

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

I declare this is my own work.

A-level FURTHER MATHEMATICS

Paper 2

Monday 3 June 2024

Afternoon

Time allowed: 2 hours

Materials

- You must have the AQA Formulae and statistical tables booklet for A-level Mathematics and A-level Further Mathematics.
- You should have a graphical or scientific calculator that meets the requirements of the specification.

Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer each question in the space provided for that question. If you require extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do **not** write outside the box around each page or on blank pages.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 100.

Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

For Examiner's Use	
Question	Mark
1	
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19	
20	
TOTAL	



Answer **all** questions in the spaces provided.

- 1** It is given that

$$\begin{bmatrix} 2 \\ 1 \\ 3 \end{bmatrix} \bullet \begin{bmatrix} 5 \\ \lambda \\ -6 \end{bmatrix} = 0$$

where λ is a constant.

Find the value of λ

Circle your answer.

[1 mark]

−28

−8

8

28

- 2** The movement of a particle is described by the simple harmonic equation

$$\ddot{x} = -25x$$

where x metres is the displacement of the particle at time t seconds, and $\ddot{x} \text{ m s}^{-2}$ is the acceleration of the particle.

The maximum displacement of the particle is 9 metres.

Find the maximum speed of the particle.

Circle your answer.

[1 mark]

15 m s^{−1}

45 m s^{−1}

75 m s^{−1}

135 m s^{−1}



- 3 The function g is defined by

$$g(x) = \operatorname{sech} x \quad (x \in \mathbb{R})$$

Which one of the following is the range of g ?

Tick (✓) **one** box.

[1 mark]

$$-\infty < g(x) \leq -1$$

☐

$$-1 \leq g(x) < 0$$

☐

$$0 < g(x) \leq 1$$

☐

$$1 \leq g(x) \leq \infty$$

☐

- 4 The function f is a quartic function with real coefficients.

The complex number $5i$ is a root of the equation $f(x) = 0$

Which **one** of the following **must** be a factor of $f(x)$?

Circle your answer.

[1 mark]

$$(x^2 - 25)$$

$$(x^2 - 5)$$

$$(x^2 + 5)$$

$$(x^2 + 25)$$

Turn over ►



5

$$S = (1 \times 2) + (2 \times 3) + (3 \times 4) + (4 \times 5) + \dots$$

5 (a)

[1 mark]

5 (b)

$$\frac{1}{3}n(n+1)(n+2)$$

[2 marks]

[illegible]

6 The cubic equation

$$x^3 + 5x^2 - 4x + 2 = 0$$

has roots α , β and γ

Find a cubic equation, with integer coefficients, whose roots are 3α , 3β and 3γ

[3 marks]

Turn over for the next question

Turn over ►



7

$$\mathbf{A} = \begin{bmatrix} p-2 & p-1 \\ 0 & 1 \end{bmatrix} \qquad \mathbf{B} = \begin{bmatrix} 1 & 2p-1 \\ 0 & 4-p \end{bmatrix}$$

Find the values of p such that **A** and **B** are commutative under matrix multiplication.

Fully justify your answer.

[4 marks]

[illegible]

Work out $(a - 4b + 3c) \times (2a)$

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

$$\frac{dy}{dx} = \frac{y^2 - x^2}{2x + 3y}$$
$$y_{r+1} = y_{r-1} + 2hf(x_r, y_r), \quad x_{r+1} = x_r + h$$

Give your answer to five significant figures.

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Turn over for the next question

$$\mathbf{C} = \begin{bmatrix} 3 & 2 \\ -4 & 5 \end{bmatrix}$$

[4 marks]

[illegible]

- 11** Latifa and Sam are studying polynomial equations of degree greater than 2, with real coefficients and no repeated roots.
- Latifa says that if such an equation has exactly one real root, it must be of degree 3
- Sam says that this is not correct.
- State, giving reasons, whether Latifa or Sam is right.
- [3 marks]**

Turn over for the next question

Turn over ►



The transformation S is represented by the matrix $\mathbf{M} = \begin{bmatrix} 1 & -6 \\ 2 & 7 \end{bmatrix}$

The point $P(x, y)$ is transformed first by S, then by T

Find the coordinates of P

[5 marks]

[illegible]

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Turn over ►



13 (a)

[5 marks]

[illegible]

[illegible]

13 (b)

[3 marks]

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14

$$\mathbf{M} = \begin{bmatrix} 5 & 2 & 1 \\ 6 & 3 & 2k+3 \\ 2 & 1 & 5 \end{bmatrix}$$

where k is a constant.

