#### Answer all the questions.

#### Section A (37 marks)

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

(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  $r = a(1 \cos \theta)$ ,  $0 \le \theta \le 2\pi$ , where  $\alpha$  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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Mike Jess

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