

- 1 The line  $l$  has equation

$$\frac{x-3}{-1} = \frac{y+5}{2} = \frac{z-3}{-3}$$

A circle  $C$  has centre  $(-2, -2, 2)$  and radius  $7\sqrt{3}$ .

Given that  $C$  intersects  $l$  at two points,  $A$  and  $B$ , find the coordinates of  $A$  and  $B$ . (6 marks)

- 2 Given that  $\mathbf{a} = 3\mathbf{i} + \mathbf{j} - \mathbf{k}$  and  $\mathbf{b} = -\mathbf{i} + 5\mathbf{j} + 3\mathbf{k}$ , find a vector which is perpendicular to both  $\mathbf{a}$  and  $\mathbf{b}$ . (4 marks)

- 3 The points  $A, B$  and  $C$  have coordinates  $A(3, -4, 6)$ ,  $B(-1, 7, 2)$  and  $C(8, 0, -5)$ .  
Find the area of triangle  $ABC$ . (6 marks)

- 4 The line with vector equation

$$\mathbf{r} = \begin{pmatrix} 1 \\ -3 \\ 1 \end{pmatrix} + \lambda \begin{pmatrix} 3 \\ -4 \\ -2 \end{pmatrix}$$

is perpendicular to the line with vector equation

$$\mathbf{r} = \begin{pmatrix} -16 \\ 5 \\ 3 \end{pmatrix} + \mu \begin{pmatrix} 2p \\ 1 \\ p \end{pmatrix}$$

- a Find the value of  $p$ . (2 marks)  
b Find the coordinates of the point of intersection of the lines. (4 marks)

- 5 The line  $l_1$  has equation

$$\mathbf{r} = \begin{pmatrix} 6 \\ 2 \\ -2 \end{pmatrix} + \lambda \begin{pmatrix} 4 \\ 5 \\ -1 \end{pmatrix}$$

The plane  $\Pi$  has equation

$$2x - y + 4z = 4$$

The line  $l_2$  is a reflection of the line  $l_1$  in the plane  $\Pi$ .

Find an exact vector equation of the line  $l_2$ . (9 marks)

- 6 A plane passes through three points  $P$ ,  $Q$  and  $R$ , whose position vectors, referred to an origin  $O$ , are  $P(2, 1, 5)$ ,  $Q(-3, 2, 0)$  and  $R(5, 4, -1)$
- a Find, in the form  $a\mathbf{i} + b\mathbf{j} + c\mathbf{k}$ , a unit vector normal to this plane. (5 marks)
- b Find a Cartesian equation for the plane. (2 marks)
- c Find the acute angle between the plane in part b and the plane with vector equation  $\mathbf{r} \cdot (3\mathbf{i} + 2\mathbf{j} - 8\mathbf{k}) = 7$  (4 marks)
- 7 Submarine A wishes to move from point  $P(6, -13, 14)$  to point  $Q(16, -9, 12)$  where the unit of distance is kilometres.
- An enemy, submarine B, is located at a fixed point  $O$ . Submarine B has a radar that can detect motion within 15 km.
- a Can submarine A move from  $P$  to  $Q$  undetected by the radar of submarine B? (7 marks)
- b State one limitation of the model. (1 mark)