



General Certificate of Education  
January 2009  
Advanced Level Examination

**MATHEMATICS**  
**Unit Further Pure 2**

**MFP2**

Monday 19 January 2009 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 maximum mark for this paper is 75.
- The marks for questions are shown in brackets.

**Advice**

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

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Answer **all** questions.

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

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

- (b) Solve the equation

$$3 \cosh 2\theta = 2 \sinh \theta + 11$$

giving each of your answers in the form  $\ln p$ . (6 marks)

- 2 (a) Indicate on an Argand diagram the region for which  $|z - 4i| \leq 2$ . (4 marks)

- (b) The complex number  $z$  satisfies  $|z - 4i| \leq 2$ . Find the range of possible values of  $\arg z$ . (4 marks)

- 3 (a) Given that  $f(r) = \frac{1}{4}r^2(r + 1)^2$ , show that

$$f(r) - f(r - 1) = r^3 \quad (3 \text{ marks})$$

- (b) Use the method of differences to show that

$$\sum_{r=n}^{2n} r^3 = \frac{3}{4}n^2(n + 1)(5n + 1) \quad (5 \text{ marks})$$

4 It is given that  $\alpha$ ,  $\beta$  and  $\gamma$  satisfy the equations

$$\begin{aligned}\alpha + \beta + \gamma &= 1 \\ \alpha^2 + \beta^2 + \gamma^2 &= -5 \\ \alpha^3 + \beta^3 + \gamma^3 &= -23\end{aligned}$$

(a) Show that  $\alpha\beta + \beta\gamma + \gamma\alpha = 3$ . (3 marks)

(b) Use the identity

$$(\alpha + \beta + \gamma)(\alpha^2 + \beta^2 + \gamma^2 - \alpha\beta - \beta\gamma - \gamma\alpha) = \alpha^3 + \beta^3 + \gamma^3 - 3\alpha\beta\gamma$$

to find the value of  $\alpha\beta\gamma$ . (2 marks)

(c) Write down a cubic equation, with integer coefficients, whose roots are  $\alpha$ ,  $\beta$  and  $\gamma$ . (2 marks)

(d) Explain why this cubic equation has two non-real roots. (2 marks)

(e) Given that  $\alpha$  is real, find the values of  $\alpha$ ,  $\beta$  and  $\gamma$ . (4 marks)

5 (a) Given that  $u = \cosh^2 x$ , show that  $\frac{du}{dx} = \sinh 2x$ . (2 marks)

(b) Hence show that

$$\int_0^1 \frac{\sinh 2x}{1 + \cosh^4 x} dx = \tan^{-1}(\cosh^2 1) - \frac{\pi}{4} \quad (5 \text{ marks})$$

6 Prove by induction that

$$\frac{2 \times 1}{2 \times 3} + \frac{2^2 \times 2}{3 \times 4} + \frac{2^3 \times 3}{4 \times 5} + \dots + \frac{2^n \times n}{(n+1)(n+2)} = \frac{2^{n+1}}{n+2} - 1$$

for all integers  $n \geq 1$ . (7 marks)

**Turn over for the next question**

**Turn over ►**

7 (a) Show that

$$\frac{d}{dx} \left( \cosh^{-1} \frac{1}{x} \right) = \frac{-1}{x\sqrt{1-x^2}} \quad (3 \text{ marks})$$

(b) A curve has equation

$$y = \sqrt{1-x^2} - \cosh^{-1} \frac{1}{x} \quad (0 < x < 1)$$

Show that:

(i)  $\frac{dy}{dx} = \frac{\sqrt{1-x^2}}{x}$ ; (4 marks)

(ii) the length of the arc of the curve from the point where  $x = \frac{1}{4}$  to the point where  $x = \frac{3}{4}$  is  $\ln 3$ . (5 marks)

8 (a) Show that

$$(z^4 - e^{i\theta})(z^4 - e^{-i\theta}) = z^8 - 2z^4 \cos \theta + 1 \quad (2 \text{ marks})$$

(b) Hence solve the equation

$$z^8 - z^4 + 1 = 0$$

giving your answers in the form  $e^{i\phi}$ , where  $-\pi < \phi \leq \pi$ . (6 marks)

(c) Indicate the roots on an Argand diagram. (3 marks)

**END OF QUESTIONS**