ANSWERS TO PROBLEMS

Chapter 1

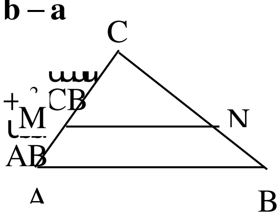
1.2 Problems

1. a. scalar b. scalar c. vector d. neither e. vector f. scalar
   g. scalar h. neither i. scalar j. vector k. vector l. vector

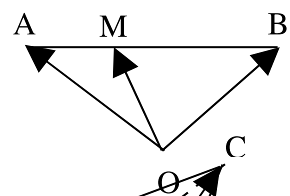
1.3 Problems

1. a. **c = b – a** b. **c = a – b** c. **c = –a – b**

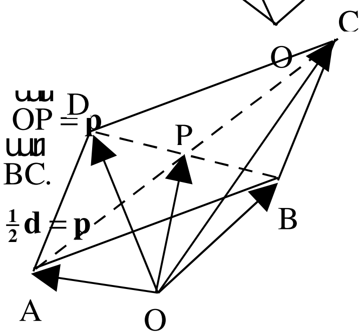
2. a. $\overrightarrow{OC} = \mathbf{a} + \mathbf{b}$ b. $\overrightarrow{AB} = \mathbf{b} - \mathbf{a}$



3. $\overrightarrow{MN} = \overrightarrow{MC} + \overrightarrow{CN} = \frac{2}{3}\overrightarrow{AC} + \frac{2}{3}\overrightarrow{CB}$
   $= \frac{2}{3}(\overrightarrow{AC} + \overrightarrow{CB}) = \frac{2}{3}\overrightarrow{AB}$

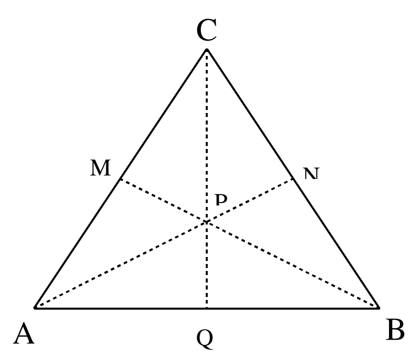


4. $\overrightarrow{OM} = \overrightarrow{OA} + \overrightarrow{AM} = \overrightarrow{OA} + t\overrightarrow{AB}$
   $= \overrightarrow{OA} + t(\overrightarrow{AO} + \overrightarrow{OB})$
   $= (1-t)\overrightarrow{OA} + t\overrightarrow{OB} = s\overrightarrow{OA} + t\overrightarrow{OB}$



5. Let $\overrightarrow{OA} = \mathbf{a}$, $\overrightarrow{OB} = \mathbf{b}$, $\overrightarrow{OC} = \mathbf{c}$, $\overrightarrow{OD} = \mathbf{d}$, $\overrightarrow{OP} = \mathbf{p}$
   Since ABCD is a parallelogram, $\overrightarrow{AD} = \overrightarrow{BC}$.
   Hence $\mathbf{d} - \mathbf{a} = \mathbf{c} - \mathbf{b}$, so $\frac{1}{2}\mathbf{a} + \frac{1}{2}\mathbf{c} = \frac{1}{2}\mathbf{b} + \frac{1}{2}\mathbf{d} = \mathbf{p}$
   This shows that P bisects AC and BD.

6. Let M and N be the mid points of AC and BC.
   Let P be the intersection of medians AN and BM.



$\overrightarrow{CP} = (1-s)\overrightarrow{CM} + s\overrightarrow{CB} = (1-s)(\frac{1}{2}\overrightarrow{CA}) + s\overrightarrow{CB}$ (1)

$\overrightarrow{CP} = t\overrightarrow{CA} + (1-t)\overrightarrow{CN} = t\overrightarrow{CA} + (1-t)(\frac{1}{2}\overrightarrow{CB})$ (2)

Equate (1) & (2).

$(1-s)(\tfrac{1}{2}\overrightarrow{CA}) + s\overrightarrow{CB} = t\overrightarrow{CA} + (1-t)(\tfrac{1}{2}\overrightarrow{CB})$

$[(1-s)(\tfrac{1}{2}) - t]\overrightarrow{CA} = [(1-t)(\tfrac{1}{2}) - s]\overrightarrow{CB}$

Since $\overrightarrow{CA}, \overrightarrow{CB}$ not parallel, $(1-s)(\tfrac{1}{2}) - t = 0$ & $(1\text{-}t)(\tfrac{1}{2}) - s = 0$.

