



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9231/12

May/June 2024

2 hours

You will need: List of formulae (MF19)

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [].

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[Turn over

- 1 The cubic equation $2x^3 + x^2 - px - 5 = 0$, where p is a positive constant, has roots α, β, γ .

(a) State, in terms of p , the value of $\alpha\beta + \beta\gamma + \gamma\alpha$. [1]

(b) Find the value of $\alpha^2\beta\gamma + \alpha\beta^2\gamma + \alpha\beta\gamma^2$. [2]

[illegible]

- (c) Deduce a cubic equation whose roots are $\alpha\beta, \beta\gamma, \alpha\gamma$. [1]

[illegible]

- (d) Given that $\alpha^2 + \beta^2 + \gamma^2 = \frac{1}{3}$, find the value of p . [2]

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.

- 2** Prove by mathematical induction that $6^{4n} + 38^n - 2$ is divisible by 74 for all positive integers n . [6]

This image shows a full page of white paper with horizontal dashed lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 3 (a)** Use standard results from the list of formulae (MF19) to show that

$$\sum_{r=1}^N r(r+1)(3r+4) = \frac{1}{12}N(N+1)(N+2)(9N+19). \quad [3]$$

[illegible]

- (b)** Express $\frac{3r+4}{r(r+1)}$ in partial fractions and hence use the method of differences to find

$$\sum_{r=1}^N \frac{3r+4}{r(r+1)} \left(\frac{1}{4}\right)^{r+1}$$

in terms of N .

[4]

[illegible]

- (c) Deduce the value of $\sum_{r=1}^{\infty} \frac{3r+4}{r(r+1)} \left(\frac{1}{4}\right)^{r+1}$. [1]

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4 The matrix $\mathbf{M}$ is given by $\mathbf{M} = \begin{pmatrix} \frac{1}{2} & -\frac{1}{2}\sqrt{3} \\ \frac{1}{2}\sqrt{3} & \frac{1}{2} \end{pmatrix} \begin{pmatrix} 14 & 0 \\ 0 & 1 \end{pmatrix}$.

(a) The matrix $\mathbf{M}$ represents a sequence of two geometrical transformations in the x - y plane.

Give full details of each transformation, and make clear the order in which they are applied. [4]

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(b) Write $\mathbf{M}^{-1}$ as the product of two matrices, neither of which is $\mathbf{I}$. [2]

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- (c) Find the equations of the invariant lines, through the origin, of the transformation represented by $\mathbf{M}$. [5]

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- (d)** The triangle ABC in the x - y plane is transformed by $\mathbf{M}$ onto triangle DEF .

Given that the area of triangle DEF is 28 cm^2 , find the area of triangle ABC . [2]

5 The points A, B, C have position vectors

$$2\mathbf{i} + 2\mathbf{j} + 4\mathbf{k},$$

$$2\mathbf{i} + 4\mathbf{j} - \mathbf{k},$$

$$-3\mathbf{i} - 3\mathbf{j} + 4\mathbf{k},$$

respectively, relative to the origin O .

(a) Find the equation of the plane ABC , giving your answer in the form $ax + by + cz = d$. [5]

[illegible]

The point D has position vector $2\mathbf{i} + \mathbf{j} + 3\mathbf{k}$.

- (b) Find the perpendicular distance from D to the plane ABC . [2]

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- (c) Find the shortest distance between the lines AB and CD . [5]

[illegible]

- 6** The curve C has equation $y = \frac{x^2 + ax + 1}{x + 2}$, where $a > \frac{5}{2}$.

(a) Find the equations of the asymptotes of C .

[3]

This image shows a single sheet of white paper with ten horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and extend across the width of the page. There is no handwriting or other markings on the paper.

(b) Show that C has no stationary points.

[4]

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

- (c) Sketch C , stating the coordinates of the point of intersection with the y -axis and labelling the asymptotes. [3]

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- (d) (i) Sketch the curve with equation $y = \left| \frac{x^2 + ax + 1}{x + 2} \right|$. [2]

- (ii) On your sketch in part (i), draw the line $y = a$. [1]

- (iii) It is given that $\left| \frac{x^2 + ax + 1}{x + 2} \right| < a$ for $-5 - \sqrt{14} < x < -3$ and $-5 + \sqrt{14} < x < 3$.

Find the value of a . [2]

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- 7** The curve C has polar equation $r^2 = (\pi - \theta) \tan^{-1}(\pi - \theta)$, for $0 \leq \theta \leq \pi$.

- (a) Sketch C and state the polar coordinates of the point of C furthest from the pole. [3]

- (b) Using the substitution $u = \pi - \theta$, or otherwise, find the area of the region enclosed by C and the initial line. [7]

and verify that this equation has a root for θ between 1.2 and 1.3. [5]

[illegible]

[illegible]

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