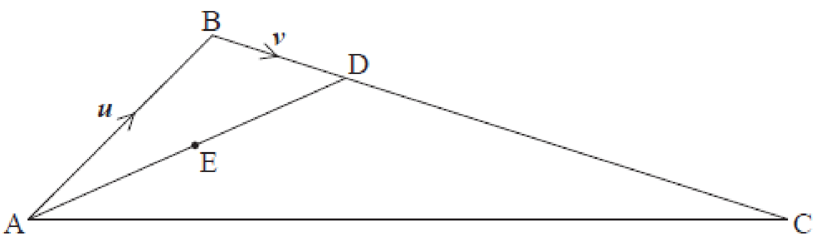
SL Paper 1

In the following diagram, $\boldsymbol{u} = \overrightarrow{\mathrm{AB}}$ and $\boldsymbol{v} = \overrightarrow{\mathrm{BD}}$.



The midpoint of $\overrightarrow{\mathrm{AD}}$ is E and $\frac{\mathrm{BD}}{\mathrm{DC}} = \frac{1}{3}$.

Express each of the following vectors in terms of $\boldsymbol{u}$ and $\boldsymbol{v}$.

a. $\overrightarrow{\mathrm{AE}}$ [3]

b. $\overrightarrow{\mathrm{EC}}$ [4]

Let $\boldsymbol{u} = -3\boldsymbol{i} + \boldsymbol{j} + \boldsymbol{k}$ and $\boldsymbol{v} = m\boldsymbol{j} + n\boldsymbol{k}$, where $m,\ n \in \mathbb{R}$. Given that $\boldsymbol{v}$ is a unit vector perpendicular to $\boldsymbol{u}$, find the possible values of m and of n.

The vectors $\boldsymbol{a} = \begin{pmatrix} 4 \\ 2 \end{pmatrix}$ and $\boldsymbol{b} = \begin{pmatrix} k+3 \\ k \end{pmatrix}$ are perpendicular to each other.

a. Find the value of k. [4]

b. Given that $\boldsymbol{c} = \boldsymbol{a} + 2\boldsymbol{b}$, find $\boldsymbol{c}$. [3]

Note: In this question, distance is in metres and time is in seconds.

Two particles P_1 and P_2 start moving from a point A at the same time, along different straight lines.

After t seconds, the position of P_1 is given by $\boldsymbol{r} = \begin{pmatrix} 4 \\ -1 \\ 3 \end{pmatrix} + t\begin{pmatrix} 1 \\ 2 \\ -1 \end{pmatrix}$.

Two seconds after leaving A, P_1 is at point B.

Two seconds after leaving A, P_2 is at point C, where $\overrightarrow{\mathrm{AC}} = \begin{pmatrix} 3 \\ 0 \\ 4 \end{pmatrix}$.

a. Find the coordinates of A. [2]

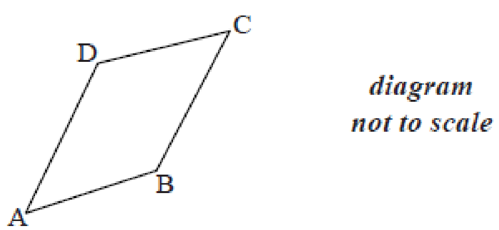
b.i. Find $\overrightarrow{\mathrm{AB}}$; [3]

b.ii. Find $\left|\overrightarrow{\mathrm{AB}}\right|$. [2]

c. Find $\cos \mathrm{B\hat{A}C}$. [5]

d. Hence or otherwise, find the distance between P_1 and P_2 two seconds after they leave A. [4]

The following diagram shows quadrilateral ABCD, with $\overrightarrow{\mathrm{AD}} = \overrightarrow{\mathrm{BC}}$, $\overrightarrow{\mathrm{AB}} = \begin{pmatrix} 3 \\ 1 \end{pmatrix}$, and $\overrightarrow{\mathrm{AC}} = \begin{pmatrix} 4 \\ 4 \end{pmatrix}$.



a. Find $\overrightarrow{\mathrm{BC}}$. [2]

b. Show that $\overrightarrow{\mathrm{BD}} = \begin{pmatrix} -2 \\ 2 \end{pmatrix}$. [2]

c. Show that vectors $\overrightarrow{\mathrm{BD}}$ and $\overrightarrow{\mathrm{AC}}$ are perpendicular. [3]

