

**Paper Reference 9MA0/02**  
**Pearson Edexcel**  
**Level 3 GCE**

**Mathematics**  
**Advanced**  
**PAPER 2: Pure Mathematics 2**

**Time: 2 hours**

**YOU MUST HAVE**

**Mathematical Formulae and Statistical Tables (Green),  
calculator**

**YOU WILL BE GIVEN**

**Diagram Booklet**  
**Answer Booklet**

**Q69602A**

**Candidates may use any calculator allowed by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.**

## **INSTRUCTIONS**

**In the boxes on the Answer Booklet and on the Diagram Booklet write your name, centre number and candidate number.**

**Answer ALL questions and ensure that your answers to parts of questions are clearly labelled.**

**Answer the questions in the spaces provided in the Answer Booklet – there may be more space than you need.**

**Do NOT write on the Question Paper.**

**You should show sufficient working to make your methods clear. Answers without working may not gain full credit.**

**Inexact answers should be given to three significant figures unless otherwise stated.**

## **INFORMATION**

**A booklet ‘Mathematical Formulae and Statistical Tables’ is provided.**

**There are 16 questions in this Question Paper.  
The total mark for this paper is 100**

**The marks for EACH question are shown in brackets  
– use this as a guide as to how much time to spend on  
each question.**

## **ADVICE**

**Read each question carefully before you start to answer  
it.**

**Try to answer every question.**

**Check your answers if you have time at the end.**

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1. In this question you must show all stages of your working.

**Solutions relying entirely on calculator technology are not acceptable.**

Refer to the diagram for Question 1 in the Diagram Booklet.

It shows a sketch of the graph with equation  $y = |3 - 2x|$

Solve

$$|3 - 2x| = 7 + x$$

(Total for Question 1 is 4 marks)

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2. (a) Sketch the curve with equation

$$y = 4^x$$

stating any points of intersection with the coordinate axes.

There are blank axes on pages 34 – 45 in the Answer Booklet if you wish to use them.

(2 marks)

(b) Solve

$$4^x = 100$$

giving your answer to 2 decimal places.

(2 marks)

(Total for Question 2 is 4 marks)

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3. A sequence of terms  $a_1, a_2, a_3, \dots$  is defined by

$$a_1 = 3$$

$$a_{n+1} = 8 - a_n$$

(a) (i) Show that this sequence is periodic.

(ii) State the order of this periodic sequence.

(2 marks)

(b) Find the value of

$$\sum_{n=1}^{85} a_n$$

(2 marks)

(Total for Question 3 is 4 marks)

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4. Given that

$$y = 2x^2$$

use differentiation from first principles to show that

$$\frac{dy}{dx} = 4x$$

(Total for Question 4 is 3 marks)

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5. Refer to the table for Question 5 in the Diagram Booklet.

It shows corresponding values of  $x$  and  $y$  for  $y = \log_3 2x$

The values of  $y$  are given to 2 decimal places as appropriate.

- (a) Using the trapezium rule with all the values of  $y$  in the table, find an estimate for

$$\int_3^9 \log_3 2x \, dx$$

(3 marks)

(continued on the next page)

5. continued.

Using your answer to part (a) and making your method clear, estimate

(b) (i)  $\int_3^9 \log_3(2x)^{10} dx$

(ii)  $\int_3^9 \log_3 18x dx$

(3 marks)

(Total for Question 5 is 6 marks)

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6. Refer to the diagram for Question 6 in the Diagram Booklet.

It shows a sketch of part of the curve with equation  $y = f(x)$  where

$$f(x) = 8 \sin\left(\frac{1}{2}x\right) - 3x + 9 \quad x > 0$$

and  $x$  is measured in radians.

The point **P**, shown in the diagram, is a local maximum point on the curve.

Using calculus and the sketch in the diagram,

- (a) find the  $x$  coordinate of **P**, giving your answer to 3 significant figures.

(4 marks)

(continued on the next page)

6. continued.

The curve crosses the  $x$ -axis at  $x = \alpha$ , as shown in the diagram.

