2}(e^x + e^{-x})$

$f(-x) = \frac{1}{2}(e^{-x} + e^{-(-x)}) = \frac{1}{2}(e^{-x} + e^x) = f(x) \ \therefore\ \cosh x$ is even — M1 A1

(b) $\ln(xy) = \text{arcosh}\,(\frac{5}{3}) = \ln\left(\frac{5}{3} + \sqrt{\frac{25}{9} - 1}\right) = \ln 3$ — M1 A1

$\therefore\ xy = 3$ — A1

$\cosh(3x - y) = 1 \ \therefore\ 3x - y = 0$ — B1

$\therefore\ 3x = y = \frac{3}{x},\ x^2 = 1$ — M1

$x > 0 \ \therefore\ x = 1, y = 3$ — A1 **(8)**

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3. $\int \frac{1}{13\cosh x - 5\sinh x}\,dx = \int \frac{1}{\frac{13}{2}(e^x + e^{-x}) - \frac{5}{2}(e^x - e^{-x})}\,dx$ — M1

$= \int \frac{1}{4e^x + 9e^{-x}}\,dx$ — A1

$= \int \frac{e^x}{4e^{2x} + 9}\,dx$ — M1

$u = e^x,\ \frac{du}{dx} = e^x$ — M1

$= \int \frac{1}{4u^2 + 9}\,du$ — A1

$= \frac{1}{4}\int \frac{1}{u^2 + \frac{9}{4}}\,du$ — M1

$= \frac{1}{4} \times \frac{2}{3}\arctan(\frac{2u}{3}) + c$ — A1

$= \frac{1}{6}\arctan(\frac{2}{3}e^x) + c$ — A1 **(8)**

4.	*(a)*	let $y = \arcsin(2x - 1)$ $\therefore$ $\sin y = 2x - 1$		
		$\therefore$ $\cos y \dfrac{dy}{dx} = 2$	M1	
		$\dfrac{dy}{dx} = \dfrac{2}{\sqrt{1-\sin^2 y}} = \dfrac{2}{\sqrt{1-(2x-1)^2}}$	M1 A1	
		$= \dfrac{2}{\sqrt{1-(4x^2-4x+1)}} = \dfrac{2}{\sqrt{4x-4x^2}} = \dfrac{1}{\sqrt{x-x^2}}$	A1	
	(b)	$x = \frac{3}{4}$, $y = \arcsin \frac{1}{2} = \frac{\pi}{6}$	B1	
		$\dfrac{dy}{dx} = \dfrac{1}{\sqrt{\frac{3}{4}-\frac{9}{16}}} = \dfrac{1}{\sqrt{\frac{3}{16}}} = \frac{4}{\sqrt{3}}$	M1	
		eqn. is $y - \frac{\pi}{6} = \frac{4}{\sqrt{3}}(x - \frac{3}{4})$	M1	
		$x = 0$ $\therefore$ $y - \frac{\pi}{6} = \frac{4}{\sqrt{3}} \times (-\frac{3}{4})$	M1	
		$y = \frac{\pi}{6} - \sqrt{3}$	A1	**(9)**

5.	*(a)*	$2y\dfrac{dy}{dx} = 4a$ $\therefore$ $\dfrac{dy}{dx} = \dfrac{2a}{y}$	M1	
		at P, $\dfrac{dy}{dx} = \dfrac{2a}{2at} = \dfrac{1}{t}$	A1	
		eqn. is $y - 2at = \frac{1}{t}(x - at^2)$	M1	
		giving $yt = x + at^2$	A1	
	(b)	at Q, $y = 0$ $\therefore$ $x = -at^2$; at R, $x = 0$ $\therefore$ $y = at$	M1 A1	
		$\therefore$ M is $(-\frac{1}{2}at^2, \frac{1}{2}at)$	A1	
	(c)	grad of $OM = \dfrac{\frac{1}{2}at-0}{-\frac{1}{2}at^2-0} = -\frac{1}{t}$; grad of $OP = \dfrac{2at-0}{at^2-0} = \dfrac{2}{t}$	M1 A1	
		OM perp. OP $\therefore$ $\frac{2}{t} \times -\frac{1}{t} = -1$ $\therefore$ $t^2 = 2$	M1 A1	**(11)**

6. *(a)* $I_n - I_{n-2} = \int \dfrac{\cos n\theta - \cos(n-2)\theta}{\sin\theta}\ d\theta$ M1

