

$$1 \quad \mathbf{a} = 3 + 2 = 5 \qquad \mathbf{b} = 12 - 5 = 7 \qquad \mathbf{c} = -5 + 4 = -1$$

$$2 \quad (\mathbf{i} + 4\mathbf{j}) \cdot (8\mathbf{i} - 2\mathbf{j}) = 8 - 8 = 0 \\ \therefore \text{perpendicular}$$

$$3 \quad \mathbf{a} \quad \begin{pmatrix} 3 \\ -1 \end{pmatrix} \cdot \begin{pmatrix} c \\ 3 \end{pmatrix} = 0 \\ 3c - 3 = 0 \\ c = 1$$

$$\mathbf{b} \quad \begin{pmatrix} 2 \\ 1 \end{pmatrix} \cdot \begin{pmatrix} 3 \\ c \end{pmatrix} = 0 \\ 6 + c = 0 \\ c = -6$$

$$\mathbf{c} \quad \begin{pmatrix} 2 \\ -5 \end{pmatrix} \cdot \begin{pmatrix} c \\ -4 \end{pmatrix} = 0 \\ 2c + 20 = 0 \\ c = -10$$

$$4 \quad \mathbf{a} \quad |\mathbf{4i} - 3\mathbf{j}| = \sqrt{16+9} = 5, \quad |\mathbf{8i} + 6\mathbf{j}| = \sqrt{64+36} = 10 \\ (\mathbf{4i} - 3\mathbf{j}) \cdot (\mathbf{8i} + 6\mathbf{j}) = 32 - 18 = 14 \\ \therefore \text{angle} = \cos^{-1} \frac{14}{5 \times 10} = \cos^{-1} \frac{7}{25} = 73.7^\circ$$

$$\mathbf{b} \quad |\mathbf{7i} + \mathbf{j}| = \sqrt{49+1} = 5\sqrt{2}, \quad |\mathbf{2i} + 6\mathbf{j}| = \sqrt{4+36} = 2\sqrt{10} \\ (\mathbf{7i} + \mathbf{j}) \cdot (\mathbf{2i} + 6\mathbf{j}) = 14 + 6 = 20 \\ \therefore \text{angle} = \cos^{-1} \frac{20}{5\sqrt{2} \times 2\sqrt{10}} = \cos^{-1} \frac{1}{\sqrt{5}} = 63.4^\circ$$

$$\mathbf{c} \quad |\mathbf{4i} + 2\mathbf{j}| = \sqrt{16+4} = 2\sqrt{5}, \quad |-\mathbf{5i} + 2\mathbf{j}| = \sqrt{25+4} = \sqrt{29} \\ (\mathbf{4i} + 2\mathbf{j}) \cdot (-\mathbf{5i} + 2\mathbf{j}) = -20 + 4 = -16 \\ \therefore \text{angle} = \cos^{-1} \frac{-16}{2\sqrt{5} \times \sqrt{29}} = \cos^{-1} \left(-\frac{8}{\sqrt{5}\sqrt{29}} \right) = 131.6^\circ$$

$$5 \quad \overrightarrow{BA} = (9\mathbf{i} + \mathbf{j}) - (3\mathbf{i} - \mathbf{j}) = 6\mathbf{i} + 2\mathbf{j} \\ \overrightarrow{BC} = (5\mathbf{i} - 2\mathbf{j}) - (3\mathbf{i} - \mathbf{j}) = 2\mathbf{i} - \mathbf{j} \\ |\overrightarrow{BA}| = \sqrt{36+4} = 2\sqrt{10}, \quad |\overrightarrow{BC}| = \sqrt{4+1} = \sqrt{5} \\ \overrightarrow{BA} \cdot \overrightarrow{BC} = (6\mathbf{i} + 2\mathbf{j}) \cdot (2\mathbf{i} - \mathbf{j}) = 12 - 2 = 10 \\ \therefore \angle ABC = \cos^{-1} \frac{10}{2\sqrt{10} \times \sqrt{5}} = \cos^{-1} \frac{1}{\sqrt{2}} = 45^\circ$$