Given that, to 3 decimal places,  $f(4) = 4.274$   
and  $f(5) = -1.212$

(b) explain why  $\alpha$  must lie in the interval  $[4, 5]$   
(1 mark)

(c) Taking  $x_0 = 5$  as a first approximation to  $\alpha$ ,  
apply the Newton–Raphson method once  
to  $f(x)$  to obtain a second approximation to  $\alpha$

Show your method and give your answer to  
3 significant figures.

(2 marks)

(Total for Question 6 is 7 marks)

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7. (a) Find the first four terms, in ascending powers of  $x$ , of the binomial expansion of

$$\sqrt{4 - 9x}$$

writing each term in simplest form.

(4 marks)

A student uses this expansion with  $x = \frac{1}{9}$  to find an approximation for  $\sqrt{3}$

Using the answer to part (a) and without doing any calculations,

- (b) state whether this approximation will be an overestimate or an underestimate of  $\sqrt{3}$  giving a brief reason for your answer.

(1 mark)

(Total for Question 7 is 5 marks)

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8. In this question you must show all stages of your working.

**Solutions relying on calculator technology are not acceptable.**

Refer to the diagram for Question 8 in the Diagram Booklet.

It shows a sketch of part of a curve with equation

$$y = \frac{(x-2)(x-4)}{4\sqrt{x}} \quad x > 0$$

The region **R**, shown shaded in the diagram, is bounded by the curve and the **X**-axis.

Find the exact area of **R**, writing your answer in the form  $a\sqrt{2} + b$ , where **a** and **b** are constants to be found.

(Total for Question 8 is 6 marks)

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9. Refer to Diagram 1 and Diagram 2 for Question 9 in the Diagram Booklet.

Diagram 1 shows a sketch of a Ferris wheel.

The height above the ground,  $H$  metres, of a passenger on the Ferris wheel,  $t$  seconds after the wheel starts turning, is modelled by the equation

$$H = |A \sin(bt + \alpha)^\circ|$$

where  $A$ ,  $b$  and  $\alpha$  are constants.

Diagram 2 shows a sketch of the graph of  $H$  against  $t$ , for one revolution of the wheel.

(continued on the next page)

9. continued.

Given that

- the maximum height of the passenger above the ground is **50** metres
- the passenger is **1** metre above the ground when the wheel starts turning
- the wheel takes **720** seconds to complete one revolution

(a) find a complete equation for the model, giving the exact value of **A**, the exact value of **b** and the value of  **$\alpha$**  to **3** significant figures.

(4 marks)

(b) Explain why an equation of the form

$$H = |A \sin(bt + \alpha)^{\circ}| + d$$

where **d** is a positive constant, would be a more appropriate model.

(1 mark)

(Total for Question 9 is 5 marks)

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Turn over

10. The function  $f$  is defined by

$$f(x) = \frac{8x + 5}{2x + 3} \quad x > -\frac{3}{2}$$

(a) Find  $f^{-1}\left(\frac{3}{2}\right)$

(2 marks)

(b) Show that

$$f(x) = A + \frac{B}{2x + 3}$$

where  $A$  and  $B$  are constants to be found.

(2 marks)

(continued on the next page)

10. continued.

The function  $g$  is defined by

$$g(x) = 16 - x^2 \quad 0 \leq x \leq 4$$

(c) State the range of  $g^{-1}$   
(1 mark)

(d) Find the range of  $fg^{-1}$   
(3 marks)

(Total for Question 10 is 8 marks)

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11. Prove, using algebra, that

$$n(n^2 + 5)$$

is even for all  $n \in \mathbb{N}$

(Total for Question 11 is 4 marks)

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12. The function  $f$  is defined by

$$f(x) = \frac{e^{3x}}{4x^2 + k}$$

where  $k$  is a positive constant.

(a) Show that

$$f'(x) = (12x^2 - 8x + 3k)g(x)$$

where  $g(x)$  is a function to be found.