Let $\vec{\mathrm{OA}} = \begin{pmatrix} 2 \\ 1 \\ 3 \end{pmatrix}$ and $\vec{\mathrm{AB}} = \begin{pmatrix} 1 \\ 3 \\ 1 \end{pmatrix}$, where O is the origin. L_1 is the line that passes through A and B.

a. Find a vector equation for L_1. [2]

b. The vector $\begin{pmatrix} 2 \\ p \\ 0 \end{pmatrix}$ is perpendicular to $\vec{AB}$. Find the value of *p*. [3]

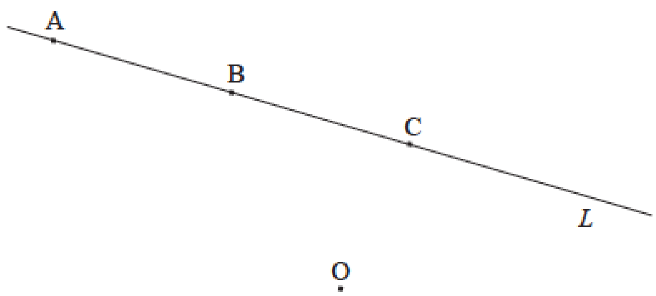
A line L passes through points $A(-2,\ 4,\ 3)$ and $B(-1,\ 3,\ 1)$.

a. (i) Show that $\overrightarrow{AB} = \begin{pmatrix} 1 \\ -1 \\ -2 \end{pmatrix}$. [3]

(ii) Find $\left|\overrightarrow{AB}\right|$.

b. Find a vector equation for L. [2]

c. The following diagram shows the line L and the origin O. The point C also lies on L. [4]



Point C has position vector $\begin{pmatrix} 0 \\ y \\ -1 \end{pmatrix}$.

Show that $y = 2$.

d. (i) Find $\overrightarrow{OC} \bullet \overrightarrow{AB}$. [3]

(ii) Hence, write down the size of the angle between C and L.

e. Hence or otherwise, find the area of triangle OAB. [4]

Let $\overrightarrow{AB} = \begin{pmatrix} 6 \\ -2 \\ 3 \end{pmatrix}$ and $\overrightarrow{AC} = \begin{pmatrix} -2 \\ -3 \\ 2 \end{pmatrix}$.

a. Find $\overrightarrow{BC}$. [2]

b. Find a unit vector in the direction of $\overrightarrow{AB}$. [3]

c. Show that $\overrightarrow{AB}$ is perpendicular to $\overrightarrow{AC}$. [3]

Consider points A$(1, -2, -1)$, B$(7, -4, 3)$ and C$(1, -2, 3)$. The line L_1 passes through C and is parallel to $\overrightarrow{AB}$.

A second line, L_2 , is given by $\boldsymbol{r} = \begin{pmatrix} -1 \\ 2 \\ 15 \end{pmatrix} + s \begin{pmatrix} 3 \\ -3 \\ p \end{pmatrix}$.

a.i. Find $\overrightarrow{AB}$. [2]

a.ii. Hence, write down a vector equation for L_1 . [2]

b. Given that L_1 is perpendicular to L_2 , show that $p = -6$. [3]

c. The line L_1 intersects the line L_2 at point Q. Find the x-coordinate of Q. [7]

A line L_1 passes through the points $\text{A}(0,\ 1,\ 8)$ and $\text{B}(3,\ 5,\ 2)$.

Given that L_1 and L_2 are perpendicular, show that $p = 2$.

a.i. Find $\overrightarrow{AB}$. [2]

a.ii. Hence, write down a vector equation for L_1. [2]

b. A second line L_2, has equation $\boldsymbol{r} = \begin{pmatrix} 1 \\ 13 \\ -14 \end{pmatrix} + s \begin{pmatrix} p \\ 0 \\ 1 \end{pmatrix}$. [3]