Solving these equations for *s, t* gives $s = t = \tfrac{1}{3}$.

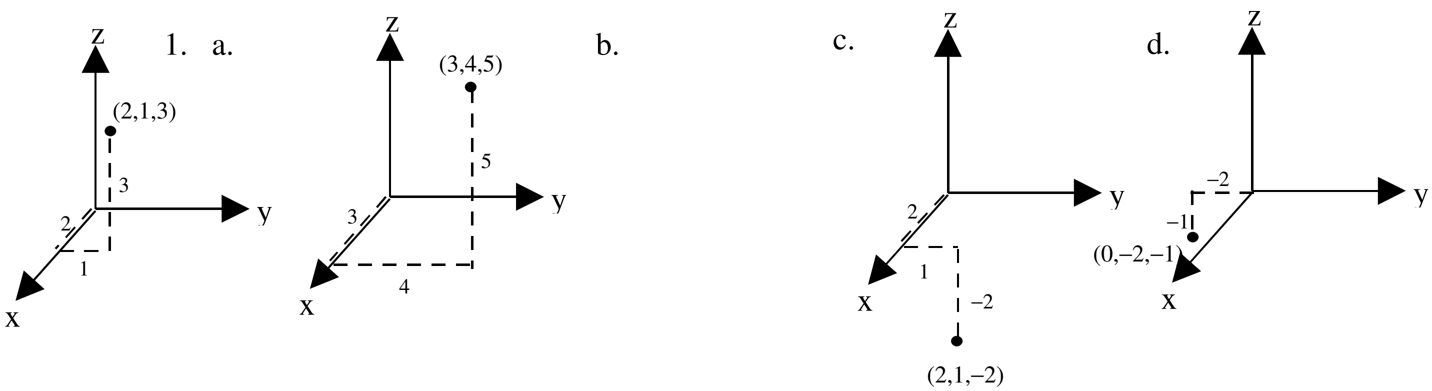
So $\overrightarrow{CP} = (1-s)(\tfrac{1}{2}\overrightarrow{CA}) + s\overrightarrow{CB} = (1-\tfrac{1}{3})(\tfrac{1}{2}\overrightarrow{CA}) + \tfrac{1}{3}\overrightarrow{CB} = \tfrac{1}{3}\overrightarrow{CA} + \tfrac{1}{3}\overrightarrow{CB}$.

Let Q be the mid point of AB. Then $\overrightarrow{CQ} = \tfrac{1}{2}\overrightarrow{CA} + \tfrac{1}{2}\overrightarrow{CB} = \tfrac{3}{2}(\tfrac{1}{3}\overrightarrow{CA} + \tfrac{1}{3}\overrightarrow{CB}) = \tfrac{3}{2}\overrightarrow{CP}$.

This shows that $\overrightarrow{CP}$ is parallel to $\overrightarrow{CQ}$ so P lies on CQ. Hence the medians are concurrent.

1.4 Problems

1. a. b. c. d.



2. (1,0,0), (1,1,0), (0,1,0), (1,0,1), (0,1,1,), (0,0,1)

3, (2,0,0), (2,3,0), (0,3,0), (0,0,1), (2,0,1), (0,3,1)

4. (2,0,0), (0,2,0), (1,1,2)

5. $(\sqrt{3}/2,\ 1/2,\ 0)$, $(\sqrt{3}/6,\ 1/2,\ \sqrt{2}/\sqrt{3})$

1.5 Problems

1. a. (5, 2, 1) b. (–1, 0, 5) c. (8, –2, 2) d. (–5, –1, 12) e. (–4, 6, –4) f. (9, 6, –1)

2. a. $\sqrt{14}$ b. $\sqrt{14}$ c. $6\sqrt{2}$ d. $\sqrt{30}$ e. $\sqrt{26}$ f. $\sqrt{14}$

3. a. (1, 2, 4) b. (2, 6, –3) c. (6, –8, 1) d. (2, –3, 3)

4. a. B = (4, 8, 6) b. B = (3, 3, 6)

5 a. A = (–1, 0, 2) b. A = (2, –4, 3)

6. a. $\pm(2/3, 2/3, 1/3)$ b. $\pm(3/5, 0, 4/5)$ c. $\pm(1/\sqrt{14}, 2/\sqrt{14}, 3/\sqrt{14})$
d. $\pm(-2/\sqrt{29}, 3/\sqrt{29}, -4/\sqrt{29})$