$$6 \quad \mathbf{a} = 3 + 2 + 8 = 13 \qquad \mathbf{b} = 6 + 6 - 2 = 10 \\ \mathbf{c} = -5 + 0 - 6 = -11 \qquad \mathbf{d} = -3 + 22 + 32 = 51 \\ \mathbf{e} = 27 - 28 - 1 = -2 \qquad \mathbf{f} = 0 + 9 + 0 = 9$$

$$7 \quad \mathbf{a} = (2\mathbf{i} + \mathbf{j} - 3\mathbf{k}) \cdot (\mathbf{i} + 5\mathbf{j} - \mathbf{k}) = 2 + 5 + 3 = 10 \\ \mathbf{b} = (2\mathbf{i} + \mathbf{j} - 3\mathbf{k}) \cdot (6\mathbf{i} - 2\mathbf{j} - 3\mathbf{k}) = 12 - 2 + 9 = 19 \\ \mathbf{c} \quad \mathbf{q} + \mathbf{r} = (\mathbf{i} + 5\mathbf{j} - \mathbf{k}) + (6\mathbf{i} - 2\mathbf{j} - 3\mathbf{k}) = 7\mathbf{i} + 3\mathbf{j} - 4\mathbf{k} \\ \mathbf{p} \cdot (\mathbf{q} + \mathbf{r}) = (2\mathbf{i} + \mathbf{j} - 3\mathbf{k}) \cdot (7\mathbf{i} + 3\mathbf{j} - 4\mathbf{k}) = 14 + 3 + 12 = 29 \\ \mathbf{p} \cdot \mathbf{q} + \mathbf{p} \cdot \mathbf{r} = 10 + 19 = 29 \\ \therefore \mathbf{p} \cdot (\mathbf{q} + \mathbf{r}) = \mathbf{p} \cdot \mathbf{q} + \mathbf{p} \cdot \mathbf{r}$$

$$8 \quad \mathbf{a} = \mathbf{p} \cdot \mathbf{q} + \mathbf{p} \cdot \mathbf{r} + \mathbf{p} \cdot \mathbf{q} - \mathbf{p} \cdot \mathbf{r} \\ = 2\mathbf{p} \cdot \mathbf{q} \qquad \mathbf{b} = \mathbf{p} \cdot \mathbf{q} + \mathbf{p} \cdot \mathbf{r} + \mathbf{q} \cdot \mathbf{r} - \mathbf{q} \cdot \mathbf{p} \\ = \mathbf{p} \cdot \mathbf{q} + \mathbf{p} \cdot \mathbf{r} + \mathbf{q} \cdot \mathbf{r} - \mathbf{p} \cdot \mathbf{q} \\ = \mathbf{p} \cdot \mathbf{r} + \mathbf{q} \cdot \mathbf{r} \\ = (\mathbf{p} + \mathbf{q}) \cdot \mathbf{r}$$

9 $(5\mathbf{i} - 3\mathbf{j} + 2\mathbf{k}) \cdot (3\mathbf{i} + \mathbf{j} - 6\mathbf{k}) = 15 - 3 - 12 = 0$
 $\therefore$ perpendicular

10 $\overrightarrow{BA} = (3\mathbf{i} + 4\mathbf{j} - 6\mathbf{k}) - (\mathbf{i} + 5\mathbf{j} - 2\mathbf{k}) = 2\mathbf{i} - \mathbf{j} - 4\mathbf{k}$
 $\overrightarrow{BC} = (8\mathbf{i} + 3\mathbf{j} + 2\mathbf{k}) - (\mathbf{i} + 5\mathbf{j} - 2\mathbf{k}) = 7\mathbf{i} - 2\mathbf{j} + 4\mathbf{k}$
 $\overrightarrow{BA} \cdot \overrightarrow{BC} = (2\mathbf{i} - \mathbf{j} - 4\mathbf{k}) \cdot (7\mathbf{i} - 2\mathbf{j} + 4\mathbf{k}) = 14 + 2 - 16 = 0$
 $\therefore \overrightarrow{BA}$ and $\overrightarrow{BC}$ are perpendicular $\therefore \angle ABC = 90^\circ$