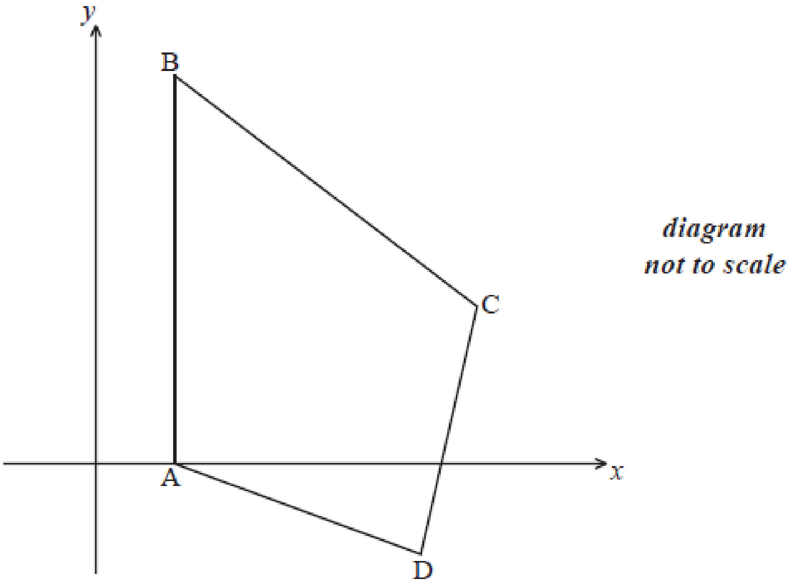
Given that L_1 and L_2 are perpendicular, show that $p = 2$.

c. The lines L_1 and L_1 intersect at $C(9,\ 13,\ z)$. Find z. [5]

d.i. Find a unit vector in the direction of L_2. [2]

d.ii. Hence or otherwise, find one point on L_2 which is $\sqrt{5}$ units from C. [3]

The diagram shows quadrilateral ABCD with vertices A$(1, 0)$, B$(1, 5)$, C$(5, 2)$ and D$(4, -1)$.



a(i), (ii) and (iii). (i) Show that $\overrightarrow{AC} = \begin{pmatrix} 4 \\ 2 \end{pmatrix}$. [5]

(ii) Find $\overrightarrow{BD}$.

(iii) Show that $\overrightarrow{AC}$ is perpendicular to $\overrightarrow{BD}$.

b(i) and (ii). The line (AC) has equation $\boldsymbol{r} = \boldsymbol{u} + s\boldsymbol{v}$. [4]

(i) Write down vector $\boldsymbol{u}$ and vector $\boldsymbol{v}$.

(ii) Find a vector equation for the line (BD).

c. The lines (AC) and (BD) intersect at the point $\mathrm{P}(3, k)$. [3]

Show that $k = 1$.

d. The lines (AC) and (BD) intersect at the point $\mathrm{P}(3, k)$. [5]

Hence find the area of triangle ACD.

The line L_1 passes through the points $\mathrm{A}(2, 1, 4)$ and $\mathrm{B}(1, 1, 5)$.

Another line L_2 has equation $\mathbf{r} = \begin{pmatrix} 4 \\ 7 \\ -4 \end{pmatrix} + s\begin{pmatrix} 0 \\ -1 \\ 1 \end{pmatrix}$. The lines L_1 and L_2 intersect at the point P.

a. Show that $\overrightarrow{AB} = \begin{pmatrix} -1 \\ 0 \\ 1 \end{pmatrix}$ [1]

b(i). Hence, write down a direction vector for L_1; [1]

b(ii)Hence, write down a vector equation for L_1. [2]

c. Find the coordinates of P. [6]

d(i).Write down a direction vector for L_2. [1]

d(ii)Hence, find the angle between L_1 and L_2. [6]

Consider the points A (1 , 5 , 4) , B (3 , 1 , 2) and D (3 , k , 2) , with (AD) perpendicular to (AB) .

The point O has coordinates (0 , 0 , 0) , point A has coordinates (1 , – 2 , 3) and point B has coordinates (– 3 , 4 , 2) .

a(i) and (ii). Find [3]

(i) $\overrightarrow{\mathrm{AB}}$;

(ii) $\overrightarrow{\mathrm{AD}}$ giving your answer in terms of k .

[3 marks]

b. Show that $k = 7$. [3]

c. The point C is such that $\overrightarrow{\mathrm{BC}} = \frac{1}{2}\overrightarrow{\mathrm{AD}}$. [4]

Find the position vector of C.

d. Find $\cos \mathrm{A\hat{B}C}$. [3]

A line L_1 passes through the points $\mathrm{A}(0,\ -3,\ 1)$ and $\mathrm{B}(-2,\ 5,\ 3)$.

a. [3]

(i) Show that $\overrightarrow{\mathrm{AB}} = \begin{pmatrix} -2 \\ 8 \\ 2 \end{pmatrix}$.