14 (a)

[5 marks]

[illegible]

14 (b) State any restrictions on the value of k

[1 mark]

14 (c) Using your answer to part (a), show that the solution to the set of simultaneous equations below is independent of the value of k

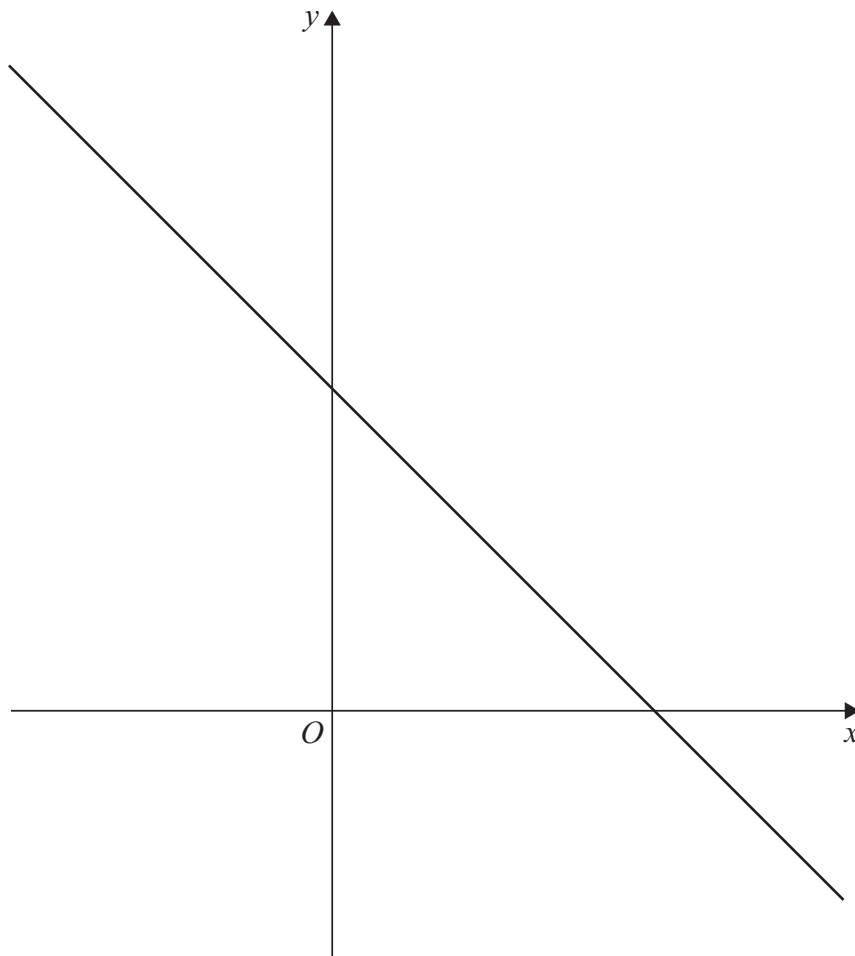
$$\begin{array}{rclcl} 5x + 2y + z & = & 1 \\ 6x + 3y + (2k+3)z & = & 4k+3 \\ 2x + y + 5z & = & 9 \end{array}$$

[4 marks]

Turn over ►



15

The diagram shows the line $y = 5 - x$ 

15 (a)

On the diagram above, sketch the graph of $y = |x^2 - 4x|$, including all parts of the graph where it intersects the line $y = 5 - x$

(You do not need to show the coordinates of the points of intersection.)

[3 marks]

15 (b)

$$|x^2 - 4x| > 5 - x$$

Give your answer in an exact form.

[4 marks]

[illegible]

Turn over ►



16 The function f is defined by

$$f(x) = \frac{ax + 5}{x + b}$$

where a and b are constants.

