1 a 
$$oldsymbol{a}-oldsymbol{b}=(oldsymbol{i}+oldsymbol{j}+2oldsymbol{k})-(2oldsymbol{i}-oldsymbol{j}+3oldsymbol{k}) \ =-oldsymbol{i}+2oldsymbol{j}-oldsymbol{k}$$

$$\begin{array}{ll} \mathbf{b} & 3\mathbf{b} - 2\mathbf{a} + \mathbf{c} = 3(2\mathbf{i} - \mathbf{j} + 3\mathbf{k}) - 2(\mathbf{i} + \mathbf{j} + 2\mathbf{k}) + (-\mathbf{i} + \mathbf{k}) \\ & = 6\mathbf{i} - 3\mathbf{j} + 9\mathbf{k} - 2\mathbf{i} - 2\mathbf{j} - 4\mathbf{k} - \mathbf{i} + \mathbf{k} \\ & = 3\mathbf{i} - 5\mathbf{j} + 6\mathbf{k} \end{array}$$

c 
$$|m{b}| = \sqrt{2^2 + (-1)^2 + 3^2}$$
 $= \sqrt{4 + 1 + 9}$ 
 $= \sqrt{14}$ 

$$egin{aligned} \mathsf{d} & |m{b}+m{c}| = |(2m{i}-m{j}+3m{k})+(-m{i}+m{k})| \ & = |m{i}-m{j}+4m{k}| \ & = \sqrt{1^2+(-1)^2+4^2} \ & = \sqrt{18} = 3\sqrt{2} \end{aligned}$$

$$\begin{array}{ll} \mathbf{e} & 3(\boldsymbol{a}-\boldsymbol{b}) + 2\boldsymbol{c} = 3((\boldsymbol{i}+\boldsymbol{j}+2\boldsymbol{k}) - (2\boldsymbol{i}-\boldsymbol{j}+3\boldsymbol{k})) + 2(-\boldsymbol{i}+\boldsymbol{k}) \\ & = 3(-\boldsymbol{i}+2\boldsymbol{j}-\boldsymbol{k}) - 2\boldsymbol{i} + 2\boldsymbol{k} \\ & = -3\boldsymbol{i} + 6\boldsymbol{j} - 3\boldsymbol{k} - 2\boldsymbol{i} + 2\boldsymbol{k} \\ & = -5\boldsymbol{i} + 6\boldsymbol{j} - \boldsymbol{k} \end{array}$$

$$egin{array}{ccc} \mathbf{2} \; \mathsf{a} & \stackrel{
ightarrow}{OB} = \stackrel{
ightarrow}{OA} + \stackrel{
ightarrow}{OC} \ &= 2oldsymbol{j} + 2oldsymbol{k} \end{array}$$

$$egin{aligned} oldsymbol{o} & \overrightarrow{OE} = \overrightarrow{OA} + \overrightarrow{OD} \ &= oldsymbol{i} + 2oldsymbol{j} \end{aligned}$$

$$egin{aligned} \mathbf{c} & \overrightarrow{OG} = \overrightarrow{OC} + \overrightarrow{OD} \ &= oldsymbol{i} + 2oldsymbol{k} \end{aligned}$$

$$egin{aligned} \mathbf{d} & \stackrel{
ightarrow}{OF} = \stackrel{
ightarrow}{OA} + \stackrel{
ightarrow}{OC} + \stackrel{
ightarrow}{OD} \ &= oldsymbol{i} + 2oldsymbol{j} + 2oldsymbol{k} \end{aligned}$$

e 
$$\overrightarrow{ED} = -\overrightarrow{OA}$$
  
=  $-2 oldsymbol{j}$ 

$$egin{aligned} \mathbf{f} & \stackrel{
ightarrow}{\overrightarrow{EG}} = -\stackrel{
ightarrow}{OA} + \stackrel{
ightarrow}{OC} \ &= -2oldsymbol{j} + 2oldsymbol{k} \end{aligned}$$

$$egin{aligned} \mathbf{g} & \stackrel{
ightarrow}{CE} = -\stackrel{
ightarrow}{OC} + \stackrel{
ightarrow}{OA} + \stackrel{
ightarrow}{OD} \ &= oldsymbol{i} + 2oldsymbol{j} - 2oldsymbol{k} \end{aligned}$$

$$egin{aligned} \mathbf{h} & \overrightarrow{BD} = -\overrightarrow{OC} - \overrightarrow{OA} + \overrightarrow{OD} \ &= oldsymbol{i} - 2oldsymbol{j} - 2oldsymbol{k} \end{aligned}$$