(ii) Write down a vector equation for L_1.

b. [5]

A line L_2 has equation $\mathbf{r} = \begin{pmatrix} -1 \\ 7 \\ -4 \end{pmatrix} + s\begin{pmatrix} 0 \\ 1 \\ -1 \end{pmatrix}$. The lines L_1 and L_2 intersect at a point C.

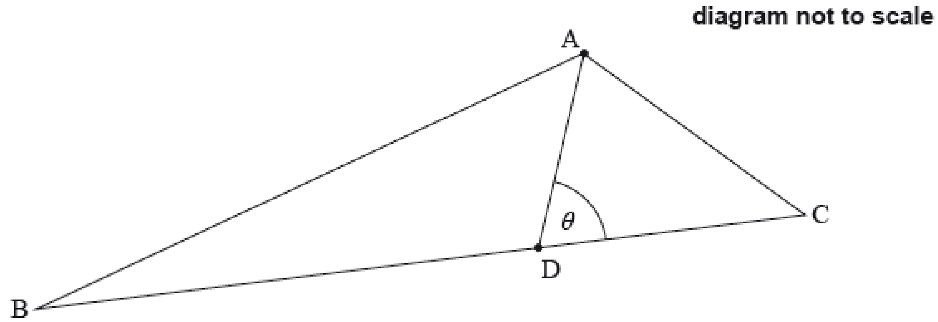
Show that the coordinates of C are $(-1,\ 1,\ 2)$.

c. A point D lies on line L_2 so that $\left|\overrightarrow{\mathrm{CD}}\right| = \sqrt{18}$ and $\overrightarrow{\mathrm{CA}} \bullet \overrightarrow{\mathrm{CD}} = -9$. Find $\mathrm{A\hat{C}D}$. [7]

Let $\overrightarrow{\mathrm{OA}} = \begin{pmatrix} -1 \\ 0 \\ 4 \end{pmatrix}$ and $\overrightarrow{\mathrm{OB}} = \begin{pmatrix} 4 \\ 1 \\ 3 \end{pmatrix}$.

The point C is such that $\overrightarrow{AC} = \begin{pmatrix} -1 \\ 1 \\ -1 \end{pmatrix}$.

The following diagram shows triangle ABC. Let D be a point on [BC], with acute angle $ADC = \theta$.



a. (i) Find $\overrightarrow{AB}$. [4]

(ii) Find $\left|\overrightarrow{AB}\right|$.

b. Show that the coordinates of C are $(-2,\ 1,\ 3)$. [1]

c. Write down an expression in terms of θ for [2]

(i) angle ADB;

(ii) area of triangle ABD.

d. Given that $\frac{\text{area } \Delta ABD}{\text{area } \Delta ACD} = 3$, show that $\frac{BD}{BC} = \frac{3}{4}$. [5]

e. Hence or otherwise, find the coordinates of point D. [4]

A line L_1 passes though points $P(-1, 6, -1)$ and $Q(0, 4, 1)$.

A second line L_2 has equation $r = \begin{pmatrix} 4 \\ 2 \\ -1 \end{pmatrix} + s\begin{pmatrix} 3 \\ 0 \\ -4 \end{pmatrix}$.

a(i) and (ii). [3]

(i) Show that $\overrightarrow{PQ} = \begin{pmatrix} 1 \\ -2 \\ 2 \end{pmatrix}$.

(ii) Hence, write down an equation for L_1 in the form $\boldsymbol{r} = \boldsymbol{a} + t\boldsymbol{b}$.

b. Find the cosine of the angle between $\overrightarrow{PQ}$ and L_2 . [7]

c. The lines L_1 and L_2 intersect at the point R. Find the coordinates of R. [7]

The line L_1 is parallel to the z-axis. The point P has position vector $\begin{pmatrix} 8 \\ 1 \\ 0 \end{pmatrix}$ and lies on L_1.

a. Write down the equation of L_1 in the form $\boldsymbol{r} = \boldsymbol{a} + t\boldsymbol{b}$. [2]

b. The line L_2 has equation $\boldsymbol{r} = \begin{pmatrix} 2 \\ 4 \\ -1 \end{pmatrix} + s\begin{pmatrix} 2 \\ -1 \\ 5 \end{pmatrix}$. The point A has position vector $\begin{pmatrix} 6 \\ 2 \\ 9 \end{pmatrix}$. [4]

Show that A lies on L_2 .

c. Let B be the point of intersection of lines L_1 and L_2 . [7]

(i) Show that $\overrightarrow{\mathrm{OB}} = \begin{pmatrix} 8 \\ 1 \\ 14 \end{pmatrix}$.