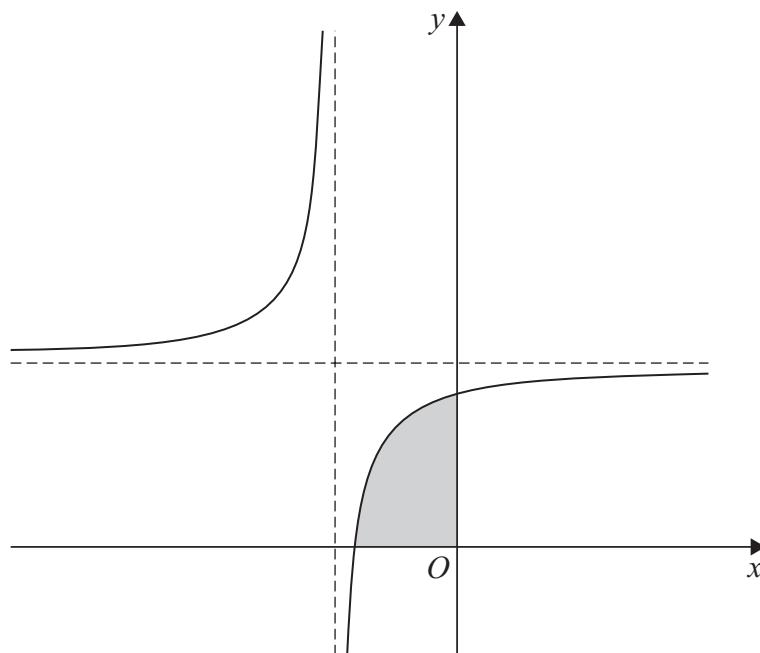
The graph of $y = f(x)$ has asymptotes $x = -2$ and $y = 3$

16 (a) Write down the value of a and the value of b

[2 marks]

16 (b) The diagram shows the graph of $y = f(x)$ and its asymptotes.

The shaded region R is enclosed by the graph of $y = f(x)$, the x -axis and the y -axis.



16 (b) (i) The shaded region R is rotated through 360° about the x -axis to form a solid.

Find the volume of this solid.

Give your answer to three significant figures.

[3 marks]



16 (b) (ii) The shaded region R is rotated through 360° about the y -axis to form a solid.

Find the volume of this solid.

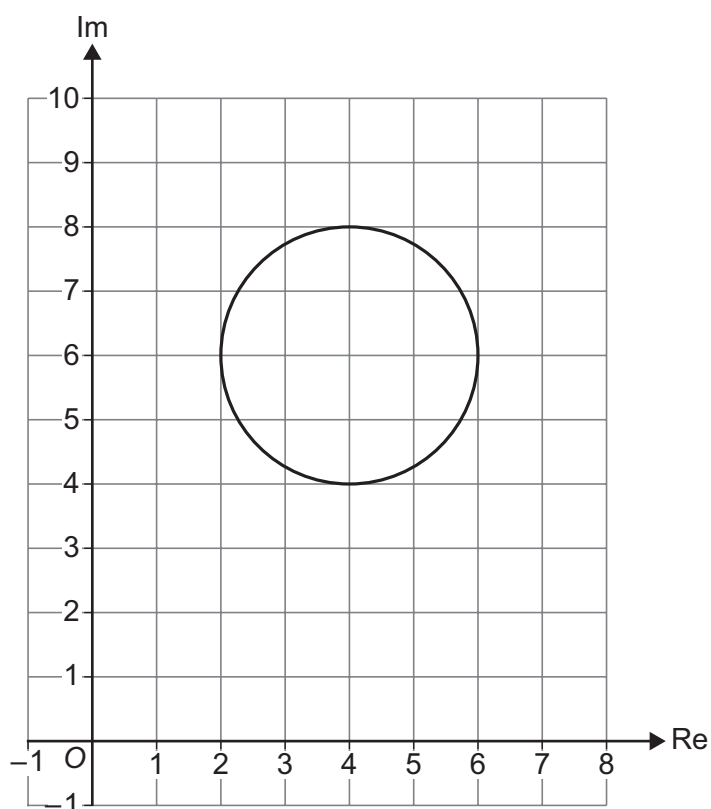
Give your answer to three significant figures.

[4 marks]

Turn over ►



- 17** The Argand diagram below shows a circle C



- 17 (a)** Write down the equation of the locus of C in the form

$$|z - w| = a$$

where w is a complex number whose real and imaginary parts are integers,
and a is an integer.

[2 marks]



17 (b) (i) Find $|z_1|$

Give your answer in an exact form.

[3 marks]

[illegible]

[4 marks]

[illegible]

In this question you may use results from the formulae booklet without proof.

[4 marks]

[illegible]

Turn over for the next question

Turn over ►



Solve the differential equation

given that $y = \frac{37}{225}$ and $\frac{dy}{dx} = 0$ when $x = 0$

[10 marks]

[illegible]

[illegible]

20

$$(n \geq 0)$$

20 (a)

$$(n \geq 2)$$

[6 marks]

[illegible]

[illegible]

20 (b)

$$\int_0^{\frac{\pi}{4}} \cos^6 x \, dx = \frac{a\pi + b}{192}$$

[3 marks]

[illegible]

END OF QUESTIONS



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3 6



2 4 6 A 7 3 6 7 / 2

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