7. $\pm\sqrt{2}$

1.6 Problems

1. a. 11 b. 2 c. 13 d. 13 e. 28

2. a. $\sqrt{6}$ b. $\sqrt{29}$ c. $\sqrt{11}$ d. $\sqrt{57}$ e. $\sqrt{153}$

3 a. $11/\sqrt{174}$ b. $2/\sqrt{66}$ c. $13/\sqrt{319}$ d. $-23/\sqrt{741}$

4 a. $(2,1,3)\bullet(1,1,-1) = (2)(1)+(1)(1)+(3)(-1) = 2+1-3 = 0$
b. $(1,3,5)\bullet(2,1,-1) = (1)(2)+(3)(1)+(5)(-1) = 2+3-5 = 0$
c. $(4,5,1)\bullet(2,-1,-3) = (4)(2)+(5)(1)+(1)(-3) = 8-5-3 = 0$
d. $(1,0,1)\bullet(0,1,0) = (1)(0)+(0)(1)+(1)(0) = 0+0+0 = 0$

5. a. (2, 3) b. (1, –2) c. (3, 1) d. (1, 3))

6. a. (3/2, 1/2, 0) b. (13/9, 26/9, 26/9) c. (6, 2, 2) d. (27/26, 18/13, 9/26)

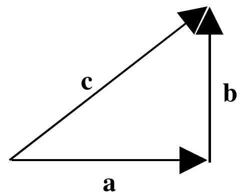
7. a. 17/5 b. 9/5 c. 60/13 d. $8/\sqrt{5}$

8. $\mathbf{c} = \mathbf{a} + \mathbf{b} \Rightarrow \mathbf{c} \bullet \mathbf{c} = (\mathbf{a} + \mathbf{b}) \bullet (\mathbf{a} + \mathbf{b}) \Rightarrow$

$\mathbf{c} \bullet \mathbf{c} = \mathbf{a} \bullet \mathbf{a} + \mathbf{a} \bullet \mathbf{b} + \mathbf{b} \bullet \mathbf{a} + \mathbf{b} \bullet \mathbf{b} \Rightarrow$

$\|\mathbf{c}\|^2 = \|\mathbf{a}\|^2 + 0 + 0 + \|\mathbf{b}\|^2 \Rightarrow$

$\|\mathbf{c}\|^2 = \|\mathbf{a}\|^2 + \|\mathbf{b}\|^2$

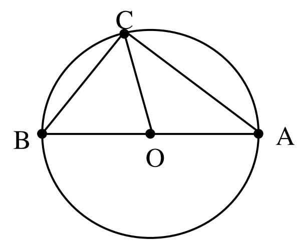


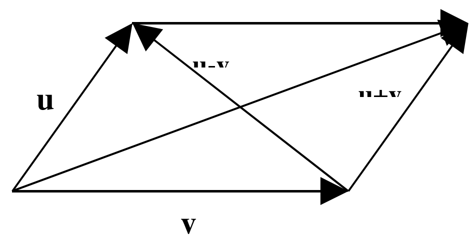
9. Let $\overrightarrow{\mathbf{OA}} = \mathbf{a}$ and $\overrightarrow{\mathbf{OC}} = \mathbf{c}$. Then

$\overrightarrow{\mathbf{BC}} \bullet \overrightarrow{\mathbf{AC}} = (\mathbf{a} + \mathbf{c}) \bullet (\mathbf{c} - \mathbf{a})$

$= \mathbf{a} \bullet \mathbf{c} - \mathbf{a} \bullet \mathbf{a} + \mathbf{c} \bullet \mathbf{c} - \mathbf{c} \bullet \mathbf{a}$

$= -\|\mathbf{a}\|^2 + \|\mathbf{c}\|^2 = 0$ since $\|\mathbf{a}\| = \|\mathbf{c}\|$ and $\mathbf{a} \perp \mathbf{c}$

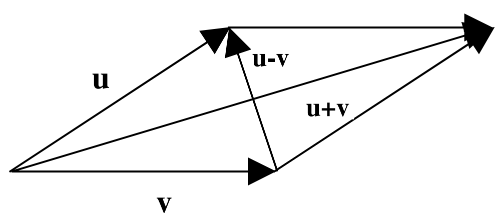




10. $\|\mathbf{u} + \mathbf{v}\|^2 + \|\mathbf{u} - \mathbf{v}\|^2 = (\mathbf{u} + \mathbf{v}) \bullet (\mathbf{u} + \mathbf{v}) + (\mathbf{u} - \mathbf{v}) \bullet (\mathbf{u} - \mathbf{v})$