(ii) Find $\overrightarrow{\mathrm{AB}}$.

d. The point C is at $(2, 1, -4)$. Let D be the point such that ABCD is a parallelogram. [3]

Find $\overrightarrow{\mathrm{OD}}$.

Consider the vectors $\boldsymbol{a} = \begin{pmatrix} 2 \\ -3 \end{pmatrix}$ and $\boldsymbol{b} = \begin{pmatrix} 1 \\ 4 \end{pmatrix}$.

Let $2\boldsymbol{a} + \boldsymbol{b} + \boldsymbol{c} = 0$, where 0 is the zero vector.

. (a) Find [6]

(i) $2\boldsymbol{a} + \boldsymbol{b}$;

(ii) $|2\boldsymbol{a} + \boldsymbol{b}|$.

Let $2\boldsymbol{a} + \boldsymbol{b} + \boldsymbol{c} = 0$, where 0 is the zero vector.

(b) Find $\boldsymbol{c}$.

a. Find [4]

(i) $2\boldsymbol{a} + \boldsymbol{b}$;

(ii) $|2\boldsymbol{a} + \boldsymbol{b}|$.

b. Find $\boldsymbol{c}$. [2]

The vertices of the triangle PQR are defined by the position vectors

$\overrightarrow{OP} = \begin{pmatrix} 4 \\ -3 \\ 1 \end{pmatrix}$, $\overrightarrow{OQ} = \begin{pmatrix} 3 \\ -1 \\ 2 \end{pmatrix}$ and $\overrightarrow{OR} = \begin{pmatrix} 6 \\ -1 \\ 5 \end{pmatrix}$.

a. Find [3]

(i) $\overrightarrow{PQ}$;

(ii) $\overrightarrow{PR}$.

b. Show that $\cos R\widehat{P}Q = \frac{1}{2}$. [7]

c. (i) Find $\sin R\widehat{P}Q$. [6]

(ii) Hence, find the area of triangle PQR, giving your answer in the form $a\sqrt{3}$.

Let A and B be points such that $\overrightarrow{OA} = \begin{pmatrix} 5 \\ 2 \\ 1 \end{pmatrix}$ and $\overrightarrow{OB} = \begin{pmatrix} 6 \\ 0 \\ 3 \end{pmatrix}$.

a. Show that $\overrightarrow{AB} = \begin{pmatrix} 1 \\ -2 \\ 2 \end{pmatrix}$. [1]

b. Let C and D be points such that ABCD is a **rectangle**. [4]

Given that $\overrightarrow{AD} = \begin{pmatrix} 4 \\ p \\ 1 \end{pmatrix}$, show that $p = 3$.

c. Let C and D be points such that ABCD is a **rectangle**. [4]

Find the coordinates of point C.

d. Let C and D be points such that ABCD is a **rectangle**. [5]

Find the area of rectangle ABCD.

Distances in this question are in metres.

Ryan and Jack have model airplanes, which take off from level ground. Jack's airplane takes off after Ryan's.

The position of Ryan's airplane t seconds after it takes off is given by $\boldsymbol{r} = \begin{pmatrix} 5 \\ 6 \\ 0 \end{pmatrix} + t\begin{pmatrix} -4 \\ 2 \\ 4 \end{pmatrix}$.

a. Find the speed of Ryan’s airplane. [3]

b. Find the height of Ryan’s airplane after two seconds. [2]

c. The position of Jack’s airplane s seconds after **it** takes off is given by $\boldsymbol{r} = \begin{pmatrix} -39 \\ 44 \\ 0 \end{pmatrix} + s\begin{pmatrix} 4 \\ -6 \\ 7 \end{pmatrix}$. [5]

Show that the paths of the airplanes are perpendicular.

d. The two airplanes collide at the point $(-23, 20, 28)$. [5]

How long after Ryan’s airplane takes off does Jack’s airplane take off?

