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 $\begin{bmatrix} m & 2 & 1 \\ 0 & 1 & -2 \\ 2 & 0 & 3 \end{bmatrix}$, 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 $M = \begin{bmatrix} k & 1 \\ -3 & 4 \end{bmatrix}$ 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 $r = a(1 - \cos\theta)$, $0 \leqslant \theta < 2\pi$, 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 $\begin{bmatrix} 2 & 0 \\ -1 & 1 \end{bmatrix}^n = \begin{bmatrix} 2^n & 0 \\ 1-2^n & 1 \end{bmatrix}$ for all positive integers n. [5]

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Puja Mehta

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