$= \mathbf{u} \bullet \mathbf{u} + \mathbf{u} \bullet \mathbf{v} + \mathbf{v} \bullet \mathbf{u} + \mathbf{v} \bullet \mathbf{v} + \mathbf{u} \bullet \mathbf{u} - \mathbf{u} \bullet \mathbf{v} - \mathbf{v} \bullet \mathbf{u} + \mathbf{v} \bullet \mathbf{v}$

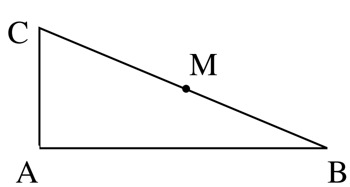
$= 2\mathbf{u} \bullet \mathbf{u} + 2\mathbf{v} \bullet \mathbf{v} = 2\|\mathbf{u}\|^2 + 2\|\mathbf{v}\|^2 = \|\mathbf{u}\|^2 + \|\mathbf{u}\|^2 + \|\mathbf{v}\|^2 + \|\mathbf{v}\|^2$



11. $(\mathbf{u} + \mathbf{v}) \bullet (\mathbf{u} - \mathbf{v}) = \mathbf{u} \bullet \mathbf{u} - \mathbf{u} \bullet \mathbf{v} + \mathbf{v} \bullet \mathbf{u} - \mathbf{v} \bullet \mathbf{v}$

$= \mathbf{u} \bullet \mathbf{u} - \mathbf{v} \bullet \mathbf{v} = \|\mathbf{u}\|^2 - \|\mathbf{v}\|^2 = 0$ since $\|\mathbf{u}\| = \|\mathbf{v}\|$

12. Let ABC be rt. Δ with hypotenuse BC. Let M be the mid point of BC. Then $\|\overrightarrow{BM}\| = \|\overrightarrow{CM}\| = \frac{1}{2}\|\overrightarrow{BC}\|$. We must show $\|\overrightarrow{AM}\| = \frac{1}{2}\|\overrightarrow{BC}\|$. Now



$\|\overrightarrow{AM}\|^2 = \overrightarrow{AM} \bullet \overrightarrow{AM} = (\frac{1}{2}\overrightarrow{AB} + \frac{1}{2}\overrightarrow{AC}) \bullet (\frac{1}{2}\overrightarrow{AB} + \frac{1}{2}\overrightarrow{AC})$

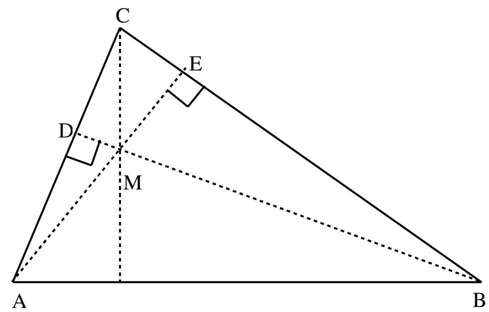
$= \frac{1}{4}\overrightarrow{AB} \bullet \overrightarrow{AB} + \frac{1}{4}\overrightarrow{AB} \bullet \overrightarrow{AC} + \frac{1}{4}\overrightarrow{AC} \bullet \overrightarrow{AB} + \frac{1}{4}\overrightarrow{AC} \bullet \overrightarrow{AC}$

$= \frac{1}{4}\|\overrightarrow{AB}\|^2 + \mathbf{0} + \mathbf{0} + \frac{1}{4}\|\overrightarrow{AC}\|^2 \quad (\overrightarrow{AB} \perp \overrightarrow{AC};\ \therefore \overrightarrow{AB} \bullet \overrightarrow{AC} = \mathbf{0})$

$= \frac{1}{4}\left(\left\|\overrightarrow{AB}\right\|^2 + \left\|\overrightarrow{AC}\right\|^2\right) = \frac{1}{4}\left\|\overrightarrow{BC}\right\|^2$ (using pythagoras' theorem)

Since $\left\|\overrightarrow{AM}\right\|^2 = \frac{1}{4}\|BC\|^2$, taking square roots gives $\left\|\overrightarrow{AM}\right\| = \frac{1}{2}\left\|\overrightarrow{BC}\right\|$ as required.

