

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

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Pearson Edexcel Level 3 GCE

Wednesday 13 October 2021 – Afternoon

Time 2 hours

Paper
reference

9MA0/02

Mathematics

Advanced

PAPER 2: Pure Mathematics 2

You must have:

Mathematical Formulae and Statistical Tables (Green), calculator

Total Marks

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

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with 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 – *there may be more space than you need.*
- 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 15 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.

Turn over ►

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3. Using the laws of logarithms, solve the equation

$$\log_3 (12y + 5) - \log_3 (1 - 3y) = 2$$

(3)

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4. Given that θ is small and measured in radians, use the small angle approximations to show that

$$4 \sin \frac{\theta}{2} + 3 \cos^2 \theta \approx a + b\theta + c\theta^2$$

where a , b and c are integers to be found.

(3)

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5. The curve C has equation

$$y = 5x^4 - 24x^3 + 42x^2 - 32x + 11 \quad x \in \mathbb{R}$$

(a) Find

(i) $\frac{dy}{dx}$

(ii) $\frac{d^2y}{dx^2}$

(3)

(b) (i) Verify that C has a stationary point at $x = 1$

(ii) Show that this stationary point is a point of inflection, giving reasons for your answer.

(4)



6.

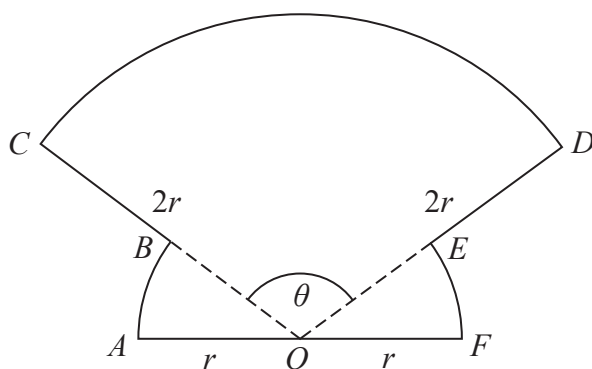


Figure 1

The shape $OABCDEFO$ shown in Figure 1 is a design for a logo.

In the design

- OAB is a sector of a circle centre O and radius r
- sector OFE is congruent to sector OAB
- ODC is a sector of a circle centre O and radius $2r$
- AOF is a straight line

Given that the size of angle COD is θ radians,

(a) write down, in terms of θ , the size of angle AOB

(1)

(b) Show that the area of the logo is

$$\frac{1}{2} r^2 (3\theta + \pi)$$

(2)

(c) Find the perimeter of the logo, giving your answer in simplest form in terms of r , θ and π .

(2)



Question 6 continued

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A large rectangular area containing 24 horizontal lines for writing.

(Total for Question 6 is 5 marks)



7.

In this question you should show all stages of your working.

Solutions relying entirely on calculator technology are not acceptable.

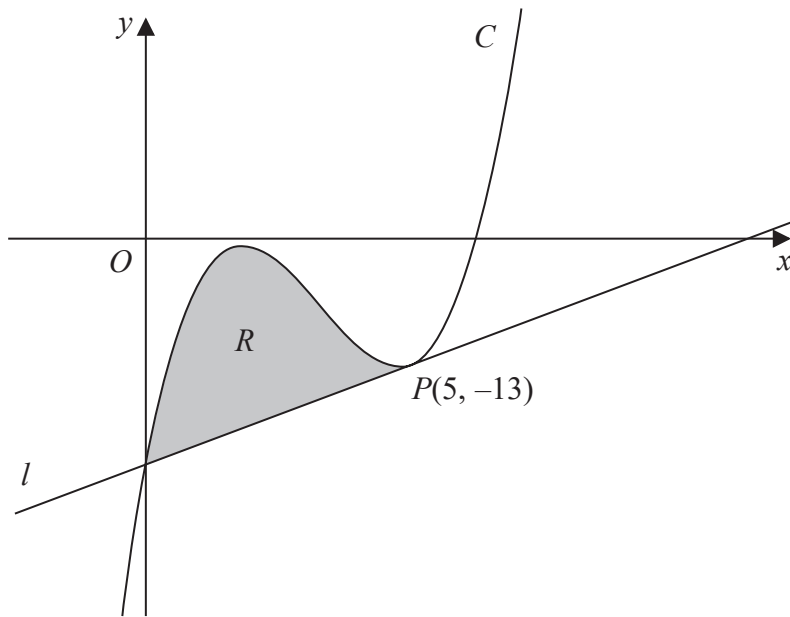


Figure 2

Figure 2 shows a sketch of part of the curve C with equation

$$y = x^3 - 10x^2 + 27x - 23$$

The point $P(5, -13)$ lies on C

The line l is the tangent to C at P

(a) Use differentiation to find the equation of l , giving your answer in the form $y = mx + c$ where m and c are integers to be found. (4)

(b) Hence verify that l meets C again on the y -axis. (1)

The finite region R , shown shaded in Figure 2, is bounded by the curve C and the line l .

