1 The points $A, B$ and $C$ have coordinates $(6,1),(2,3)$ and $(-4,3)$ respectively and $O$ is the origin. Find, in terms of $\mathbf{i}$ and $\mathbf{j}$, the vectors
a $\overrightarrow{O A}$
b $\overrightarrow{A B}$
c $\overrightarrow{B C}$
d $\overrightarrow{C A}$

2 Given that $\mathbf{p}=\mathbf{i}-3 \mathbf{j}$ and $\mathbf{q}=4 \mathbf{i}+2 \mathbf{j}$, find expressions in terms of $\mathbf{i}$ and $\mathbf{j}$ for
a 4 p
b $\mathbf{q}-\mathbf{p}$
c $2 \mathbf{p}+3 \mathbf{q}$
d $4 \mathbf{p}-2 \mathbf{q}$

3 Given that $\mathbf{p}=\binom{3}{-4}$ and $\mathbf{q}=\binom{1}{2}$, find
a $|\mathbf{p}|$
b $|2 q|$
c $|\mathbf{p}+2 \boldsymbol{q}|$
d $|3 \mathbf{q}-2 \mathbf{p}|$

4 Given that $\mathbf{p}=2 \mathbf{i}+\mathbf{j}$ and $\mathbf{q}=\mathbf{i}-3 \mathbf{j}$, find, in degrees to 1 decimal place, the angle made with the vector $\mathbf{i}$ by the vector
a $\mathbf{p}$
b $\mathbf{q}$
c $5 \mathbf{p}+\mathbf{q}$
d $\mathbf{p - 3 q}$

5 Find a unit vector in the direction
a $\binom{4}{3}$
b $\binom{7}{-24}$
c $\binom{-1}{1}$
d $\binom{2}{4}$

6 Find a vector
a of magnitude 26 in the direction $5 \mathbf{i}+12 \mathbf{j}$,
b of magnitude 15 in the direction $-6 \mathbf{i}-8 \mathbf{j}$,
c of magnitude 5 in the direction $2 \mathbf{i}-4 \mathbf{j}$.
7 Given that $\mathbf{m}=2 \mathbf{i}+\lambda \mathbf{j}$ and $\mathbf{n}=\mu \mathbf{i}-5 \mathbf{j}$, find the values of $\lambda$ and $\mu$ such that
a $\mathbf{m}+\mathbf{n}=3 \mathbf{i}-\mathbf{j}$
b $2 \mathbf{m}-\mathbf{n}=-3 \mathbf{i}+8 \mathbf{j}$

8 Given that $\mathbf{r}=6 \mathbf{i}+c \mathbf{j}$, where $c$ is a positive constant, find the value of $c$ such that
a $\mathbf{r}$ is parallel to the vector $2 \mathbf{i}+\mathbf{j}$
b $\mathbf{r}$ is parallel to the vector $-9 \mathbf{i}-6 \mathbf{j}$
c $|\mathbf{r}|=10$
d $|\mathbf{r}|=3 \sqrt{5}$
9 Given that $\mathbf{p}=\mathbf{i}+3 \mathbf{j}$ and $\mathbf{q}=4 \mathbf{i}-2 \mathbf{j}$,
a find the values of $a$ and $b$ such that $a \mathbf{p}+b \mathbf{q}=-5 \mathbf{i}+13 \mathbf{j}$,
b find the value of $c$ such that $c \mathbf{p}+\mathbf{q}$ is parallel to the vector $\mathbf{j}$,
c find the value of $d$ such that $\mathbf{p}+d \mathbf{q}$ is parallel to the vector $3 \mathbf{i}-\mathbf{j}$.
10 Relative to a fixed origin $O$, the points $A$ and $B$ have position vectors $\binom{3}{6}$ and $\binom{-5}{2}$ respectively.
Find
a the vector $\overrightarrow{A B}$,
b $|\overrightarrow{A B}|$,
c the position vector of the mid-point of $A B$,
d the position vector of the point $C$ such that $O A B C$ is a parallelogram.

