

Answer all the questions.

**Section A (37 marks)**

1 (a) By considering  $(r+1)^3 - r^3$ , find  $\sum_{r=1}^n (3r^2 + 3r + 1)$ . [3]

(b) Use this result to find  $\sum_{r=1}^n r(r+1)$ , expressing your answer in fully factorised form. [4]

2 In this question you must show detailed reasoning.

Find the exact value of  $\int_3^{\infty} \frac{1}{x^2 - 4x + 5} dx$ . [5]

3 In this question you must show detailed reasoning.

Solve the equation  $3 \cosh x = 2 \sinh^2 x$ , giving your solutions in exact logarithmic form. [6]

4 (a) A transformation with associated matrix  $\begin{pmatrix} m & 2 & 1 \\ 0 & 1 & -2 \\ 2 & 0 & 3 \end{pmatrix}$ , where  $m$  is a constant, maps the vertices of a cube to points that all lie in a plane. [3]

Find  $m$ . [3]

(b) The transformations S and T of the plane have associated matrices M and N respectively, where  $M = \begin{pmatrix} k & 1 \\ -3 & 4 \end{pmatrix}$  and the determinant of N is  $3k+1$ . The transformation U is equivalent to the combined transformation consisting of S followed by T.

Given that U preserves orientation and has an area scale factor 2, find the possible values of  $k$ . [4]

5 (a) Sketch the polar curve  $r = a(1 - \cos \theta)$ ,  $0 \leq \theta < 2\pi$ , where  $a$  is a positive constant. [2]

(b) Determine the exact area of the region enclosed by the curve. [5]

6 Prove by mathematical induction that  $\begin{pmatrix} 2 & 0 \\ -1 & 1 \end{pmatrix}^n = \begin{pmatrix} 2^n & 0 \\ 1-2^n & 1 \end{pmatrix}$  for all positive integers  $n$ . [5]

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**none**



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