(c) Use algebraic integration to find the exact area of R . (4)

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Question 7 continued

A large rectangular area with horizontal lines for writing.



Question 7 continued

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Question 7 continued

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(Total for Question 7 is 9 marks)



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Question 8 continued

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Question 8 continued

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(Total for Question 8 is 9 marks)



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9. Show that

$$\sum_{n=2}^{\infty} \left(\frac{3}{4}\right)^n \cos(180n)^\circ = \frac{9}{28}$$

(3)

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Question 9 continued

Lined area for writing the answer to Question 9.

(Total for Question 9 is 3 marks)

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10. The time, T seconds, that a pendulum takes to complete one swing is modelled by the formula

$$T = al^b$$

where l metres is the length of the pendulum and a and b are constants.

(a) Show that this relationship can be written in the form

$$\log_{10} T = b \log_{10} l + \log_{10} a \quad (2)$$

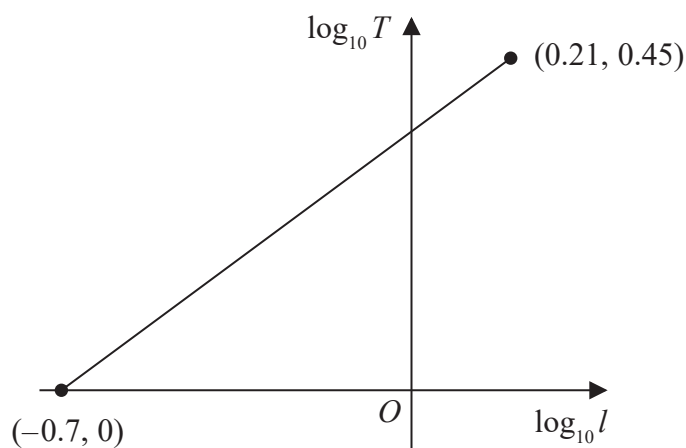


Figure 3

A student carried out an experiment to find the values of the constants a and b .

The student recorded the value of T for different values of l .

Figure 3 shows the linear relationship between $\log_{10} l$ and $\log_{10} T$ for the student's data.

The straight line passes through the points $(-0.7, 0)$ and $(0.21, 0.45)$

Using this information,

(b) find a complete equation for the model in the form

$$T = al^b$$

giving the value of a and the value of b , each to 3 significant figures.

(3)

(c) With reference to the model, interpret the value of the constant a .

(1)



Question 10 continued

Lined writing area for the student's answer.

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Question 10 continued

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11.

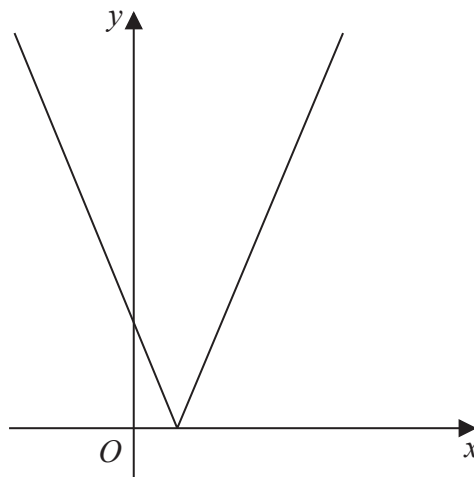


Figure 4

Figure 4 shows a sketch of the graph with equation

$$y = |2x - 3k|$$

where k is a positive constant.

(a) Sketch the graph with equation $y = f(x)$ where

$$f(x) = k - |2x - 3k|$$

stating

- the coordinates of the maximum point
- the coordinates of any points where the graph cuts the coordinate axes

(4)

(b) Find, in terms of k , the set of values of x for which

$$k - |2x - 3k| > x - k$$

giving your answer in set notation.

(4)

(c) Find, in terms of k , the coordinates of the minimum point of the graph with equation

$$y = 3 - 5f\left(\frac{1}{2}x\right)$$

(2)

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Question 11 continued

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Question 11 continued

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(Total for Question 11 is 10 marks)



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12. (a) Use the substitution $u = 1 + \sqrt{x}$ to show that

$$\int_0^{16} \frac{x}{1+\sqrt{x}} dx = \int_p^q \frac{2(u-1)^3}{u} du$$

where p and q are constants to be found.

