



Cambridge International AS & A Level

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FURTHER MATHEMATICS

9231/01

Paper 1 Further Pure Mathematics 1

For examination from 2020

SPECIMEN PAPER

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 [].

This document has **16** pages. Blank pages are indicated.

- 1 (a) Given that $f(r) = \frac{1}{(r+1)(r+2)}$, show that

$$f(r-1) - f(r) = \frac{2}{r(r+1)(r+2)}. \quad [2]$$

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- (b) Hence find $\sum_{r=1}^n \frac{1}{r(r+1)(r+2)}$. [3]

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- (c) Deduce the value of $\sum_{r=1}^{\infty} \frac{1}{r(r+1)(r+2)}$. [1]

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- 2 It is given that $\phi(n) = 5^n(4n + 1) - 1$, for $n = 1, 2, 3, \dots$.

Prove, by mathematical induction, that $\phi(n)$ is divisible by 8 for every positive integer n . [7]

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3 The curve C has polar equation $r = 2 + 2 \cos \theta$, for $0 \leq \theta \leq \pi$.

(a) Sketch C .

[3]

(b) Find the area of the region enclosed by C and the initial line.

[4]

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- (c) Show that the Cartesian equation of C can be expressed as $4(x^2 + y^2) = (x^2 + y^2 - 2x)^2$. [3]

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4 The cubic equation

$$z^3 - z^2 - z - 5 = 0$$

has roots α, β and γ .

(a) Show that the value of $\alpha^3 + \beta^3 + \gamma^3$ is 19.

[4]

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(b) Find the value of $\alpha^4 + \beta^4 + \gamma^4$. [2]

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(c) Find a cubic equation with roots $\alpha + 1$, $\beta + 1$ and $\gamma + 1$, giving your answer in the form

$$px^3 + qx^2 + rx + s = 0,$$

where p , q , r and s are constants to be determined. [3]

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5 The matrix \mathbf{A} is given by

$$\mathbf{A} = \begin{pmatrix} 5 & k \\ -3 & -4 \end{pmatrix}.$$

(a) Find the value of k for which \mathbf{A} is singular. [2]

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It is now given that $k = 6$ so that $\mathbf{A} = \begin{pmatrix} 5 & 6 \\ -3 & -4 \end{pmatrix}$.

(b) Find the equations of the invariant lines, through the origin, of the transformation in the x - y plane represented by \mathbf{A} . [6]

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(c) The triangle DEF in the x - y plane is transformed by A onto triangle PQR .

(i) Given that the area of triangle DEF is 10 cm^2 , find the area of triangle PQR . [2]

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(ii) Find the matrix which transforms triangle PQR onto triangle DEF . [2]

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6 The position vectors of the points A, B, C, D are

$$2\mathbf{i} + 4\mathbf{j} - 3\mathbf{k}, \quad -2\mathbf{i} + 5\mathbf{j} - 4\mathbf{k}, \quad \mathbf{i} + 4\mathbf{j} + \mathbf{k}, \quad \mathbf{i} + 5\mathbf{j} + m\mathbf{k},$$

respectively, where m is an integer. It is given that the shortest distance between the line through A and B and the line through C and D is 3.

(a) Show that the only possible value of m is 2. [7]

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(b) Find the shortest distance of D from the line through A and C . [3]

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7 The curve C has equation $y = \frac{2x^2 - 3x - 2}{x^2 - 2x + 1}$.

(a) State the equations of the asymptotes of C . [2]

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(b) Show that $y \leq \frac{25}{12}$ at all points on C . [4]

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(c) Find the coordinates of any stationary points of C . [3]

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(d) Sketch C , stating the coordinates of any intersections of C with the coordinate axes and the asymptotes. [4]

- (e) Sketch the curve with equation $y = \left| \frac{2x^2 - 3x - 2}{x^2 - 2x + 1} \right|$ and find the set of values of x for which

$$\left| \frac{2x^2 - 3x - 2}{x^2 - 2x + 1} \right| < 2. \quad [4]$$

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Additional page

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