The line L_1 passes through the points P(2, 4, 8) and Q(4, 5, 4) .

The line L_2 is perpendicular to L_1 , and parallel to $\begin{pmatrix} 3p \\ 2p \\ 4 \end{pmatrix}$, where $p \in \mathbb{Z}$.

a(i) and (ii). (i) Find $\overrightarrow{\mathrm{PQ}}$. [4]

(ii) Hence write down a vector equation for L_1 in the form $\boldsymbol{r} = \boldsymbol{a} + s\boldsymbol{b}$.

b(i) and (ii). (i) Find the value of p . [7]

(ii) Given that L_2 passes through $\mathrm{R}(10, 6, -40)$, write down a vector equation for L_2 .

c. The lines L_1 and L_2 intersect at the point A. Find the x-coordinate of A. [7]

A line L passes through points $\mathrm{A}(-3,\ 4,\ 2)$ and $\mathrm{B}(-1,\ 3,\ 3)$.

The line L also passes through the point $\mathrm{C}(3,\ 1,\ p)$.

a.i. Show that $\overrightarrow{\mathrm{AB}} = \begin{pmatrix} 2 \\ -1 \\ 1 \end{pmatrix}$. [1]

a.ii. Find a vector equation for L. [2]

b. Find the value of p. [5]

c. The point D has coordinates $(q^2,\ 0,\ q)$. Given that $\overrightarrow{\mathrm{DC}}$ is perpendicular to L, find the possible values of q. [7]

The line L is parallel to the vector $\begin{pmatrix} 3 \\ 2 \end{pmatrix}$.

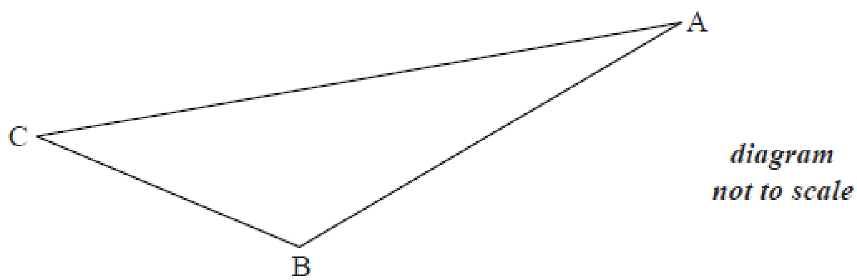
The line L passes through the point $(9, 4)$.

a. Find the gradient of the line L. [2]

b. Find the equation of the line L in the form $y = ax + b$. [3]

c. Write down a vector equation for the line L. [2]

The following diagram shows the obtuse-angled triangle ABC such that $\overrightarrow{AB} = \begin{pmatrix} -3 \\ 0 \\ -4 \end{pmatrix}$ and $\overrightarrow{AC} = \begin{pmatrix} -2 \\ 2 \\ -6 \end{pmatrix}$.



a(i) and (ii). (i) Write down $\overrightarrow{BA}$. [3]

(ii) Find $\overrightarrow{BC}$.

b(i) and (ii). (i) Find $\cos A\hat{B}C$. [7]

(ii) Hence, find $\sin A\hat{B}C$.

c(i) and (ii). [6]

The point D is such that $\overrightarrow{CD} = \begin{pmatrix} -4 \\ 5 \\ p \end{pmatrix}$, where $p > 0$.

(i) Given that $|\overrightarrow{CD}| = \sqrt{50}$, show that $p = 3$.

(ii) Hence, show that $\overrightarrow{CD}$ is perpendicular to $\overrightarrow{BC}$.

The line L passes through the point $(5, -4, 10)$ and is parallel to the vector $\begin{pmatrix} 4 \\ -2 \\ 5 \end{pmatrix}$.

a. Write down a vector equation for line L. [2]

b. The line L intersects the x-axis at the point P. Find the x-coordinate of P. [6]

A particle is moving with a constant velocity along line L . Its initial position is A(6 , −2 , 10) . After one second the particle has moved to B(9, −6 , 15) .

a(i) and (ii). (i) Find the velocity vector, $\overrightarrow{\mathrm{AB}}$. [4]

(ii) Find the speed of the particle.

b. Write down an equation of the line L . [2]

The line L_1 is represented by the vector equation $\boldsymbol{r} = \begin{pmatrix} -3 \\ -1 \\ -25 \end{pmatrix} + p\begin{pmatrix} 2 \\ 1 \\ -8 \end{pmatrix}$.

