

VECTORS

1. The position vectors $\mathbf{a}$ and $\mathbf{b}$ are given by

$$\mathbf{a} = 2p\mathbf{i} + 3p\mathbf{j} + 6p\mathbf{k} \quad \text{and} \quad \mathbf{b} = \mathbf{i} - 2\mathbf{j} + 2\mathbf{k},$$

where $p > 0$. It is given that $|\mathbf{a}| = |\mathbf{b}|$.

- (i) Find the exact value of p . [2]

- (ii) Show that $(\mathbf{a} + \mathbf{b}) \cdot (\mathbf{a} - \mathbf{b}) = 0$. [3]

SERIES

2. (i) Find the first ~~three~~ terms of the Maclaurin series for $e^x(1 + \sin 2x)$. [You may use standard results given in the List of Formulae (MF15).] [3]

- (ii) It is given that the first two terms of this series are equal to the first two terms in the series expansion, in ascending powers of x , of $(1 + \frac{1}{3}x)^n$. Find n and show that the third terms in each of these series are equal. [3]

SEQUENCES

3. The sum, S_n , of the first n terms of a sequence $u_1, u_2, u_3, \dots$ is given by

$$S_n = n(2n + c),$$

where c is a constant.

- (i) Find u_n in terms of c and n . [3]

- (ii) Find a recurrence relation of the form $u_{n+1} = f(u_n)$. [2]

IMPLICIT DIFFERENTIATION

4. (i) Given that $x^2 - y^2 + 2xy + 4 = 0$, find $\frac{dy}{dx}$ in terms of x and y . [4]

- (ii) For the curve with equation $x^2 - y^2 + 2xy + 4 = 0$, find the coordinates of each point at which the tangent is parallel to the x -axis. [4]

TRANSFORMATION

5. The curve with equation $y = x^3$ is transformed by a translation of 2 units in the positive x -direction, followed by a stretch with scale factor $\frac{1}{2}$ parallel to the y -axis, followed by a translation of 6 units in the negative y -direction.

- (i) Find the equation of the new curve in the form $y = f(x)$ and the exact coordinates of the points where this curve crosses the x - and y -axes. Sketch the new curve. [5]

- (ii) On the same diagram, sketch the graph of $y = f^{-1}(x)$, stating the exact coordinates of the points where the graph crosses the x - and y -axes. [3]

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