3 a j 
$$|a| = \sqrt{3^2 + 1^2 + 1^2}$$
  
 $= \sqrt{11}$   
 $\hat{a} = \frac{1}{\sqrt{11}} (3i + j - k)$   
 $= \frac{3}{\sqrt{11}} i + \frac{1}{\sqrt{11}} j - \frac{1}{\sqrt{11}} k$ 

ii 
$$-2\hat{m{a}} = -rac{6}{\sqrt{11}}m{i} - rac{2}{\sqrt{11}}m{j} + rac{2}{\sqrt{11}}m{k}$$

**b** 
$$5\hat{a} = \frac{15}{\sqrt{11}}i + \frac{5}{\sqrt{11}}j - \frac{5}{\sqrt{11}}k$$

4 
$$|a| = \sqrt{1^2 + 1^2 + 5^2}$$
  
 $= \sqrt{27} = 3\sqrt{3}$   
 $|b| = \sqrt{2^2 + 1^2 + 3^2}$   
 $= \sqrt{14}$   
 $c = \frac{|a|}{|b|}a$   
 $= \frac{\sqrt{14}}{3\sqrt{3}}(i - j + 5k)$ 

$$=rac{3\sqrt{3}}{9}(oldsymbol{i}-oldsymbol{j}+5oldsymbol{k})$$

5 a 
$$\stackrel{
ightarrow}{PQ}=oldsymbol{i}-3oldsymbol{j}$$

$$\begin{array}{ll} \mathbf{b} & |\overrightarrow{PQ}| = \sqrt{1^2 + 3^2 + 0^2} \\ & = \sqrt{10} \end{array}$$

$$\mathbf{c} \qquad \overrightarrow{OM} = \overrightarrow{OP} + \overrightarrow{PM}$$

$$= \overrightarrow{OP} + \frac{1}{2}\overrightarrow{PQ}$$

$$= \mathbf{i} + 2\mathbf{j} - \mathbf{k} + \frac{1}{2}\mathbf{i} - \frac{3}{2}\mathbf{j}$$

$$= \frac{3}{2}\mathbf{i} + \frac{1}{2}\mathbf{j} - \mathbf{k}$$

$$\overrightarrow{OE} = \overrightarrow{OA} + \overrightarrow{AE}$$

$$= \mathbf{i} + 3\mathbf{j}$$

$$\overrightarrow{OM} = \frac{1}{3} \overrightarrow{OE}$$

$$=rac{1}{3}m{i}+m{j}$$

$$\overrightarrow{BF} = \overrightarrow{OD}$$

$$\overrightarrow{BN} = \frac{1}{2}\overrightarrow{BF}$$

$$=rac{1}{2}m{i}$$

$$\overrightarrow{ON} = \overrightarrow{OC} + \overrightarrow{CB} + \overrightarrow{BN}$$

$$=rac{1}{2}oldsymbol{i}+3oldsymbol{j}+2oldsymbol{k}$$

$$\overrightarrow{MN} = \overrightarrow{ON} - \overrightarrow{OM}$$

$$=rac{1}{2}oldsymbol{i}+3oldsymbol{j}+2oldsymbol{k}-\left(rac{1}{3}oldsymbol{i}+oldsymbol{j}
ight)$$

$$=rac{1}{6}m{i}+2m{j}+2m{k}$$

$$|\overrightarrow{MN}| = \sqrt{\left(rac{1}{6}
ight)^2 + 2^2 + 2^2}$$

$$= 4\sqrt{\frac{1+144+144}{36}}$$

$$= \sqrt{\frac{289}{36}}$$

$$= \frac{17}{6}$$