11 a $(2\mathbf{i} + 3\mathbf{j} + \mathbf{k}) \cdot (c\mathbf{i} - 3\mathbf{j} + \mathbf{k}) = 0$
 $2c - 9 + 1 = 0$
 $c = 4$

b $(-5\mathbf{i} + 3\mathbf{j} + 2\mathbf{k}) \cdot (c\mathbf{i} - \mathbf{j} + 3c\mathbf{k}) = 0$
 $-5c - 3 + 6c = 0$
 $c = 3$

c $(c\mathbf{i} - 2\mathbf{j} + 8\mathbf{k}) \cdot (c\mathbf{i} + c\mathbf{j} - 3\mathbf{k}) = 0$
 $c^2 - 2c - 24 = 0$
 $(c + 4)(c - 6) = 0$
 $c = -4, 6$

d $(3c\mathbf{i} + 2\mathbf{j} + c\mathbf{k}) \cdot (5\mathbf{i} - 4\mathbf{j} + 2c\mathbf{k}) = 0$
 $15c - 8 + 2c^2 = 0$
 $2c^2 + 15c - 8 = 0$
 $(2c - 1)(c + 8) = 0$
 $c = -8, \frac{1}{2}$

12 a $\left| \begin{pmatrix} 1 \\ 2 \\ -2 \end{pmatrix} \right| = \sqrt{1+4+4} = 3, \left| \begin{pmatrix} 8 \\ 1 \\ -4 \end{pmatrix} \right| = \sqrt{64+1+16} = 9, \begin{pmatrix} 1 \\ 2 \\ -2 \end{pmatrix} \cdot \begin{pmatrix} 8 \\ 1 \\ -4 \end{pmatrix} = 8 + 2 + 8 = 18$
 $\therefore \cos \theta = \frac{18}{3 \times 9} = \frac{2}{3}$

b $\left| \begin{pmatrix} 4 \\ 1 \\ -2 \end{pmatrix} \right| = \sqrt{16+1+4} = \sqrt{21}, \left| \begin{pmatrix} -2 \\ 3 \\ -6 \end{pmatrix} \right| = \sqrt{4+9+36} = 7, \begin{pmatrix} 4 \\ 1 \\ -2 \end{pmatrix} \cdot \begin{pmatrix} -2 \\ 3 \\ -6 \end{pmatrix} = -8 + 3 + 12 = 7$
 $\therefore \cos \theta = \frac{7}{\sqrt{21} \times 7} = \frac{1}{\sqrt{21}} \text{ or } \frac{1}{21} \sqrt{21}$

c $\left| \begin{pmatrix} 1 \\ 2 \\ -1 \end{pmatrix} \right| = \sqrt{1+4+1} = \sqrt{6}, \left| \begin{pmatrix} 1 \\ -7 \\ 2 \end{pmatrix} \right| = \sqrt{1+49+4} = 3\sqrt{6}, \begin{pmatrix} 1 \\ 2 \\ -1 \end{pmatrix} \cdot \begin{pmatrix} 1 \\ -7 \\ 2 \end{pmatrix} = 1 - 14 - 2 = -15$
 $\therefore \cos \theta = \frac{-15}{\sqrt{6} \times 3\sqrt{6}} = -\frac{5}{6}$

d $\left| \begin{pmatrix} 5 \\ -3 \\ 4 \end{pmatrix} \right| = \sqrt{25+9+16} = 5\sqrt{2}, \left| \begin{pmatrix} 3 \\ -4 \\ -1 \end{pmatrix} \right| = \sqrt{9+16+1} = \sqrt{26}, \begin{pmatrix} 5 \\ -3 \\ 4 \end{pmatrix} \cdot \begin{pmatrix} 3 \\ -4 \\ -1 \end{pmatrix} = 15 + 12 - 4 = 23$
 $\therefore \cos \theta = \frac{23}{5\sqrt{2} \times \sqrt{26}} = \frac{23}{10\sqrt{13}} \text{ or } \frac{23}{130} \sqrt{13}$