13. Let AE and BD be altitudes of ΔABC. Let altitudes AE and BD intersect at M. We must show $CM \perp AB$ or $\overrightarrow{CM} \bullet \overrightarrow{AB} = 0$. Now



$$\overrightarrow{CM} \bullet \overrightarrow{AB} = \overrightarrow{CM} \bullet (\overrightarrow{AM} + \overrightarrow{MB}) = \overrightarrow{CM} \bullet \overrightarrow{AM} + \overrightarrow{CM} \bullet \overrightarrow{MB}$$
$$= (\overrightarrow{CB} + \overrightarrow{BM}) \bullet \overrightarrow{AM} + (\overrightarrow{CA} + \overrightarrow{AM}) \bullet \overrightarrow{MB}$$
$$= \overrightarrow{CB} \bullet \overrightarrow{AM} + \overrightarrow{BM} \bullet \overrightarrow{AM} + \overrightarrow{CA} \bullet \overrightarrow{MB} + \overrightarrow{AM} \bullet \overrightarrow{MB}$$
$$= \mathbf{0} + \overrightarrow{BM} \bullet \overrightarrow{AM} + \mathbf{0} + \overrightarrow{AM} \bullet \overrightarrow{MB} = \overrightarrow{AM} \bullet (\overrightarrow{BM} + \overrightarrow{MB})$$
$$= \overrightarrow{AM} \bullet (\overrightarrow{BM} - \overrightarrow{BM}) = \overrightarrow{AM} \bullet \mathbf{0} = 0$$

14. a. $\mathbf{i} \bullet \mathbf{i} = (1,0) \bullet (1,0) = 1 \quad \mathbf{i} \bullet \mathbf{j} = (1,0) \bullet (0,1) = 0$

b. $\mathbf{a} = \overrightarrow{OA} = \overrightarrow{OY} + \overrightarrow{YA} = \cos\alpha\,\mathbf{i} + \sin\alpha\,\mathbf{j}$

$\mathbf{b} = \overrightarrow{OB} = \overrightarrow{OX} + \overrightarrow{XB} = \cos\beta\,\mathbf{i} + \sin\beta\,\mathbf{j}$

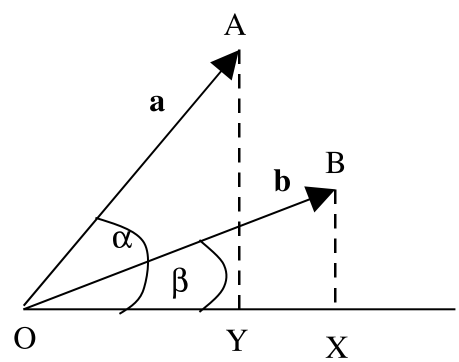
c. $\mathbf{a} \bullet \mathbf{b} = \|\mathbf{a}\|\,\|\mathbf{b}\|\cos(\alpha - \beta) = 1 \cdot 1 \cdot \cos(\alpha - \beta) = \cos(\alpha - \beta)$

But $\mathbf{a} \bullet \mathbf{b} = (\cos\alpha\,\mathbf{i} + \sin\alpha\,\mathbf{j}) \bullet (\cos\beta\,\mathbf{i} + \sin\beta\,\mathbf{j})$

$= \cos\alpha\cos\beta + \sin\alpha\sin\beta$

Equating the two expressions for $\mathbf{a} \bullet \mathbf{b}$ gives

$\cos(\alpha - \beta) = \cos\alpha\cos\beta + \sin\alpha\sin\beta$



1.6 Problems

1. a. (7, –2, 11) b. (10, –12, –2) c. (1, –14, 3) d. (17, –14, –13)

2. a. (37, –10, –59) b. (3, –50, 11) c. 0

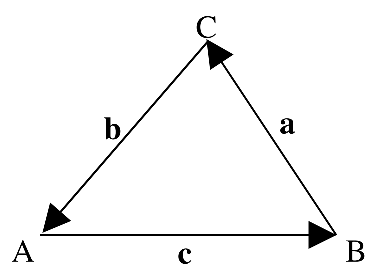
3. a. (7, –2, –11) b.(10, –12, –2)