A second line L_2 is parallel to L_1 and passes through the point B(−8, −5, 25) .

a. Write down a vector equation for L_2 in the form $\boldsymbol{r} = \boldsymbol{a} + t\boldsymbol{b}$. [2]

b. A third line L_3 is perpendicular to L_1 and is represented by $\boldsymbol{r} = \begin{pmatrix} 5 \\ 0 \\ 3 \end{pmatrix} + q\begin{pmatrix} -7 \\ -2 \\ k \end{pmatrix}$. [5]

Show that $k = -2$.

c. The lines L_1 and L_3 intersect at the point A. [6]

Find the coordinates of A.

d(i) and (ii). The lines L_2 and L_3 intersect at point C where $\overrightarrow{\mathrm{BC}} = \begin{pmatrix} 6 \\ 3 \\ -24 \end{pmatrix}$. [5]

(i) Find $\overrightarrow{\mathrm{AB}}$.

(ii) Hence, find $|\overrightarrow{\mathrm{AC}}|$.

The position vectors of points P and Q are $\boldsymbol{i} + 2\boldsymbol{j} - \boldsymbol{k}$ and $7\boldsymbol{i} + 3\boldsymbol{j} - 4\boldsymbol{k}$ respectively.

a. Find a vector equation of the line that passes through P and Q. [4]

b. The line through P and Q is perpendicular to the vector $2\boldsymbol{i} + n\boldsymbol{k}$. Find the value of n. [3]

A line L passes through $\mathrm{A}(1,\ -1,\ 2)$ and is parallel to the line $\boldsymbol{r} = \begin{pmatrix} -2 \\ 1 \\ 5 \end{pmatrix} + s\begin{pmatrix} 1 \\ 3 \\ -2 \end{pmatrix}$.

The line L passes through point P when $t = 2$.

a. Write down a vector equation for L in the form $\boldsymbol{r} = \boldsymbol{a} + t\boldsymbol{b}$. [2]

b(i) and (ii). Find [4]

(i) $\overrightarrow{\mathrm{OP}}$;

(ii) $|\overrightarrow{\mathrm{OP}}|$.

Let L_x be a family of lines with equation given by $r = \begin{pmatrix} x \\ \frac{2}{x} \end{pmatrix} + t\begin{pmatrix} x^2 \\ -2 \end{pmatrix}$, where $x > 0$.

a. Write down the equation of L_1. [2]

b. A line L_a crosses the y-axis at a point P. [6]

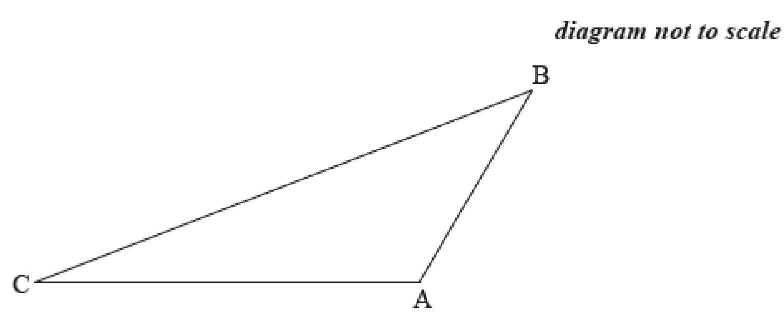
Show that P has coordinates $\left(0,\ \frac{4}{a}\right)$.

c. The line L_a crosses the x-axis at $\mathrm{Q}(2a,\ 0)$. Let $d = \mathrm{PQ}^2$. [2]

Show that $d = 4a^2 + \frac{16}{a^2}$.

d. There is a minimum value for d. Find the value of a that gives this minimum value. [7]

The following diagram shows triangle ABC.



Let $\overrightarrow{\mathrm{AB}} \bullet \overrightarrow{\mathrm{AC}} = -5\sqrt{3}$ and $\left|\overrightarrow{\mathrm{AB}}\right|\left|\overrightarrow{\mathrm{AC}}\right| = 10$. Find the area of triangle ABC.

