

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. 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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**Jan Dangerfield, Rose Jewell, Sue
Pope, Andrew Roberts, Nick Geere**



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