13 a $|(3\mathbf{i} - 4\mathbf{k})| = \sqrt{9+16} = 5$
 $|(7\mathbf{i} - 4\mathbf{j} + 4\mathbf{k})| = \sqrt{49+16+16} = 9$
 $(3\mathbf{i} - 4\mathbf{k}) \cdot (7\mathbf{i} - 4\mathbf{j} + 4\mathbf{k}) = 21 + 0 - 16 = 5$
 $\therefore \text{angle} = \cos^{-1} \frac{5}{5 \times 9} = \cos^{-1} \frac{1}{9} = 83.6^\circ$

b $|(2\mathbf{i} - 6\mathbf{j} + 3\mathbf{k})| = \sqrt{4+36+9} = 7$
 $|(i - 3j - k)| = \sqrt{1+9+1} = \sqrt{11}$
 $(2\mathbf{i} - 6\mathbf{j} + 3\mathbf{k}) \cdot (\mathbf{i} - 3\mathbf{j} - \mathbf{k}) = 2 + 18 - 3 = 17$
 $\therefore \text{angle} = \cos^{-1} \frac{17}{7 \times \sqrt{11}} = 42.9^\circ$

c $|(6\mathbf{i} - 2\mathbf{j} - 9\mathbf{k})| = \sqrt{36+4+81} = 11$
 $|(3\mathbf{i} + \mathbf{j} + 4\mathbf{k})| = \sqrt{9+1+16} = \sqrt{26}$
 $(6\mathbf{i} - 2\mathbf{j} - 9\mathbf{k}) \cdot (3\mathbf{i} + \mathbf{j} + 4\mathbf{k}) = 18 - 2 - 36 = -20$
 $\therefore \text{angle} = \cos^{-1} \frac{-20}{11 \times \sqrt{26}} = 110.9^\circ$

d $|(i + 5j - 3k)| = \sqrt{1+25+9} = \sqrt{35}$
 $|(-3i - 4j + 2k)| = \sqrt{9+16+4} = \sqrt{29}$
 $(i + 5j - 3k) \cdot (-3i - 4j + 2k) = -3 - 20 - 6 = -29$
 $\therefore \text{angle} = \cos^{-1} \frac{-29}{\sqrt{35} \times \sqrt{29}} = \cos^{-1} \left(-\sqrt{\frac{29}{35}} \right) = 155.5^\circ$

14 a $\overrightarrow{BA} = (7+1)\mathbf{i} + (2-6)\mathbf{j} + (-2+3)\mathbf{k} = 8\mathbf{i} - 4\mathbf{j} + \mathbf{k}$

$\overrightarrow{BC} = (-3+1)\mathbf{i} + (1-6)\mathbf{j} + (2+3)\mathbf{k} = -2\mathbf{i} - 5\mathbf{j} + 5\mathbf{k}$

b $|\overrightarrow{BA}| = \sqrt{64+16+1} = 9$

$|\overrightarrow{BC}| = \sqrt{4+25+25} = 3\sqrt{6}$

$\overrightarrow{BA} \cdot \overrightarrow{BC} = (8\mathbf{i} - 4\mathbf{j} + \mathbf{k}) \cdot (-2\mathbf{i} - 5\mathbf{j} + 5\mathbf{k}) = -16 + 20 + 5 = 9$

