Question	Scheme	Marks	AOs
1(a)	Attempts to compare the two position vectors. Allow an attempt using two of $\overrightarrow{AO}, \overrightarrow{OB}$ or $\overrightarrow{AB}$ E.g. $(-24\mathbf{i}-10\mathbf{j}) = -2\times(12\mathbf{i}+5\mathbf{j})$	M1	1.1b
	Explains that as $\overrightarrow{AO}$ is parallel to $\overrightarrow{OB}$ (and the stone is travelling in a straight line) the stone passes through the point *O*.	A1	2.4
		(2)	
(b)	Attempts distance $AB = \sqrt{(12+24)^2+(10+5)^2}$	M1	1.1b
	Attempts speed = $\dfrac{\sqrt{(12+24)^2+(10+5)^2}}{4}$	dM1	3.1a
	Speed = 9.75 ms^{-1}	A1	3.2a
		(3)	
			(5 marks)
Alt(a)	Attempts to find the equation of the line which passes through *A* and *B* E.g. $y-5=\dfrac{5+10}{12+24}(x-12) \quad (y=\dfrac{5}{12}x)$	M1	1.1b
	Shows that when $x=0,\ y=0$ and concludes the stone passes through the point *O*.	A1	2.4

Notes

(a)

M1: Attempts to compare the two position vectors. Allow an attempt using two of $\overrightarrow{AO}, \overrightarrow{OB}$ or $\overrightarrow{AB}$ either way around.
E.g. States that $(-24\mathbf{i}-10\mathbf{j}) = -2\times(12\mathbf{i}+5\mathbf{j})$
Alternatively, allow an attempt finding the gradient using any two of *AO*, *OB* or *AB*

Alternatively attempts to find the equation of the line through *A* and *B* proceeding as far as $y=...x$ Condone sign slips.

A1: States that as $\overrightarrow{AO}$ is parallel to $\overrightarrow{OB}$ or as *AO* is parallel to *OB* (and the stone is travelling in a straight line) the stone passes through the point *O*. Alternatively, shows that the point $(0,0)$ is on the line and concludes (the stone) passes through the point *O*.

(b)

M1: Attempts to find the distance *AB* using a correct method.
Condone slips but expect to see an attempt at $\sqrt{a^2+b^2}$ where *a* or *b* is correct

dM1: Dependent upon the previous mark. Look for an attempt at $\dfrac{\text{distance } AB}{4}$

A1: 9.75 ms^{-1} Requires units

Question	Scheme	Marks	AOs
2(a)	$\overrightarrow{QR}=\overrightarrow{PR}-\overrightarrow{PQ}=13\mathbf{i}-15\mathbf{j}-(3\mathbf{i}+5\mathbf{j})$	M1	1.1a
	$=10\mathbf{i}-20\mathbf{j}$	A1	1.1b
		(2)	
(b)	$\left\|\overrightarrow{QR}\right\|=\sqrt{"10"^2+"(-20)"^2}$	M1	2.5
	$=10\sqrt{5}$	A1ft	1.1b
		(2)	
(c)	$\overrightarrow{PS}=\overrightarrow{PQ}+\frac{3}{5}\overrightarrow{QR}=3\mathbf{i}+5\mathbf{j}+\frac{3}{5}("10\mathbf{i}-20\mathbf{j}")=...$ or $\overrightarrow{PS}=\overrightarrow{PR}+\frac{2}{5}\overrightarrow{RQ}=13\mathbf{i}-15\mathbf{j}+\frac{2}{5}("-10\mathbf{i}+20\mathbf{j}")=...$	M1	3.1a
	$=9\mathbf{i}-7\mathbf{j}$	A1	1.1b
		(2)	
			(6 marks)

Notes

(a)

M1: Attempts subtraction either way round. This cannot be awarded for adding the two vectors. If no method shown it may be implied by one correct component. eg $10\mathbf{i}-10\mathbf{j}$ on its own can score M1.