(3 marks)

Given that the curve with equation  $y = f(x)$  has at least one stationary point,

(b) find the range of possible values of  $k$

(3 marks)

(Total for Question 12 is 6 marks)

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13. Relative to a fixed origin  $O$ 

- the point  $A$  has position vector  $4\mathbf{i} - 3\mathbf{j} + 5\mathbf{k}$
- the point  $B$  has position vector  $4\mathbf{j} + 6\mathbf{k}$
- the point  $C$  has position vector  $-16\mathbf{i} + p\mathbf{j} + 10\mathbf{k}$

where  $p$  is a constant.

Given that  $A$ ,  $B$  and  $C$  lie on a straight line,

- (a) find the value of  $p$   
(3 marks)

The line segment  $OB$  is extended to a point  $D$  so that  $\overrightarrow{CD}$  is parallel to  $\overrightarrow{OA}$

- (b) Find  $|\overrightarrow{OD}|$ , writing your answer as a fully simplified surd.  
(3 marks)

(Total for Question 13 is 6 marks)

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14. (a) Express  $\frac{3}{(2x-1)(x+1)}$  in partial fractions.

(3 marks)

When chemical **A** and chemical **B** are mixed, oxygen is produced.

A scientist mixed these two chemicals and measured the total volume of oxygen produced over a period of time.

The total volume of oxygen produced,  $V \text{ m}^3$ ,  $t$  hours after the chemicals were mixed, is modelled by the differential equation

$$\frac{dV}{dt} = \frac{3V}{(2t-1)(t+1)} \quad V \geq 0 \quad t \geq k$$

where  $k$  is a constant.

(continued on the next page)

14. continued.

Given that exactly 2 hours after the chemicals were mixed, a total volume of  $3 \text{ m}^3$  of oxygen had been produced,

(b) solve the differential equation to show that

$$V = \frac{3(2t - 1)}{(t + 1)}$$

(5 marks)

(continued on the next page)

14. continued.

The scientist noticed that

- there was a **TIME DELAY** between the chemicals being mixed and oxygen being produced
- there was a **LIMIT** to the total volume of oxygen produced

Deduce from the model

(c) (i) the **TIME DELAY** giving your answer in minutes,

(ii) the **LIMIT** giving your answer in  $\text{m}^3$

(2 marks)

(Total for Question 14 is 10 marks)

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**15. In this question you must show all stages of your working.**

**Solutions relying on calculator technology are not acceptable.**

**Given that the first three terms of a geometric series are**

**$12 \cos \theta$        $5 + 2 \sin \theta$       and       $6 \tan \theta$**

**(a) show that**

$$4 \sin^2 \theta - 52 \sin \theta + 25 = 0$$

**(3 marks)**

**(continued on the next page)**

15. continued.

Given that  $\theta$  is an obtuse angle measured in radians,

(b) solve the equation in part (a) to find the exact value of  $\theta$

(2 marks)

(c) show that the sum to infinity of the series can be expressed in the form

$$k(1 - \sqrt{3})$$

where  $k$  is a constant to be found.

(5 marks)

(Total for Question 15 is 10 marks)

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16. Refer to the diagram for Question 16 in the Diagram Booklet.

It shows a sketch of the curve **C** with parametric equations

$$x = 2 \tan t + 1 \quad y = 2 \sec^2 t + 3 \quad -\frac{\pi}{4} \leq t \leq \frac{\pi}{3}$$

The line **L** is the normal to **C** at the point **P** where

$$t = \frac{\pi}{4}$$

(a) Using parametric differentiation, show that an equation for **L** is

$$y = -\frac{1}{2}x + \frac{17}{2}$$

(5 marks)

(continued on the next page)

16. continued.

(b) Show that all points on **C** satisfy the equation

$$y = \frac{1}{2}(x - 1)^2 + 5$$

(2 marks)

The straight line with equation

$$y = -\frac{1}{2}x + k \quad \text{where } k \text{ is a constant}$$

intersects **C** at two distinct points.

(c) Find the range of possible values for **k**

(5 marks)

(Total for Question 16 is 12 marks)

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**TOTAL FOR PAPER IS 100 MARKS**

**END OF PAPER**

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