$\therefore \angle ABC = \cos^{-1} \frac{9}{9 \times 3\sqrt{6}} = \cos^{-1} \frac{1}{3\sqrt{6}} = 82.2^\circ$

c $= \frac{1}{2} \times 9 \times 3\sqrt{6} \times \sin 82.18^\circ = 32.8$

15 a $\overrightarrow{AB} = (4\mathbf{i} + 3\mathbf{j} - 2\mathbf{k}) - (3\mathbf{i} - 2\mathbf{j} - \mathbf{k}) = \mathbf{i} + 5\mathbf{j} - \mathbf{k}$

$\overrightarrow{AC} = (2\mathbf{i} - \mathbf{j}) - (3\mathbf{i} - 2\mathbf{j} - \mathbf{k}) = -\mathbf{i} + \mathbf{j} + \mathbf{k}$

$|\overrightarrow{AB}| = \sqrt{1+25+1} = 3\sqrt{3}$

$|\overrightarrow{AC}| = \sqrt{1+1+1} = \sqrt{3}$

$\overrightarrow{AB} \cdot \overrightarrow{AC} = (\mathbf{i} + 5\mathbf{j} - \mathbf{k}) \cdot (-\mathbf{i} + \mathbf{j} + \mathbf{k}) = -1 + 5 - 1 = 3$

$\cos(\angle BAC) = \frac{3}{3\sqrt{3} \times \sqrt{3}} = \frac{1}{3}$

b $\sin^2(\angle BAC) = 1 - \left(\frac{1}{3}\right)^2 = \frac{8}{9}$

$\sin(\angle BAC) = \sqrt{\frac{8}{9}} = \frac{2}{3}\sqrt{2}$

area $= \frac{1}{2} \times 3\sqrt{3} \times \sqrt{3} \times \frac{2}{3}\sqrt{2} = 3\sqrt{2}$

16 a $\left| \begin{pmatrix} 4 \\ -4 \\ 2 \end{pmatrix} \right| = \sqrt{16+16+4} = 6, \left| \begin{pmatrix} 8 \\ 0 \\ -6 \end{pmatrix} \right| = \sqrt{64+36} = 10, \begin{pmatrix} 4 \\ -4 \\ 2 \end{pmatrix} \cdot \begin{pmatrix} 8 \\ 0 \\ -6 \end{pmatrix} = 32 + 0 - 12 = 20$

$\therefore \text{acute angle} = \cos^{-1} \left| \frac{20}{6 \times 10} \right| = \cos^{-1} \frac{1}{3} = 70.5^\circ$

b $\left| \begin{pmatrix} 6 \\ -1 \\ -18 \end{pmatrix} \right| = \sqrt{36+1+324} = 19, \left| \begin{pmatrix} 4 \\ -12 \\ 3 \end{pmatrix} \right| = \sqrt{16+144+9} = 13, \begin{pmatrix} 6 \\ -1 \\ -18 \end{pmatrix} \cdot \begin{pmatrix} 4 \\ -12 \\ 3 \end{pmatrix} = 24 + 12 - 54 = -18$

$\therefore \text{acute angle} = \cos^{-1} \left| \frac{-18}{19 \times 13} \right| = \cos^{-1} \frac{18}{247} = 85.8^\circ$

c $\left| \begin{pmatrix} 1 \\ -1 \\ 3 \end{pmatrix} \right| = \sqrt{1+1+9} = \sqrt{11}, \left| \begin{pmatrix} 2 \\ -5 \\ 3 \end{pmatrix} \right| = \sqrt{4+25+9} = \sqrt{38}, \begin{pmatrix} 1 \\ -1 \\ 3 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ -5 \\ 3 \end{pmatrix} = 2 + 5 + 9 = 16$

$\therefore \text{acute angle} = \cos^{-1} \left| \frac{16}{\sqrt{11} \times \sqrt{38}} \right| = \cos^{-1} \frac{16}{\sqrt{418}} = 38.5^\circ$

d $\left| \begin{pmatrix} -4 \\ -6 \\ 7 \end{pmatrix} \right| = \sqrt{16+36+49} = \sqrt{101}, \left| \begin{pmatrix} 5 \\ -1 \\ -8 \end{pmatrix} \right| = \sqrt{25+1+64} = \sqrt{90}, \begin{pmatrix} -4 \\ -6 \\ 7 \end{pmatrix} \cdot \begin{pmatrix} 5 \\ -1 \\ -8 \end{pmatrix} = -20 + 6 - 56 = -70$