A1: Correct answer. Allow $10\mathbf{i}-20\mathbf{j}$ and $\begin{pmatrix}10\\-20\end{pmatrix}$ but not $\begin{pmatrix}10\mathbf{i}\\-20\mathbf{j}\end{pmatrix}$

(b)

M1: Correct use of Pythagoras. Attempts to "square and add" before square rooting. The embedded values are sufficient. Follow through on their $\overrightarrow{QR}$

A1ft: $10\sqrt{5}$ following (a) of the form $\pm10\mathbf{i}\pm20\mathbf{j}$

(c)

M1: Full attempt at finding a $\overrightarrow{PS}$. They must be attempting $\overrightarrow{PQ}\pm\frac{3}{5}\overrightarrow{QR}$ or $\overrightarrow{PS}=\overrightarrow{PR}\pm\frac{2}{5}\overrightarrow{RQ}$ but condone arithmetical slips after that.

Cannot be scored for just stating eg $\overrightarrow{PQ}\pm\frac{3}{5}\overrightarrow{QR}$

Follow through on their $\overrightarrow{QR}$. Terms do not need to be collected for this mark. If no method shown it may be implied by one correct component following through on their $\overrightarrow{QR}$

A1: Correct vector as shown. Allow $9\mathbf{i}-7\mathbf{j}$ and $\begin{pmatrix}9\\-7\end{pmatrix}$.

Only withhold the mark for $\begin{pmatrix}9\mathbf{i}\\-7\mathbf{j}\end{pmatrix}$ if the mark has not already been withheld in (a) for $\begin{pmatrix}10\mathbf{i}\\-20\mathbf{j}\end{pmatrix}$

Alt (c) (Expressing $\overrightarrow{PS}$ in terms of the given vectors) They must be attempting $\frac{2}{5}\overrightarrow{PQ}+\frac{3}{5}\overrightarrow{PR}$

M1: $(\overrightarrow{PS}=\overrightarrow{PQ}+\frac{3}{5}\overrightarrow{QR}=\overrightarrow{PQ}+\frac{3}{5}(\overrightarrow{PR}-\overrightarrow{PQ}))$

$\Rightarrow\frac{2}{5}\overrightarrow{PQ}+\frac{3}{5}\overrightarrow{PR}=\frac{2}{5}(3\mathbf{i}+5\mathbf{j})+\frac{3}{5}(13\mathbf{i}-15\mathbf{j})=\ldots$

A1: Correct vector as shown. Allow $9\mathbf{i}-7\mathbf{j}$ and $\begin{pmatrix}9\\-7\end{pmatrix}$.

Only withhold the mark for $\begin{pmatrix}9\mathbf{i}\\-7\mathbf{j}\end{pmatrix}$ if the mark has not already been withheld in (a) for $\begin{pmatrix}10\mathbf{i}\\-20\mathbf{j}\end{pmatrix}$

Question	Scheme	Marks	AOs
3 (a)	$\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA} = (-8\mathbf{i}+9\mathbf{j}) - (10\mathbf{i}-3\mathbf{j})$	M1	1.1b
	$= -18\mathbf{i}+12\mathbf{j}$	A1	1.1b
		(2)	
(b)	$\lvert\overrightarrow{AB}\rvert = \sqrt{"18"^2+"12"^2}\ \{= \sqrt{468}\}$	M1	1.1b
	$= 6\sqrt{13}$	A1	1.1b
		(2)	
(c)	For the key step in using the fact that *BCA* forms a straight line in an attempt to find "*p*" $\overrightarrow{AB} = \lambda\overrightarrow{BC} \Rightarrow -18\mathbf{i}+12\mathbf{j} = 6\lambda\mathbf{i}+\lambda(p-9)\mathbf{j}$ with components equated leading to a value for λ and to $p = \ldots$	M1	2.1
	(i) $p = 5$	A1	1.1b
	(ii) ratio = 2: 3	B1 (A1 on EPEN)	2.2a
		(3)	
		(7 marks)	

Notes:

(a) **Must be seen in (a)**

M1: Attempts subtraction either way round. This cannot be awarded for adding the two vectors. If no method shown it may be implied by one correct component.
Allow as coordinates for this mark. Condone missing brackets, e.g., $-8\mathbf{i}+9\mathbf{j}-10\mathbf{i}-3\mathbf{j}$

A1: cao $-18\mathbf{i}+12\mathbf{j}$ o.e. $\begin{pmatrix}-18\\12\end{pmatrix}$ Condone $\begin{matrix}-18\\12\end{matrix}$

Do not allow $\begin{pmatrix}-18\mathbf{i}\\12\mathbf{j}\end{pmatrix}$ or $(-18,\ 12)$ or $\left(\dfrac{-18}{12}\right)$ for the A1.