4. a. $\sqrt{174}$ b. $2\sqrt{62}$ c. $\sqrt{206}$

5. a. $\sqrt{174}/2$ b. $\sqrt{62}$ c. $\sqrt{206}/2$

6. a. $\sqrt{26}/2$ b. $5\sqrt{5}/2$

7. $\mathbf{a}+\mathbf{b}+\mathbf{c}=\mathbf{0} \Rightarrow \mathbf{a}\times(\mathbf{a}+\mathbf{b}+\mathbf{c})=\mathbf{a}\times\mathbf{0} \Rightarrow$
$\mathbf{a}\times\mathbf{a}+\mathbf{a}\times\mathbf{b}+\mathbf{a}\times\mathbf{c}=\mathbf{0}$. But $\mathbf{a}\times\mathbf{a}=\mathbf{0} \Rightarrow$
$\mathbf{a}\times\mathbf{b}=-\mathbf{a}\times\mathbf{c} \Rightarrow \mathbf{a}\times\mathbf{b}=\mathbf{c}\times\mathbf{a} \Rightarrow$
$\|\mathbf{a}\|\cdot\|\mathbf{b}\|\cdot\sin \mathrm{C}=\|\mathbf{c}\|\cdot\|\mathbf{a}\|\cdot\sin \mathrm{B} \Rightarrow$
$\dfrac{\sin \mathrm{C}}{\|\mathbf{c}\|}=\dfrac{\sin \mathrm{B}}{\|\mathbf{b}\|}$. Similarly $\dfrac{\sin \mathrm{B}}{\|\mathbf{b}\|}=\dfrac{\sin \mathrm{A}}{\|\mathbf{a}\|}$



8. a. $\mathbf{u}$ parallel to $\mathbf{v} \Rightarrow \mathbf{v}=k\mathbf{u} \Rightarrow \mathbf{v}=(ku_1, ku_2, ku_3)$

$$\mathbf{u}\times\mathbf{v}=\left(\begin{vmatrix} u_2 & u_3 \\ ku_2 & ku_3 \end{vmatrix}, -\begin{vmatrix} u_1 & u_3 \\ ku_1 & ku_3 \end{vmatrix}, \begin{vmatrix} u_1 & u_2 \\ ku_1 & ku_2 \end{vmatrix}\right)$$
$$=(u_2ku_3-u_3ku_2, -u_1ku_3+u_3ku_1, u_1ku_2-u_2ku_1)$$
$$=(0, 0, 0)=\mathbf{0}.$$

b. $\mathbf{u}\times\mathbf{v}=\mathbf{0} \Rightarrow \|\mathbf{u}\|\,\|\mathbf{v}\|\sin\theta=0 \Rightarrow \sin\theta=0 \Rightarrow \theta=0.$

1.8 Problems

1. a. $4\mathbf{i}+3\mathbf{j}+7\mathbf{k}$ b. $3\mathbf{i}-\mathbf{j}+2\mathbf{k}$ c. $-2\mathbf{i}+5\mathbf{j}+6\mathbf{k}$ d. $\mathbf{i}+2\mathbf{k}$

2. a. $\mathbf{i}\bullet\mathbf{i}=(1,0,0)\bullet(1,0,0)=(1)(1)+(0)(0)+(0)(0)=1+0+0=1$

   b. $\mathbf{j}\bullet\mathbf{j}=(0,1,0)\bullet(0,1,0)=(0)(0)+(1)(1)+(0)(0)=0+1+0=1$

   c. $\mathbf{i}\bullet\mathbf{j}=(1,0,0)\bullet(0,1,0)=(1)(0)+(0)(1)+(0)(0)=0+0+0=0$

   d. $\mathbf{j}\bullet\mathbf{k}=(0,1,0)\bullet(0,0,1)=(0)(0)+(1)(0)+(0)(1)=0+0+0=0$

   e. $\mathbf{i}\times\mathbf{i}=(1,0,0)\times(1,0,0)=\left(\begin{vmatrix}0&0\\0&0\end{vmatrix},-\begin{vmatrix}1&0\\1&0\end{vmatrix},\begin{vmatrix}1&0\\1&0\end{vmatrix}\right)=(0,0,0)=\mathbf{0}$

   f. $\mathbf{i}\times\mathbf{j}=(1,0,0)\times(0,1,0)=\left(\begin{vmatrix}0&0\\1&0\end{vmatrix},-\begin{vmatrix}1&0\\0&0\end{vmatrix},\begin{vmatrix}1&0\\0&1\end{vmatrix}\right)=(0,0,1)=\mathbf{k}$

   g. $\mathbf{i}\times\mathbf{k}=(1,0,0)\times(0,0,1)=\left(\begin{vmatrix}0&0\\0&1\end{vmatrix},-\begin{vmatrix}1&0\\0&1\end{vmatrix},\begin{vmatrix}1&0\\0&0\end{vmatrix}\right)=(0,-1,0)=-(0,1,0)=-\mathbf{j}$

   h. $\mathbf{j}\times\mathbf{k}=(0,1,0)\times(0,0,1)=\left(\begin{vmatrix}1&0\\0&1\end{vmatrix},-\begin{vmatrix}0&0\\0&1\end{vmatrix},\begin{vmatrix}0&1\\0&0\end{vmatrix}\right)=(1,0,0)=\mathbf{i}$

