



General Certificate of Education
Advanced Level Examination
January 2010

Mathematics

MFP2

Unit Further Pure 2

Friday 15 January 2010 1.30 pm to 3.00 pm

For this paper you must have:

- an 8-page answer book
- the blue AQA booklet of formulae and statistical tables.
You may use a graphics calculator.

Time allowed

- 1 hour 30 minutes

Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The **Examining Body** for this paper is AQA. The **Paper Reference** is MFP2.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

- 1 (a) Use the definitions $\cosh x = \frac{1}{2}(e^x + e^{-x})$ and $\sinh x = \frac{1}{2}(e^x - e^{-x})$ to show that

$$\cosh^2 x - \sinh^2 x = 1 \quad (3 \text{ marks})$$

- (b) (i) Express

$$5 \cosh^2 x + 3 \sinh^2 x$$

in terms of $\cosh x$. (1 mark)

- (ii) Sketch the curve $y = \cosh x$. (1 mark)

- (iii) Hence solve the equation

$$5 \cosh^2 x + 3 \sinh^2 x = 9.5$$

giving your answers in logarithmic form. (4 marks)

- 2 (a) On the same Argand diagram, draw:

- (i) the locus of points satisfying $|z - 4 + 2i| = 4$; (3 marks)

- (ii) the locus of points satisfying $|z| = |z - 2i|$. (3 marks)

- (b) Indicate on your sketch the set of points satisfying both

$$|z - 4 + 2i| \leq 4$$

and $|z| \geq |z - 2i|$ (2 marks)

3 The cubic equation

$$2z^3 + pz^2 + qz + 16 = 0$$

where p and q are real, has roots α , β and γ .

It is given that $\alpha = 2 + 2\sqrt{3}i$.

- (a) (i) Write down another root, β , of the equation. (1 mark)
- (ii) Find the third root, γ . (3 marks)
- (iii) Find the values of p and q . (3 marks)
- (b) (i) Express α in the form $re^{i\theta}$, where $r > 0$ and $-\pi < \theta \leq \pi$. (2 marks)
- (ii) Show that

$$(2 + 2\sqrt{3}i)^n = 4^n \left(\cos \frac{n\pi}{3} + i \sin \frac{n\pi}{3} \right) \quad (2 \text{ marks})$$

- (iii) Show that

$$\alpha^n + \beta^n + \gamma^n = 2^{2n+1} \cos \frac{n\pi}{3} + \left(-\frac{1}{2} \right)^n$$

where n is an integer. (3 marks)

4 A curve C is given parametrically by the equations

$$x = \frac{1}{2} \cosh 2t, \quad y = 2 \sinh t$$

- (a) Express

$$\left(\frac{dx}{dt} \right)^2 + \left(\frac{dy}{dt} \right)^2$$

in terms of $\cosh t$. (6 marks)

- (b) The arc of C from $t = 0$ to $t = 1$ is rotated through 2π radians about the x -axis.

- (i) Show that S , the area of the curved surface generated, is given by

$$S = 8\pi \int_0^1 \sinh t \cosh^2 t \, dt \quad (2 \text{ marks})$$

- (ii) Find the exact value of S . (2 marks)

Turn over ►

5 The sum to r terms, S_r , of a series is given by

$$S_r = r^2(r+1)(r+2)$$

Given that u_r is the r th term of the series whose sum is S_r , show that:

(a) (i) $u_1 = 6$; (1 mark)

(ii) $u_2 = 42$; (1 mark)

(iii) $u_n = n(n+1)(4n-1)$. (3 marks)

(b) Show that

$$\sum_{r=n+1}^{2n} u_r = 3n^2(n+1)(5n+2) \quad (3 \text{ marks})$$

6 (a) Show that the substitution $t = \tan \theta$ transforms the integral

$$\int \frac{d\theta}{9 \cos^2 \theta + \sin^2 \theta}$$

into

$$\int \frac{dt}{9+t^2} \quad (3 \text{ marks})$$

(b) Hence show that

$$\int_0^{\frac{\pi}{3}} \frac{d\theta}{9 \cos^2 \theta + \sin^2 \theta} = \frac{\pi}{18} \quad (3 \text{ marks})$$

7 The sequence u_1, u_2, u_3, \dots is defined by

$$u_1 = 2, \quad u_{k+1} = 2u_k + 1$$

(a) Prove by induction that, for all $n \geq 1$,

$$u_n = 3 \times 2^{n-1} - 1 \quad (5 \text{ marks})$$

(b) Show that

$$\sum_{r=1}^n u_r = u_{n+1} - (n+2) \quad (3 \text{ marks})$$

8 (a) (i) Show that $\omega = e^{\frac{2\pi i}{7}}$ is a root of the equation $z^7 = 1$. (1 mark)

(ii) Write down the five other non-real roots in terms of ω . (2 marks)

(b) Show that

$$1 + \omega + \omega^2 + \omega^3 + \omega^4 + \omega^5 + \omega^6 = 0 \quad (2 \text{ marks})$$

(c) Show that:

(i) $\omega^2 + \omega^5 = 2 \cos \frac{4\pi}{7}$; (3 marks)

(ii) $\cos \frac{2\pi}{7} + \cos \frac{4\pi}{7} + \cos \frac{6\pi}{7} = -\frac{1}{2}$. (4 marks)

END OF QUESTIONS

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