(b)

M1: Attempts to use Pythagoras' theorem on their vector from part (a). Allow restarts.
$\lvert\overrightarrow{AB}\rvert = \sqrt{"18"^2+"12"^2}\ \{= \sqrt{468}\}$ Note that -18 will commonly be squared as 18
May be implied by awrt 21.6 This will need checking if (a) is incorrect.

A1: cao $6\sqrt{13}$ May come from $\begin{pmatrix}\pm 18\\ \pm 12\end{pmatrix}$

(c)

M1: For the key step in using the fact that *BCA* forms a straight line in an attempt to find "*p*"
Condone sign slips. Award, for example, for $\pm\dfrac{p-9}{6} = \pm\dfrac{2}{3}$ leading to $p = \ldots$
It is implied by $p = 5$ unless it comes directly from work that is clearly incorrect.

e.g., award for an attempt to use

- $\overrightarrow{AB} = \alpha\overrightarrow{AC} \Rightarrow -18\mathbf{i} + 12\mathbf{j} = -12\alpha\mathbf{i} + \alpha(p+3)\mathbf{j}$ with components equated leading to a value for α and to $p = \ldots$
- gradient BC = gradient BA = $-\frac{2}{3}$ e.g., $\frac{p-9}{6} = \frac{9--3}{-8-10}$ leading to $p = \ldots$
- triangles BCM and BAN are similar with lengths in a ratio 1:3. e.g., $p = 9 - \frac{1}{3} \times 12$ **or** $p = -3 + \frac{2}{3} \times 12$
- attempt to find the equation of line AB using both points (FYI line AB has equation $y = -\frac{2}{3}x + \frac{11}{3}$) and then sub in $x = -2$ leading to $p = \ldots$
- $\frac{p+3}{12} = \frac{2}{3}$ **or** $\frac{p+3}{2} = 9 - p$ leading to $p = \ldots$

A1: $p = 5$ Correct answer implies both marks, unless it comes directly from work that is clearly incorrect.

B1: States ratio = 2: 3 or equivalent such as 1: 1.5 or 22:33
Note that 3:2 is incorrect but condone {Area}AOB : {Area}AOC = 3: 2
This might follow incorrect work or even incorrect p
For reference, area AOC = 22, area AOB = 33 and area BOC = 11

Question	Scheme	Marks	AOs
4(a)	$\overrightarrow{AC}=\overrightarrow{AB}+\overrightarrow{BC}=-3\mathbf{i}-4\mathbf{j}-5\mathbf{k}+\mathbf{i}+\mathbf{j}+4\mathbf{k}=...$	M1	1.1b
	$=-2\mathbf{i}-3\mathbf{j}-\mathbf{k}$	A1	1.1b
		(2)	
(b)	At least 2 of $\left(AC^2\right)="2^2+3^2+1^2",\left(AB^2\right)=3^2+4^2+5^2,\ \left(BC^2\right)=1^2+1^2+4^2$	M1	1.1b
	$2^2+3^2+1^2=3^2+4^2+5^2+1^2+1^2+4^2-2\sqrt{3^2+4^2+5^2}\sqrt{1^2+1^2+4^2}\cos ABC$	M1	3.1a
	$14=50+18-2\sqrt{50}\sqrt{18}\cos ABC$ $\Rightarrow \cos ABC=\dfrac{50+18-14}{2\sqrt{50}\sqrt{18}}=\dfrac{9}{10}*$	A1*	2.1
		(3)	
	(b) Alternative		
	$AB^2=3^2+4^2+5^2,\ BC^2=1^2+1^2+4^2$	M1	1.1b
	$\overrightarrow{BA}.\overrightarrow{BC}=(3\mathbf{i}+4\mathbf{j}+5\mathbf{k})\bullet(\mathbf{i}+\mathbf{j}+4\mathbf{k})=27=\sqrt{3^2+4^2+5^2}\sqrt{1^2+1^2+4^2}\cos ABC$	M1	3.1a
	$27=\sqrt{50}\sqrt{18}\cos ABC\Rightarrow \cos ABC=\dfrac{27}{\sqrt{50}\sqrt{18}}==\dfrac{9}{10}*$	A1*	2.1
			(5 marks)