$\therefore \text{acute angle} = \cos^{-1} \left| \frac{-70}{\sqrt{101} \times \sqrt{90}} \right| = \cos^{-1} \frac{70}{\sqrt{9090}} = 42.8^\circ$

17 a $\overrightarrow{AB} = (6\mathbf{i} + 5\mathbf{j} + \mathbf{k}) - (5\mathbf{i} + 8\mathbf{j} - \mathbf{k}) = \mathbf{i} - 3\mathbf{j} + 2\mathbf{k}$

$\therefore \mathbf{r} = 5\mathbf{i} + 8\mathbf{k} - \mathbf{k} + \lambda(\mathbf{i} - 3\mathbf{j} + 2\mathbf{k})$

b $5 + \lambda = 4 - 5\mu \quad (1)$

$8 - 3\lambda = -3 + \mu \quad (2)$

$-1 + 2\lambda = 5 - 2\mu \quad (3)$

$3 \times (1) + (2) \Rightarrow 23 = 9 - 14\mu$

$\mu = -1, \lambda = 4$

check (3) $-1 + 2(4) = 5 - 2(-1)$

true $\therefore$ intersect

pos. vector of int. $= 9\mathbf{i} - 4\mathbf{j} + 7\mathbf{k}$

c $|\mathbf{i} - 3\mathbf{j} + 2\mathbf{k}| = \sqrt{1+9+4} = \sqrt{14}$

$|(-5\mathbf{i} + \mathbf{j} - 2\mathbf{k})| = \sqrt{25+1+4} = \sqrt{30}$

$(\mathbf{i} - 3\mathbf{j} + 2\mathbf{k}) \cdot (-5\mathbf{i} + \mathbf{j} - 2\mathbf{k}) = -5 - 3 - 4 = -12$

acute angle $= \cos^{-1} \left| \frac{-12}{\sqrt{14} \times \sqrt{30}} \right| = \cos^{-1} \frac{6}{\sqrt{105}} = 54.2^\circ \text{ (1dp)}$

18 $\lambda = \frac{x-2}{3} = \frac{y}{2} = \frac{z+5}{-6}$

$\mu = \frac{x-4}{-4} = \frac{y+1}{7} = \frac{z-3}{-4}$

$x = 2 + 3\lambda, y = 2\lambda, z = -5 - 6\lambda$

$x = 4 - 4\mu, y = -1 + 7\mu, z = 3 - 4\mu$

$\mathbf{r} = 2\mathbf{i} - 5\mathbf{k} + \lambda(3\mathbf{i} + 2\mathbf{j} - 6\mathbf{k})$

$\mathbf{r} = 4\mathbf{i} - \mathbf{j} + 3\mathbf{k} + \mu(-4\mathbf{i} + 7\mathbf{j} - 4\mathbf{k})$

$|(3\mathbf{i} + 2\mathbf{j} - 6\mathbf{k})| = \sqrt{9+4+36} = 7$

$|(-4\mathbf{i} + 7\mathbf{j} - 4\mathbf{k})| = \sqrt{16+49+16} = 9$

$(3\mathbf{i} + 2\mathbf{j} - 6\mathbf{k}) \cdot (-4\mathbf{i} + 7\mathbf{j} - 4\mathbf{k}) = -12 + 14 + 24 = 26$

$\therefore$ acute angle $= \cos^{-1} \left| \frac{26}{7 \times 9} \right| = \cos^{-1} \frac{26}{63} = 65.6^\circ$

