

Section 1: Vectors in three dimensions

Solutions to Exercise level 1

1. (i) $\overrightarrow{MN} = \overrightarrow{ON} - \overrightarrow{OM}$

$$= \begin{pmatrix} 2 \\ 0 \\ -4 \end{pmatrix} - \begin{pmatrix} 3 \\ -1 \\ 2 \end{pmatrix}$$

$$= \begin{pmatrix} -1 \\ 1 \\ -6 \end{pmatrix}$$

(ii) $|\overrightarrow{MN}| = \sqrt{(-1)^2 + 1^2 + (-6)^2} = \sqrt{38}$

2. (i) $\underline{p} + \underline{q} = (2\underline{i} + \underline{j} - 3\underline{k}) + (3\underline{i} - 2\underline{j} + 4\underline{k})$
 $= 5\underline{i} - \underline{j} + \underline{k}$

(ii) $\underline{p} - \underline{q} = (2\underline{i} + \underline{j} - 3\underline{k}) - (3\underline{i} - 2\underline{j} + 4\underline{k})$
 $= -\underline{i} + 3\underline{j} - 7\underline{k}$

(iii) $2\underline{p} + 3\underline{q} = 2(2\underline{i} + \underline{j} - 3\underline{k}) + 3(3\underline{i} - 2\underline{j} + 4\underline{k})$
 $= 13\underline{i} - 4\underline{j} + 6\underline{k}$

(iv) $2\underline{p} - 5\underline{q} = 2(2\underline{i} + \underline{j} - 3\underline{k}) - 5(3\underline{i} - 2\underline{j} + 4\underline{k})$
 $= -11\underline{i} + 12\underline{j} - 26\underline{k}$

3. (i) $\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA}$

$$= \begin{pmatrix} 3 \\ -1 \\ 2 \end{pmatrix} - \begin{pmatrix} 1 \\ 2 \\ 0 \end{pmatrix}$$

$$= \begin{pmatrix} 2 \\ -3 \\ 2 \end{pmatrix}$$

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$$\begin{aligned}\overrightarrow{BC} &= \overrightarrow{OC} - \overrightarrow{OB} \\ &= \begin{pmatrix} -2 \\ 4 \\ 1 \end{pmatrix} - \begin{pmatrix} 3 \\ -1 \\ 2 \end{pmatrix} \\ &= \begin{pmatrix} -5 \\ 5 \\ -1 \end{pmatrix}\end{aligned}$$

$$\begin{aligned}\overrightarrow{CA} &= \overrightarrow{OA} - \overrightarrow{OC} \\ &= \begin{pmatrix} 1 \\ 2 \\ 0 \end{pmatrix} - \begin{pmatrix} -2 \\ 4 \\ 1 \end{pmatrix} \\ &= \begin{pmatrix} 3 \\ -2 \\ -1 \end{pmatrix}\end{aligned}$$

$$(ii) |\overrightarrow{AB}| = \sqrt{2^2 + (-3)^2 + 2^2} = \sqrt{17}$$

$$|\overrightarrow{BC}| = \sqrt{(-5)^2 + 5^2 + 1^2} = \sqrt{51}$$

$$|\overrightarrow{CA}| = \sqrt{3^2 + (-2)^2 + (-1)^2} = \sqrt{14}$$

$$(iii) \overrightarrow{AB} = \begin{pmatrix} 2 \\ -3 \\ 2 \end{pmatrix} \text{ and } |\overrightarrow{AB}| = \sqrt{17}$$

so a unit vector in the direction of \overrightarrow{AB} is $\frac{1}{\sqrt{17}} \begin{pmatrix} 2 \\ -3 \\ 2 \end{pmatrix}$