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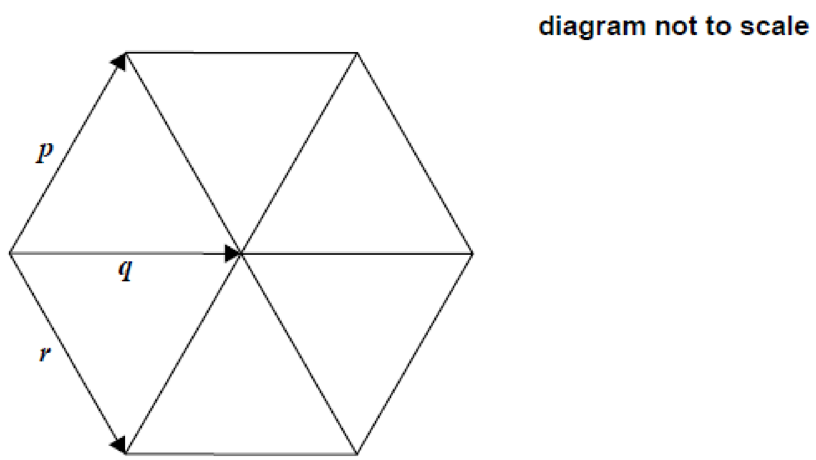
a. Let $\boldsymbol{u} = \begin{pmatrix} 2 \\ 3 \\ -1 \end{pmatrix}$ and $\boldsymbol{w} = \begin{pmatrix} 3 \\ -1 \\ p \end{pmatrix}$. Given that $\boldsymbol{u}$ is perpendicular to $\boldsymbol{w}$, find the value of p. [3]

b. Let $\boldsymbol{v} = \begin{pmatrix} 1 \\ q \\ 5 \end{pmatrix}$. Given that $|\boldsymbol{v}| = \sqrt{42}$, find the possible values of q. [3]

Find the cosine of the angle between the two vectors $3\boldsymbol{i} + 4\boldsymbol{j} + 5\boldsymbol{k}$ and $4\boldsymbol{i} - 5\boldsymbol{j} - 3\boldsymbol{k}$.

Six equilateral triangles, each with side length 3 cm, are arranged to form a hexagon.

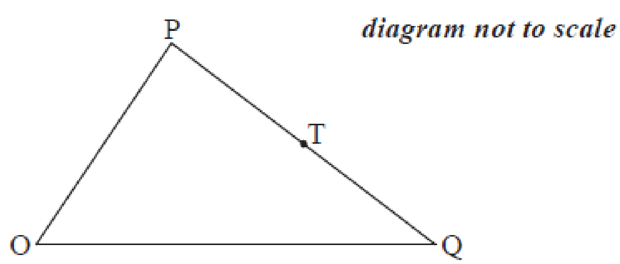
This is shown in the following diagram.



The vectors ***p*** , ***q*** and ***r*** are shown on the diagram.

Find $\boldsymbol{p} \cdot (\boldsymbol{p} + \boldsymbol{q} + \boldsymbol{r})$.

In the following diagram, $\overrightarrow{OP} = \boldsymbol{p}$, $\overrightarrow{OQ} = \boldsymbol{q}$ and $\overrightarrow{PT} = \frac{1}{2}\overrightarrow{PQ}$.



Express each of the following vectors in terms of $\boldsymbol{p}$ and $\boldsymbol{q}$,

a. $\overrightarrow{QP}$; [2]

b. $\overrightarrow{OT}$. [3]

Point A has coordinates (−4, −12, 1) and point B has coordinates (2, −4, −4).

The line *L* passes through A and B.

a. Show that $\vec{AB} = \begin{pmatrix} 6 \\ 8 \\ -5 \end{pmatrix}$ [1]

b.i. Find a vector equation for *L*. [2]

b.ii. Point *C* (*k* , 12 , −*k*) is on *L*. Show that *k* = 14. [4]

c.i. Find $\vec{OB} \bullet \vec{AB}$. [2]

c.ii. Write down the value of angle OBA. [1]

d. Point D is also on *L* and has coordinates (8, 4, −9). [6]

Find the area of triangle OCD.