19 a $7 + 2\lambda = -4 + 5\mu \quad (1)$

$-\lambda = 7 - 4\mu \quad (2)$

$-2 + 2\lambda = -6 - 2\mu \quad (3)$

$(1) - (3) \Rightarrow 9 = 2 + 7\mu$

$\mu = 1$

$\therefore A(1, 3, -8)$

b $|(2\mathbf{i} - \mathbf{j} + 2\mathbf{k})| = \sqrt{4+1+4} = 3$

$|(5\mathbf{i} - 4\mathbf{j} - 2\mathbf{k})| = \sqrt{25+16+4} = 3\sqrt{5}$

$(2\mathbf{i} - \mathbf{j} + 2\mathbf{k}) \cdot (5\mathbf{i} - 4\mathbf{j} - 2\mathbf{k}) = 10 + 4 - 4 = 10$

acute angle $= \cos^{-1} \left| \frac{10}{3 \times 3\sqrt{5}} \right| = \cos^{-1} \left(\frac{2}{9}\sqrt{5} \right) = 60.2^\circ \text{ (1dp)}$

c $7 + 2\lambda = 5 \Rightarrow \lambda = -1$

sub. $\lambda = -1$ in eqn for l

$\mathbf{r} = 7\mathbf{i} - 2\mathbf{k} - (2\mathbf{i} - \mathbf{j} + 2\mathbf{k}) = 5\mathbf{i} + \mathbf{j} - 4\mathbf{k}$

$\therefore B$ lies on l

d $\overrightarrow{AB} = (5\mathbf{i} + \mathbf{j} - 4\mathbf{k}) - (\mathbf{i} + 3\mathbf{j} - 8\mathbf{k}) = 4\mathbf{i} - 2\mathbf{j} + 4\mathbf{k}$

$|\overrightarrow{AB}| = \sqrt{16+4+16} = 6$

$\therefore$ dist. of B from $m = 6 \sin 60.20^\circ = 5.21 \text{ (3sf)}$

20 **a** $\overrightarrow{AB} = (11\mathbf{i} + 5\mathbf{j} + \mathbf{k}) - (9\mathbf{i} + 6\mathbf{j}) = 2\mathbf{i} - \mathbf{j} + \mathbf{k}$

$$\overrightarrow{OC} = 9\mathbf{i} + 6\mathbf{j} + \lambda(2\mathbf{i} - \mathbf{j} + \mathbf{k})$$

$$= \overrightarrow{OA} + \lambda \overrightarrow{AB}$$

$\therefore C$ lies on l

b $[(9 + 2\lambda)\mathbf{i} + (6 - \lambda)\mathbf{j} + \lambda\mathbf{k}] \cdot [2\mathbf{i} - \mathbf{j} + \mathbf{k}] = 0$

$$2(9 + 2\lambda) - (6 - \lambda) + \lambda = 0$$

$$\lambda = -2$$

c sub. $\lambda = -2$ in $\overrightarrow{OC}$

$$\therefore 5\mathbf{i} + 8\mathbf{j} - 2\mathbf{k}$$

21 **a** $[(-4 + \lambda)\mathbf{i} + (2 + 3\lambda)\mathbf{j} + (7 - 4\lambda)\mathbf{k}] \cdot [\mathbf{i} + 3\mathbf{j} - 4\mathbf{k}] = 0$

$$(-4 + \lambda) + 3(2 + 3\lambda) - 4(7 - 4\lambda) = 0$$

$$\lambda = 1$$

$$\therefore (-3, 5, 3)$$

b $[(7 + 6\lambda)\mathbf{i} + (11 - 9\lambda)\mathbf{j} + (-9 + 3\lambda)\mathbf{k}] \cdot [6\mathbf{i} - 9\mathbf{j} + 3\mathbf{k}] = 0$

$$6(7 + 6\lambda) - 9(11 - 9\lambda) + 3(-9 + 3\lambda) = 0$$

$$\lambda = \frac{2}{3}$$

$$\therefore (11, 5, -7)$$