1 a $\quad a - b = (i + j + 2k) - (2i - j + 3k)$
$\qquad\qquad = -i + 2j - k$

b $\quad 3b - 2a + c = 3(2i - j + 3k) - 2(i + j + 2k) + (-i + k)$
$\qquad\qquad\qquad = 6i - 3j + 9k - 2i - 2j - 4k - i + k$
$\qquad\qquad\qquad = 3i - 5j + 6k$

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

d $\quad |b + c| = |(2i - j + 3k) + (-i + k)|$
$\qquad\qquad = |i - j + 4k|$
$\qquad\qquad = \sqrt{1^2 + (-1)^2 + 4^2}$
$\qquad\qquad = \sqrt{18} = 3\sqrt{2}$

e $\quad 3(a - b) + 2c = 3((i + j + 2k) - (2i - j + 3k)) + 2(-i + k)$
$\qquad\qquad\qquad = 3(-i + 2j - k) - 2i + 2k$
$\qquad\qquad\qquad = -3i + 6j - 3k - 2i + 2k$
$\qquad\qquad\qquad = -5i + 6j - k$

2 a $\quad \vec{OB} = \vec{OA} + \vec{OC}$
$\qquad\quad = 2j + 2k$

b $\quad \vec{OE} = \vec{OA} + \vec{OD}$
$\qquad\quad = i + 2j$

c $\quad \vec{OG} = \vec{OC} + \vec{OD}$
$\qquad\quad = i + 2k$

d $\quad \vec{OF} = \vec{OA} + \vec{OC} + \vec{OD}$
$\qquad\quad = i + 2j + 2k$

e $\quad \vec{ED} = -\vec{OA}$
$\qquad\quad = -2j$

f $\quad \vec{EG} = -\vec{OA} + \vec{OC}$
$\qquad\quad = -2j + 2k$

g $\quad \vec{CE} = -\vec{OC} + \vec{OA} + \vec{OD}$
$\qquad\quad = i + 2j - 2k$

h $\quad \vec{BD} = -\vec{OC} - \vec{OA} + \vec{OD}$
$\qquad\quad = i - 2j - 2k$

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

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

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

4 $|a| = \sqrt{1^2 + 1^2 + 5^2}$
$= \sqrt{27} = 3\sqrt{3}$
$|b| = \sqrt{2^2 + 1^2 + 3^2}$
$= \sqrt{14}$
$c = \dfrac{|a|}{|b|}a$
$= \dfrac{\sqrt{14}}{3\sqrt{3}}(i - j + 5k)$
$= \dfrac{\sqrt{42}}{9}(i - j + 5k)$

5 a $\overrightarrow{PQ} = i - 3j$

b $|\overrightarrow{PQ}| = \sqrt{1^2 + 3^2 + 0^2}$
$= \sqrt{10}$

c $\overrightarrow{OM} = \overrightarrow{OP} + \overrightarrow{PM}$
$= \overrightarrow{OP} + \dfrac{1}{2}\overrightarrow{PQ}$
$= i + 2j - k + \dfrac{1}{2}i - \dfrac{3}{2}j$
$= \dfrac{3}{2}i + \dfrac{1}{2}j - k$

6 a $\overrightarrow{OE} = \overrightarrow{OA} + \overrightarrow{AE}$
$= i + 3j$
$\overrightarrow{OM} = \dfrac{1}{3}\overrightarrow{OE}$
$= \dfrac{1}{3}i + j$
$\overrightarrow{BF} = \overrightarrow{OD}$
$= i$
$\overrightarrow{BN} = \dfrac{1}{2}\overrightarrow{BF}$
$= \dfrac{1}{2}i$
$\overrightarrow{ON} = \overrightarrow{OC} + \overrightarrow{CB} + \overrightarrow{BN}$
$= \dfrac{1}{2}i + 3j + 2k$
$\overrightarrow{MN} = \overrightarrow{ON} - \overrightarrow{OM}$
$= \dfrac{1}{2}i + 3j + 2k - \left(\dfrac{1}{3}i + j\right)$
$= \dfrac{1}{6}i + 2j + 2k$

b $|\overrightarrow{MN}| = \sqrt{\left(\dfrac{1}{6}\right)^2 + 2^2 + 2^2}$

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

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

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