11 Given the coordinates of the points $A$ and $B$, find the length $A B$ in each case.
a $A(4,0,9), B(2,-3,3)$
b $A(11,-3,5), B(7,-1,3)$

12 Find the magnitude of each vector.
a $4 \mathbf{i}+2 \mathbf{j}-4 \mathbf{k}$
b $\mathbf{i}+\mathbf{j}+\mathbf{k}$
c $-8 \mathbf{i}-\mathbf{j}+4 \mathbf{k}$
d $3 \mathbf{i}-5 \mathbf{j}+\mathbf{k}$

13 Find
a a unit vector in the direction $5 \mathbf{i}-2 \mathbf{j}+14 \mathbf{k}$,
b a vector of magnitude 10 in the direction $2 \mathbf{i}+11 \mathbf{j}-10 \mathbf{k}$,
c a vector of magnitude 20 in the direction $-5 \mathbf{i}-4 \mathbf{j}+2 \mathbf{k}$.
14 Given that $\mathbf{r}=\lambda \mathbf{i}+12 \mathbf{j}-4 \mathbf{k}$, find the two possible values of $\lambda$ such that $|\mathbf{r}|=14$.
15 Given that $\mathbf{p}=\left(\begin{array}{c}1 \\ 3 \\ -1\end{array}\right), \mathbf{q}=\left(\begin{array}{c}4 \\ -2 \\ 1\end{array}\right)$ and $\mathbf{r}=\left(\begin{array}{c}-2 \\ 5 \\ -3\end{array}\right)$, find as column vectors,
a $\mathbf{p}+2 \mathbf{q}$
b $\mathbf{p}-\mathbf{r}$
c $\mathbf{p}+\mathbf{q}+\mathbf{r}$
d $2 \mathbf{p}-3 \mathbf{q}+\mathbf{r}$

16 Given that $\mathbf{r}=-2 \mathbf{i}+\lambda \mathbf{j}+\mu \mathbf{k}$, find the values of $\lambda$ and $\mu$ such that
a $\mathbf{r}$ is parallel to $4 \mathbf{i}+2 \mathbf{j}-8 \mathbf{k}$
b $\mathbf{r}$ is parallel to $-5 \mathbf{i}+20 \mathbf{j}-10 \mathbf{k}$

17 Given that $\mathbf{p}=\mathbf{i}-2 \mathbf{j}+4 \mathbf{k}, \mathbf{q}=-\mathbf{i}+2 \mathbf{j}+2 \mathbf{k}$ and $\mathbf{r}=2 \mathbf{i}-4 \mathbf{j}-7 \mathbf{k}$,
a find $|2 \mathbf{p}-\mathbf{q}|$,
b find the value of $k$ such that $\mathbf{p}+k \mathbf{q}$ is parallel to $\mathbf{r}$.
18 Relative to a fixed origin $O$, the points $A, B$ and $C$ have position vectors $(-2 \mathbf{i}+7 \mathbf{j}+4 \mathbf{k})$, $(-4 \mathbf{i}+\mathbf{j}+8 \mathbf{k})$ and $(6 \mathbf{i}-5 \mathbf{j})$ respectively.
a Find the position vector of the mid-point of $A B$.
b Find the position vector of the point $D$ on $A C$ such that $A D: D C=3: 1$
19 Given that $\mathbf{r}=\lambda \mathbf{i}-2 \lambda \mathbf{j}+\mu \mathbf{k}$, and that $\mathbf{r}$ is parallel to the vector ( $2 \mathbf{i}-4 \mathbf{j}-3 \mathbf{k}$ ), a show that $3 \lambda+2 \mu=0$.
Given also that $|\mathbf{r}|=2 \sqrt{29}$ and that $\mu>0$,
b find the values of $\lambda$ and $\mu$.
20 Relative to a fixed origin $O$, the points $A, B$ and $C$ have position vectors $\left(\begin{array}{c}6 \\ -2 \\ -4\end{array}\right),\left(\begin{array}{c}12 \\ -7 \\ -4\end{array}\right)$ and $\left(\begin{array}{c}6 \\ 1 \\ -8\end{array}\right)$ respectively.
a Find the position vector of the point $M$, the mid-point of $B C$.
b Show that $O, A$ and $M$ are collinear.
21 The position vector of a model aircraft at time $t$ seconds is $(9-t) \mathbf{i}+(1+2 t) \mathbf{j}+(5-t) \mathbf{k}$, relative to a fixed origin $O$. One unit on each coordinate axis represents 1 metre.
a Find an expression for $d^{2}$ in terms of $t$, where $d$ metres is the distance of the aircraft from $O$.
b Find the value of $t$ when the aircraft is closest to $O$ and hence, the least distance of the aircraft from $O$.

