



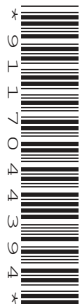
Cambridge International AS & A Level

CANDIDATE
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**FURTHER MATHEMATICS****9231/12**

Paper 1 Further Pure Mathematics 1

October/November 2020**2 hours**

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- 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.

INFORMATION

- 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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[illegible]

3 (a) By simplifying $(x^n - \sqrt{x^{2n} + 1})(x^n + \sqrt{x^{2n} + 1})$, show that $\frac{1}{x^n - \sqrt{x^{2n} + 1}} = -x^n - \sqrt{x^{2n} + 1}$. [1]

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Let $u_n = x^{n+1} + \sqrt{x^{2n+2} + 1} + \frac{1}{x^n - \sqrt{x^{2n} + 1}}$.

(b) Use the method of differences to find $\sum_{n=1}^N u_n$ in terms of N and x . [3]

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(c) Deduce the set of values of x for which the infinite series

$u_1 + u_2 + u_3 + \dots$

is convergent and give the sum to infinity when this exists. [3]

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4 The matrices **A** and **B** are given by

$$\mathbf{A} = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \text{ and } \mathbf{B} = \begin{pmatrix} \frac{1}{2} & -\frac{1}{2}\sqrt{3} \\ \frac{1}{2}\sqrt{3} & \frac{1}{2} \end{pmatrix}.$$

(a) Give full details of the geometrical transformation in the *x-y* plane represented by **A**. [1]

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(b) Give full details of the geometrical transformation in the *x-y* plane represented by **B**. [2]

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The triangle *DEF* in the *x-y* plane is transformed by **AB** onto triangle *PQR*.

(c) Show that the triangles *DEF* and *PQR* have the same area. [3]

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(e) Find the equations of the invariant lines, through the origin, of the transformation in the x - y plane represented by **AB**. [5]

[Turn over

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- $$\frac{1}{2}(1+\pi)\ln(1+\pi)(\ln(1+\pi)-2)+\pi. \quad [6]$$

[illegible]

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(c) Show that, at the point of C furthest from the initial line,

$$(1 + \pi - \theta)\ln(1 + \pi - \theta) - \tan \theta = 0$$

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

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6 Let a be a positive constant.

(a) The curve C_1 has equation $y = \frac{x-a}{x-2a}$. [2]

Sketch C_1 .

The curve C_2 has equation $y = \left(\frac{x-a}{x-2a}\right)^2$. The curve C_3 has equation $y = \left|\frac{x-a}{x-2a}\right|$.

(b) (i) Find the coordinates of any stationary points of C_2 . [3]

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- (ii) Find also the coordinates of any points of intersection of C_2 and C_3 . [3]

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- (c) Sketch C_2 and C_3 on a single diagram, clearly identifying each curve. Hence find the set of values of x for which $\left(\frac{x-a}{x-2a}\right)^2 \leq \left|\frac{x-a}{x-2a}\right|$. [5]

7 The points A, B, C have position vectors

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

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]

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(b) Find the acute angle between the planes OBC and ABC . [4]

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The point D has position vector $t\mathbf{i} - \mathbf{j}$.

- (c) Given that the shortest distance between the lines AB and CD is $\sqrt{10}$, find the value of t . [6]

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