

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

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

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

- (i) Find the exact value of  $\mu$ . [2]

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

### EXPANSION 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]

### SEQ. & SERIES

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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**Roman Wölfel**



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