3. a. $6-6+5=5$ b. $6-5+24=25$ c. $8-10-9=-11$ d. $6-3-6=-3$

4. a. $\left(\begin{vmatrix}3&1\\-1&5\end{vmatrix},-\begin{vmatrix}2&1\\3&5\end{vmatrix},\begin{vmatrix}2&3\\3&-2\end{vmatrix}\right)=(17,-7,-13)=17\mathbf{i}-7\mathbf{j}-13\mathbf{k}$

   b. $\left(\begin{vmatrix}1&4\\-5&6\end{vmatrix},-\begin{vmatrix}3&4\\2&6\end{vmatrix},\begin{vmatrix}3&1\\2&-5\end{vmatrix}\right)=(26,-10,-17)=26\mathbf{i}-10\mathbf{j}-17\mathbf{k}$

c. $\left(\begin{vmatrix}-5 & 3\\ 2 & -3\end{vmatrix}, -\begin{vmatrix}2 & 3\\ 4 & -3\end{vmatrix}, \begin{vmatrix}2 & -5\\ 4 & 2\end{vmatrix}\right) = (9,18,24) = 9\mathbf{i} + 18\mathbf{j} + 24\mathbf{k}$

d. $\left(\begin{vmatrix}-3 & 2\\ 1 & -3\end{vmatrix}, -\begin{vmatrix}1 & 2\\ 6 & -3\end{vmatrix}, \begin{vmatrix}1 & -3\\ 6 & 1\end{vmatrix}\right) = (7,15,19) = 7\mathbf{i} + 15\mathbf{j} + 19\mathbf{k}$

5. a. $a - 6a - 5 = 0 \Rightarrow -5a = 5 \Rightarrow a = -1$ b. $6a - 12 - 3a = 0 \Rightarrow 3a = 12 \Rightarrow a = 4$

1.9 Problems

1. a. (6,6,2,5) b. (–13,–3,4,5) c. (3,4,3,1)

2. a. 18 b. 25 c. 41

3. a. $\sqrt{30}$ b. $\sqrt{115}$ c. $\sqrt{29}$

4. a. $(1/\sqrt{30},\ \ 3/\sqrt{30},\ \ 2/\sqrt{30},\ \ 4/\sqrt{30})$ b. $\frac{1}{\sqrt{35}}(5,3,0,1)$ c. $\frac{1}{\sqrt{30}}(3,2,-1,4)$

5. a. $(1,2,3,1) \bullet (3,1,1,-8) = (1)(3) + (2)(1) + (3)(1) + (1)(-8) = 3 + 2 + 3 - 8 = 0$
   b. c. d. similar to a. as shown above.

6. a. $(1,1,0,0) \bullet (1,-1,2,3) = (1)(1) + (1)(-1) + (0)(2) + (0)(3) = 1 - 1 + 0 + 0 = 0$
   $(1,1,0,0) \bullet (2,-2,1,-2) = (1)(2) + (1)(-2) + (0)(1) + (0)(-2) = 2 - 2 + 0 + 0 = 0$
   $(1,-1,2,3) \bullet (2,-2,1,-2) = (1)(2) + (-1)(-2) + (2)(1) + (3)(-2) = 2 + 2 + 2 - 6 = 0$
   b. c. d. similar to a. as shown above.

Chapter 2

2.2 Problems

1. a. (2, 3, 4) b. (1, 3, –2) c. (3, 0, 5)

2. a. $(3,2,3)\bullet(x-1, y-0, z-1)=(0,0,0)$ b. $(1,2,3)\bullet(x-2, y-2, z-2)=(0,0,0)$

