

General Certificate of Education  
January 2007  
Advanced Level Examination



**MATHEMATICS**  
**Unit Further Pure 3**

**MFP3**

Friday 26 January 2007 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 blue or black ink or 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 MFP3.
- 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 The function  $y(x)$  satisfies the differential equation

$$\frac{dy}{dx} = f(x, y)$$

where  $f(x, y) = \ln(1 + x^2 + y)$

and  $y(1) = 0.6$

(a) Use the Euler formula

$$y_{r+1} = y_r + h f(x_r, y_r)$$

with  $h = 0.05$ , to obtain an approximation to  $y(1.05)$ , giving your answer to four decimal places. (3 marks)

(b) Use the improved Euler formula

$$y_{r+1} = y_r + \frac{1}{2}(k_1 + k_2)$$

where  $k_1 = h f(x_r, y_r)$  and  $k_2 = h f(x_r + h, y_r + k_1)$  and  $h = 0.05$ , to obtain an approximation to  $y(1.05)$ , giving your answer to four decimal places. (6 marks)

2 A curve has polar equation  $r(1 - \sin \theta) = 4$ . Find its cartesian equation in the form  $y = f(x)$ . (6 marks)

3 (a) Show that  $x^2$  is an integrating factor for the first-order differential equation

$$\frac{dy}{dx} + \frac{2}{x}y = 3(x^3 + 1)^{\frac{1}{2}} \quad (3 \text{ marks})$$

(b) Solve this differential equation, given that  $y = 1$  when  $x = 2$ . (6 marks)

4 (a) Explain why  $\int_0^e \frac{\ln x}{\sqrt{x}} dx$  is an improper integral. (1 mark)

(b) Use integration by parts to find  $\int x^{-\frac{1}{2}} \ln x dx$ . (3 marks)

(c) Show that  $\int_0^e \frac{\ln x}{\sqrt{x}} dx$  exists and find its value. (4 marks)

5 Find the general solution of the differential equation

$$\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 3y = 6 + 5 \sin x \quad (12 \text{ marks})$$

6 The function  $f$  is defined by  $f(x) = (1 + 2x)^{\frac{1}{2}}$ .

(a) (i) Find  $f'''(x)$ . (4 marks)

(ii) Using Maclaurin's theorem, show that, for small values of  $x$ ,

$$f(x) \approx 1 + x - \frac{1}{2}x^2 + \frac{1}{2}x^3 \quad (4 \text{ marks})$$

(b) Use the expansion of  $e^x$  together with the result in part (a)(ii) to show that, for small values of  $x$ ,

$$e^x(1 + 2x)^{\frac{1}{2}} \approx 1 + 2x + x^2 + kx^3$$

where  $k$  is a rational number to be found. (3 marks)

(c) Write down the first four terms in the expansion, in ascending powers of  $x$ , of  $e^{2x}$ . (1 mark)

(d) Find

$$\lim_{x \rightarrow 0} \frac{e^x(1 + 2x)^{\frac{1}{2}} - e^{2x}}{1 - \cos x} \quad (4 \text{ marks})$$

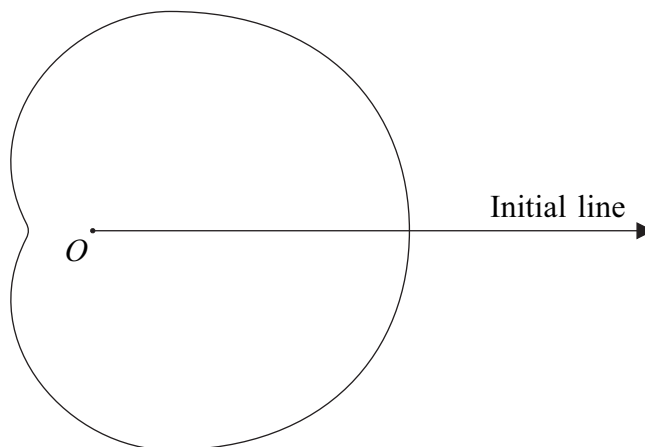
**Turn over for the next question**

**Turn over ►**

7 A curve  $C$  has polar equation

$$r = 6 + 4 \cos \theta, \quad -\pi \leq \theta \leq \pi$$

The diagram shows a sketch of the curve  $C$ , the pole  $O$  and the initial line.



(a) Calculate the area of the region bounded by the curve  $C$ . (6 marks)

(b) The point  $P$  is the point on the curve  $C$  for which  $\theta = \frac{2\pi}{3}$ .

The point  $Q$  is the point on  $C$  for which  $\theta = \pi$ .

Show that  $QP$  is parallel to the line  $\theta = \frac{\pi}{2}$ . (4 marks)

(c) The line  $PQ$  intersects the curve  $C$  again at a point  $R$ .

The line  $RO$  intersects  $C$  again at a point  $S$ .

(i) Find, in surd form, the length of  $PS$ . (4 marks)

(ii) Show that the angle  $OPS$  is a right angle. (1 mark)

**END OF QUESTIONS**