7 a i 2j ii j − k iii −k − j b i j − k ii $\overrightarrow{JX} = \overrightarrow{KJ}$, and point J is common.

8 a a − 3b

b $\overrightarrow{NM} = \frac{1}{2}(\mathbf{a} - \mathbf{b})$; $\overrightarrow{NC} = 2(\mathbf{a} - \mathbf{b})$; $\overrightarrow{NC}$ is a multiple of $\overrightarrow{NM}$ and point N is common, so NMC is a straight line.

9 a 3q − 2p b $\overrightarrow{OR} = \frac{6}{5}(p + q)$; $\overrightarrow{OR}$ is a multiple of p + q and so it is parallel to **p** + q.

10 a a − b b $-\frac{1}{5}(3a + 2b)$

11 a i 2q − 4p ii 3(q − p) iii 2(q − p)

b $\overrightarrow{AB}$ and $\overrightarrow{AC}$ are multiples of **q** − **p**. Point A is common, so ABC is a straight line. c 9 cm

12 a b − a b 2b − a

13 a 6b − 3a b $\overrightarrow{AX} = \frac{1}{3}\overrightarrow{AB} = 2b - a$
$\overrightarrow{OX} = \overrightarrow{OA} + \overrightarrow{AX} = 2(\mathbf{b} + \mathbf{a})$
$\overrightarrow{OY} = \overrightarrow{OB} + \overrightarrow{BY} = 5(\mathbf{b} + \mathbf{a})$
So $\overrightarrow{OX} = \frac{2}{5}\overrightarrow{OY}$

18 Unit test

1 a $\begin{pmatrix} 10 \\ -15 \end{pmatrix}$ **[1]** b $\begin{pmatrix} 7 \\ 1 \end{pmatrix}$ **[1]** c $\begin{pmatrix} -11 \\ -18 \end{pmatrix}$ **[2]**

2 Vectors **a** followed by 2**b** correctly drawn **[2]** [Allow **1** if only 2**b** drawn]
Resultant **a** + 2**b** correctly drawn **[1]**

3 a $\overrightarrow{AE} = 2\mathbf{q}$ **[1]** b $\overrightarrow{AC} = \mathbf{p} + \mathbf{q}$ **[1]**

4 a $\begin{pmatrix} 3 \\ 6 \end{pmatrix} - \begin{pmatrix} 1 \\ 4 \end{pmatrix}$ **[1]** $= \begin{pmatrix} 2 \\ 2 \end{pmatrix}$ **[1]**

b M(2, 5) and N(5, 5) **[1]**
$\overrightarrow{MN} = \begin{pmatrix} 5 \\ 5 \end{pmatrix} - \begin{pmatrix} 2 \\ 5 \end{pmatrix}$ **[1]** $= \begin{pmatrix} 3 \\ 0 \end{pmatrix}$ **[1]**

5 a i $\overrightarrow{FE} = \mathbf{b}$ **[1]** ii $\overrightarrow{CE} = \mathbf{b} - 2\mathbf{a}$ **[1]**

b $\overrightarrow{CD} = -2\mathbf{a} + \mathbf{b} + \mathbf{a} = \mathbf{b} - \mathbf{a}$ **[1]**
$\overrightarrow{FX} = \mathbf{b} + \mathbf{b} - 2\mathbf{a} = 2\mathbf{b} - 2\mathbf{a}$ **[1]**
$\overrightarrow{FX} = 2(\mathbf{b} - \mathbf{a})$ so $\overrightarrow{FX}$ is parallel to $\overrightarrow{CD}$ **[1]**

6 a B(8, 3) **[1]** b D(−1, 3) **[1]**
$\overrightarrow{BD} = \begin{pmatrix} -9 \\ 0 \end{pmatrix}$ **[1]**

7 $\overrightarrow{PQ} = 2\mathbf{r}$ **[1]**
$\overrightarrow{PX} = \frac{3}{2}\mathbf{r}$ **[1]**
$\overrightarrow{OX} = \mathbf{p} + \frac{3}{2}\mathbf{r}$ **[1]**

8 a $\overrightarrow{ON} = \overrightarrow{OA} + \overrightarrow{AN}$ seen or implied **[1]**
$\overrightarrow{AB} = -\mathbf{a} + \mathbf{b}$ so $\overrightarrow{AN} = -\frac{2}{3}\mathbf{a} + \frac{2}{3}b$ **[1]**
$\overrightarrow{ON} = \mathbf{a} - \frac{2}{3}\mathbf{a} + \frac{2}{3}\mathbf{b} = \frac{1}{3}\mathbf{a} + \frac{2}{3}\mathbf{b}$ **[1]**
OR
$\overrightarrow{ON} = \overrightarrow{OB} + \overrightarrow{BN}$ seen or implied **[1]**
$\overrightarrow{BA} = -\mathbf{b} + \mathbf{a}$ so $\overrightarrow{BN} = -\frac{1}{3}\mathbf{b} + \frac{1}{3}\mathbf{a}$ **[1]**
$\overrightarrow{ON} = \mathbf{b} - \frac{1}{3}\mathbf{b} + \frac{1}{3}\mathbf{a} = \frac{1}{3}\mathbf{a} + \frac{2}{3}\mathbf{b}$ **[1]**

b $\overrightarrow{OD} = \overrightarrow{OA} + \overrightarrow{AC} + \overrightarrow{CD} = \mathbf{a} + \mathbf{b} + \mathbf{b} = \mathbf{a} + 2\mathbf{b}$ **[1]**
$\overrightarrow{OD} = 3\left(\frac{1}{3}\mathbf{a} + \frac{2}{3}\mathbf{b}\right)$ so $\overrightarrow{OD} = 3\overrightarrow{ON}$ **[1]**
$\overrightarrow{OD}$ is a multiple of $\overrightarrow{ON}$ and they have a common point, so OND is a straight line. **[1]**

9 a $\overrightarrow{AB} = \begin{pmatrix} -4 \\ -4 \end{pmatrix}$ **[1]**

b C(1, 5) **[1]**

c X(1, 2) **[1]**
$\overrightarrow{OX} = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$ **[1]**

d $|AB| = \sqrt{(-4)^2 + (-4)^2}$ **[1]** $= 4\sqrt{2}$ **[1]**

Sample student answer

a The answer should say $\overrightarrow{AB} = 2\mathbf{n} - 2\mathbf{m} = 2(\mathbf{n} - \mathbf{m})$ and $\overrightarrow{MN} = \mathbf{n} - \mathbf{m}$. The student has forgotten the direction of the vectors.

b The answer could be improved by adding a sentence at the end, e.g. 'This means AB is parallel to MN and is twice the length.'