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9231/11

May/June 2020

2 hours

You must answer on the question paper.

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 [].

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

1 Let a be a positive constant.

(a) Sketch the curve with equation $y = \frac{ax}{x+7}$.

[2]

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook 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.

2 The cubic equation $6x^3 + px^2 - 3x - 5 = 0$, where p is a constant, has roots α, β, γ .

(a) Find a cubic equation whose roots are $\alpha^2, \beta^2, \gamma^2$. [3]

This image shows a full page of white paper designed for handwriting practice. It features 15 evenly spaced, horizontal dashed lines that run across the entire width of the page. The lines are thin and black, providing a guide for letter height and placement. There are no margins, text, or other markings on the page.

(b) It is given that $\alpha^2 + \beta^2 + \gamma^2 = 2(\alpha + \beta + \gamma)$.

(i) Find the value of p . [3]

[illegible]

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.

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

(a) Find the equations of the asymptotes of C . [3]

This image shows a blank 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.

(b) Find the coordinates of the stationary points on C . [3]

[illegible]

(c) Sketch C .

[3]

- 4 (a) By first expressing $\frac{1}{r^2 - 1}$ in partial fractions, show that

$$\sum_{r=2}^n \frac{1}{r^2-1} = \frac{3}{4} - \frac{an+b}{2n(n+1)},$$

where a and b are integers to be found.

[5]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

This image shows a blank 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) Find the limit, as $n \rightarrow \infty$, of $\sum_{r=n+1}^{2n} \frac{n}{r^2 - 1}$. [4]

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- 5** The lines l_1 and l_2 have equations $\mathbf{r} = 3\mathbf{i} + 3\mathbf{k} + \lambda(\mathbf{i} + 4\mathbf{j} + 4\mathbf{k})$ and $\mathbf{r} = 3\mathbf{i} - 5\mathbf{j} - 6\mathbf{k} + \mu(5\mathbf{j} + 6\mathbf{k})$ respectively.

- (a) Find the shortest distance between l_1 and l_2 . [5]

[illegible]

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- 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.

- [illegible]

6 Let $\mathbf{A} = \begin{pmatrix} 2 & 0 \\ 1 & 1 \end{pmatrix}$.

- (a) The transformation in the x - y plane represented by $\mathbf{A}^{-1}$ transforms a triangle of area 30 cm^2 into a triangle of area $d \text{ cm}^2$.

Find the value of d .

[3]

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- (b)** Prove by mathematical induction that, for all positive integers n ,

$$\mathbf{A}^n = \begin{pmatrix} 2^n & 0 \\ 2^n - 1 & 1 \end{pmatrix}. \quad [5]$$

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.

- 7** The curve C_1 has polar equation $r = \theta \cos \theta$, for $0 \leq \theta \leq \frac{1}{2}\pi$.

- (a) The point on C_1 furthest from the line $\theta = \frac{1}{2}\pi$ is denoted by P . Show that, at P ,

$$2\theta \tan \theta - 1 = 0$$

and verify that this equation has a root between 0.6 and 0.7.

[5]

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.

The curve C_2 has polar equation $r = \theta \sin \theta$, for $0 \leq \theta \leq \frac{1}{2}\pi$. The curves C_1 and C_2 intersect at the pole, denoted by O , and at another point Q .

- (b)** Find the polar coordinates of Q , giving your answers in exact form.

[2]

[illegible]

- (d) Find, in terms of π , the area of the region bounded by the arc OQ of C_1 and the arc OQ of C_2 . [7]

[illegible]

[illegible]

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