$= \int \dfrac{-2\sin(n-1)\theta \times \sin\theta}{\sin\theta}\ d\theta$ M1 A1

$= \int -2\sin(n-1)\theta\ d\theta$

$= \frac{2}{n-1}\cos(n-1)\theta$ M1

$\therefore I_n = \frac{2}{n-1}\cos(n-1)\theta + I_{n-2}$ A1

(b) $I_n = [\frac{2}{n-1}\cos(n-1)\theta]_{\frac{\pi}{4}}^{\frac{\pi}{2}} + I_{n-2}$

$I_1 = \int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \dfrac{\cos\theta}{\sin\theta}\ d\theta = [\ln|\sin\theta|]_{\frac{\pi}{4}}^{\frac{\pi}{2}}$ M1 A1

$= \ln 1 - \ln\frac{1}{\sqrt{2}} = -\ln 2^{-\frac{1}{2}} = \frac{1}{2}\ln 2$ M1 A1

$I_3 = [\frac{2}{2}\cos 2\theta]_{\frac{\pi}{4}}^{\frac{\pi}{2}} + I_1 = -1 - 0 + \frac{1}{2}\ln 2 = \frac{1}{2}\ln 2 - 1$ M1 A1

$I_5 = [\frac{2}{4}\cos 4\theta]_{\frac{\pi}{4}}^{\frac{\pi}{2}} + I_3 = \frac{1}{2} - (-\frac{1}{2}) + \frac{1}{2}\ln 2 - 1 = \frac{1}{2}\ln 2$ M1 A1 **(13)**

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7. *(a)* $ae = \sqrt{3},\ \frac{a}{e} = \frac{4}{\sqrt{3}}\ \therefore ae \times \frac{a}{e} = a^2 = 4$ M1

$a > 0\ \therefore a = 2$ A1

$b^2 = a^2(1 - e^2) = a^2 - (ae)^2 = 4 - 3 = 1$ M1

$b > 0\ \therefore b = 1$ A1

(b) $\frac{x^2}{4} + y^2 = 1,\ \frac{1}{2}x + 2y\dfrac{dy}{dx} = 0\ \therefore \dfrac{dy}{dx} = \frac{-x}{4y}$ M1 A1

$A = \int_{-2}^{2} 2\pi y\sqrt{1 + \dfrac{x^2}{16y^2}}\ dx$ M1 A1

$= 2\pi\int_{-2}^{2} y\sqrt{\dfrac{16y^2 + x^2}{16y^2}}\ dx$

$= 2\pi\int_{-2}^{2} \dfrac{y}{4y}\sqrt{16(1 - \frac{x^2}{4}) + x^2}\ dx$ M1

$= \frac{\pi}{2}\int_{-2}^{2} \sqrt{16 - 4x^2 + x^2}\ dx$

$= \frac{\pi}{2}\int_{-2}^{2} \sqrt{16 - 3x^2}\ dx$ A1

(c) $3x^2 = 16\sin^2\theta,\ x = \frac{4}{\sqrt{3}}\sin\theta,\ \dfrac{dx}{d\theta} = \frac{4}{\sqrt{3}}\cos\theta$ M1 A1

$A = \frac{\pi}{2}\int_{-\frac{\pi}{3}}^{\frac{\pi}{3}} \sqrt{16 - 16\sin^2\theta} \times \frac{4}{\sqrt{3}}\cos\theta\ d\theta$ M1

$= \frac{\pi}{2}\int_{-\frac{\pi}{3}}^{\frac{\pi}{3}} 4\cos\theta \times \frac{4}{\sqrt{3}}\cos\theta\ d\theta$

$= \frac{8\pi}{\sqrt{3}}\int_{-\frac{\pi}{3}}^{\frac{\pi}{3}} \cos^2\theta\ d\theta$ A1

$= \frac{4\pi}{\sqrt{3}}\int_{-\frac{\pi}{3}}^{\frac{\pi}{3}} 1 + \cos 2\theta\ d\theta$ M1

$= \frac{4\pi}{\sqrt{3}}[\theta + \frac{1}{2}\sin 2\theta]_{-\frac{\pi}{3}}^{\frac{\pi}{3}}$ A1

$= \frac{4\pi}{\sqrt{3}}[\frac{\pi}{3} + \frac{\sqrt{3}}{4} - (-\frac{\pi}{3} - \frac{\sqrt{3}}{4})] = \frac{4\pi}{\sqrt{3}}(\frac{2\pi}{3} + \frac{\sqrt{3}}{2}) = \frac{8}{9}\pi^2\sqrt{3} + 2\pi$ M1 A1 **(18)**

Total **(75)**

Performance Record – FP2 Paper H

Question no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	Total
Topic(s)	rad. of curv.	eqn. in hyp. fns.	integr. hyp. fns	diff. inv. trig.	parabola, tangent	reduction formula	ellipse, surface area	
Marks	8	8	8	9	11	13	18	75
Student								