(3)

(b) Hence show that

$$\int_0^{16} \frac{x}{1+\sqrt{x}} dx = A - B \ln 5$$

where A and B are constants to be found.

(4)

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Question 12 continued

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14.

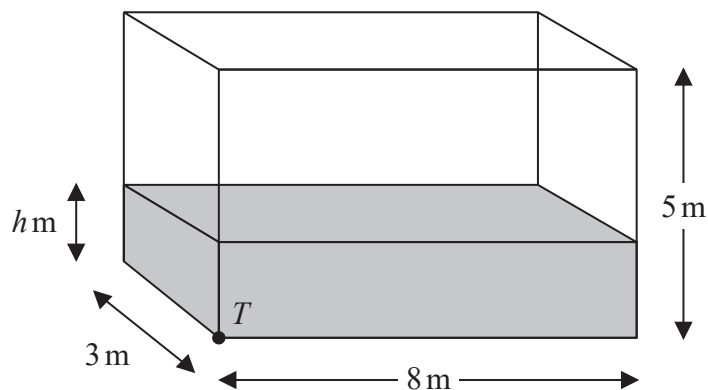


Figure 5

Water flows at a constant rate into a large tank.

The tank is a cuboid, with all sides of negligible thickness.

The base of the tank measures 8 m by 3 m and the height of the tank is 5 m.

There is a tap at a point T at the bottom of the tank, as shown in Figure 5.

At time t minutes after the tap has been opened

- the depth of water in the tank is h metres
- water is flowing into the tank at a constant rate of 0.48 m^3 per minute
- water is modelled as leaving the tank through the tap at a rate of $0.1h \text{ m}^3$ per minute

(a) Show that, according to the model,

$$1200 \frac{dh}{dt} = 24 - 5h \quad (4)$$

Given that when the tap was opened, the depth of water in the tank was 2 m,

(b) show that, according to the model,

$$h = A + Be^{-kt}$$

where A , B and k are constants to be found. (6)

Given that the tap remains open,

(c) determine, according to the model, whether the tank will ever become full, giving a reason for your answer. (2)



Question 14 continued

Ruled area for writing answers, consisting of approximately 25 horizontal lines.

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Question 14 continued

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A large rectangular area with rounded corners, containing numerous horizontal lines for writing.

(Total for Question 14 is 12 marks)



P 6 8 7 3 2 A 0 4 3 4 8

15. (a) Express $2\cos\theta - \sin\theta$ in the form $R\cos(\theta + \alpha)$, where $R > 0$ and $0 < \alpha < \frac{\pi}{2}$

Give the exact value of R and the value of α in radians to 3 decimal places.

(3)

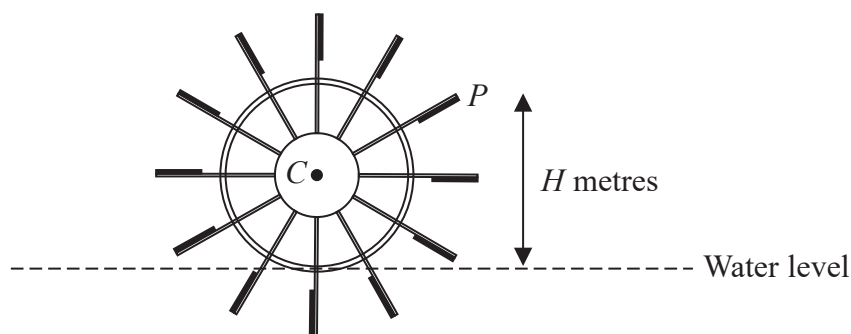


Figure 6

Figure 6 shows the cross-section of a water wheel.

The wheel is free to rotate about a fixed axis through the point C .

The point P is at the end of one of the paddles of the wheel, as shown in Figure 6.

The water level is assumed to be horizontal and of constant height.

The vertical height, H metres, of P above the water level is modelled by the equation

$$H = 3 + 4\cos(0.5t) - 2\sin(0.5t)$$

where t is the time in seconds after the wheel starts rotating.

Using the model, find

- (b) (i) the maximum height of P above the water level,
 (ii) the value of t when this maximum height first occurs, giving your answer to one decimal place.

(3)

In a single revolution of the wheel, P is below the water level for a total of T seconds.

According to the model,

- (c) find the value of T giving your answer to 3 significant figures.

(Solutions based entirely on calculator technology are not acceptable.)

(4)

In reality, the water level may not be of constant height.

- (d) Explain how the equation of the model should be refined to take this into account.

(1)



Question 15 continued

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Area with horizontal lines for writing.



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Question 15 continued

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Question 15 continued

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(Total for Question 15 is 11 marks)

TOTAL FOR PAPER IS 100 MARKS