c. $(5,2,-3)\bullet(x-1, y-1, z-0)=(0,0,0)$

3. a. $2x+3y+z=23$ b. $5x+2y+3z=28$ c. $x+z=8$ d. $2x-y+3z=-4$

4. a. $2x+y-z=1$ b. $5x-y+6z=43$ c. $x+2y+z=2$ d. $2x-2y-z=2$

2.3 Problems

1. a. $\mathbf{x}=(1,2,3)+t(2,1,4)$ $x=1+2t,\ y=2+t,\ z=3+4t$

b. $\mathbf{x}=(3,1,3)+t(4,2,5)$ $x=3+4t,\ y=1+2t,\ z=3+5t$

c. $\mathbf{x}=(4,1,5)+t(1,0,3)$ $x=4+t,\ y=1+0t,\ z=5+3t$

d. $\mathbf{x}=(1,-2,2)+t(2,3,-1)$ $x=1+2t,\ y=-2+3t,\ z=2-t$

e. $\mathbf{x}=(2,0,-1)+t(1,-2,3)$ $x=2+t,\ y=0-2t,\ z=-1+3t$

f. $\mathbf{x}=(-3,2,0)+t(0,-1,3)$ $x=-3,\ y=2-t,\ z=3t$

2. a. $x=1+t,\ y=3+2t,\ z=4-3t$ b. $x=4-2t,\ y=3-t,\ z=-1+4t$

c. $x=2-t,\ y=-1+t,\ z=-3+t$ d. $x=5-4t,\ y=1-2t,\ z=3-t$

e. $x=4-3t,\ y=3t,\ z=-5+t$ f. $x=2+t,\ y=2-5t,\ z=-2+2t$

3. a. $\frac{x-1}{1}=\frac{y-3}{2}=\frac{z-4}{-3}$ b. $\frac{x-4}{-2}=\frac{y-3}{-1}=\frac{z+1}{4}$

c. $\frac{x-2}{-1}=\frac{y+1}{1}=\frac{z+3}{1}$ d. $\frac{x-5}{-4}=\frac{y-1}{-2}=\frac{z-3}{-1}$

e. $\frac{x-4}{-3}=\frac{y-0}{3}=\frac{z+5}{1}$ f. $\frac{x-2}{1}=\frac{y-2}{-5}=\frac{z+2}{2}$

2.4 Problems

1. a. 90º b. 60º c. 60º d. 30º e. 45° f. 45°

2. a. $-17/\sqrt{231}$ b. $15/2\sqrt{105}$ c. $14/3\sqrt{22}$ d. $\sqrt{15}/7$

2.5 Problems

1. a. 3 b. $37/5\sqrt{2}$ c. 1 d. 0

2. a. 5/3 b. $16/\sqrt{11}$

3. a. $\sqrt{13}/\sqrt{22}$ b. $10/\sqrt{3}$ c. $\sqrt{14}$ d. $\sqrt{21}$

4. a. $2/\sqrt{51}$ b. $8/\sqrt{83}$ c. 0 d. $8/\sqrt{510}$

5. a. $1/\sqrt{3}$ b. $10/\sqrt{17}$ c. $13/\sqrt{35}$

2.6 Problems

1. a. $x=\frac{6}{5}-t,\ y=\frac{7}{5}-7t,\ z=0-5t$ b. $x = 0 + 4t,\ y = 1 - 7t,\ z = 1 - 2t$

   c. $x = 1 + 3t,\ y = 2 - 7t,\ z = 0 + 2t$ d. $x=0+4t,\ y=\frac{3}{2}+2t,\ z=\frac{11}{4}-t$

   e. $x=2+t,\ y=1+4t,\ z=3+7t$ f. $x=\frac{9}{5}+4t,\ y=\frac{7}{5}+4t,\ z=0-5t$

2. a. (3, 2, 1) b. (2,2,1) c. (–3, 4, –5) d. (1, 4, 1)

3. a. (3, 2, 1) b. (0, 1, 1) c. (3, 0, 2) d. do not intersect.

2.7 Problems

1. a. (2, 3, 1) $\left(2/\sqrt{14},\ 3/\sqrt{14},\ 1/\sqrt{14}\right)$ b. (4, 1, 1) $\left(4/3\sqrt{2}, 1/3\sqrt{2}, 1/3\sqrt{2}\right)$

   c. (1, 2, 3) $\left(1/\sqrt{14},\ 2/\sqrt{14},\ 3/\sqrt{14}\right)$ d. (1, 3, 5) $\left(1/\sqrt{35},\ 3/\sqrt{35},\ 5/\sqrt{35}\right)$

2. a. (1, –3, 4) $\left(1/\sqrt{26},\ -3/\sqrt{26},\ 4/\sqrt{26}\right)$ b. (–1, 2, 0) $\left(-1/\sqrt{5},\ 2/\sqrt{5},\ 0\right)$

   c. (4, 2, 3) $\left(4/\sqrt{29},\ 2/\sqrt{29},\ 3/\sqrt{29}\right)$ d. (3, 0, –4) $\left(3/5,\ 0, -4/5\right)$

3. a. $x=2+3t,\ y=5+2t,\ z=1+4t$ b. $x=3-t,\ y=-2,\ z=1+2t$

   c. $x=4+3t,\ y=1,\ z=3+2t$ d. $x=5+2t,\ y=t,\ z=-2-2t$

4. a. $3x+2y+4z=20$ b. $x-2z=1$ c. $3x+2z=18$ d. $2x+y-2z=6$