Notes

(a)

M1: Attempts $\overrightarrow{AC}=\overrightarrow{AB}+\overrightarrow{BC}$

There must be attempt to add not subtract.

If no method shown it may be implied by **two** correct components

A1: Correct vector. Allow $-2\mathbf{i}-3\mathbf{j}-\mathbf{k}$ and $\begin{pmatrix}-2\\-3\\-1\end{pmatrix}$ but not $\begin{pmatrix}-2\mathbf{i}\\-3\mathbf{j}\\-1\mathbf{k}\end{pmatrix}$

(b)

M1: Attempts to "square and add" for at least 2 of the 3 sides. Follow through on their $\overrightarrow{AC}$

Look for an attempt at either $a^2+b^2+c^2$ or $\sqrt{a^2+b^2+c^2}$

M1: A correct attempt to apply a correct cosine rule to the given problem; Condone **slips** on the lengths of the sides but the sides must be in the correct position to find angle ABC

A1*: Correct completion with sufficient intermediate work to establish the printed result.

Condone different labelling, e.g. $ABC\leftrightarrow\theta$ as long as it is clear what is meant

It is OK to move from a correct cosine rule $14=50+18-2\sqrt{50}\sqrt{18}\cos ABC$

via $\cos ABC=\dfrac{54}{2\sqrt{50}\sqrt{18}}$ o.e. such as $\cos ABC=\dfrac{\left(5\sqrt{2}\right)^2+\left(3\sqrt{2}\right)^2-\left(\sqrt{14}\right)^2}{2\times5\sqrt{2}\times3\sqrt{2}}$ to $\cos ABC=\dfrac{9}{10}$

Alternative:

M1: Correct application of Pythagoras for sides AB and BC or their squares

M1: Recognises the requirement for and applies the scalar product

A1*: Correct completion with sufficient intermediate work to establish the printed result

Question	Scheme	Marks	AOs
5(a)	Attempts both $\lvert\overrightarrow{PQ}\rvert = \sqrt{2^2+3^2+(-4)^2}$ and $\lvert\overrightarrow{QR}\rvert = \sqrt{5^2+(-2)^2}$	M1	3.1a
	States that $\lvert\overrightarrow{PQ}\rvert = \lvert\overrightarrow{QR}\rvert = \sqrt{29}$ so *PQRS* is a rhombus	A1	2.4
		(2)	
(b)	Attempts BOTH $\overrightarrow{PR} = \overrightarrow{PQ} + \overrightarrow{QR} = 7\mathbf{i} + 3\mathbf{j} - 6\mathbf{k}$ AND $\overrightarrow{QS} = -\overrightarrow{PQ} + \overrightarrow{PS} = 3\mathbf{i} - 3\mathbf{j} + 2\mathbf{k}$	M1	3.1a
	Correct $\overrightarrow{PR} = 7\mathbf{i} + 3\mathbf{j} - 6\mathbf{k}$ and $\overrightarrow{QS} = 3\mathbf{i} - 3\mathbf{j} + 2\mathbf{k}$	A1	1.1b
	Correct method for area *PQRS*. E.g. $\frac{1}{2} \times \lvert\overrightarrow{PR}\rvert \times \lvert\overrightarrow{QS}\rvert$	dM1	2.1
	$= \sqrt{517}$	A1	1.1b
		(4)	
			(6 marks)
Alt (b) Example using the cosine rule	Attempts $\lvert\overrightarrow{QS}\rvert = \sqrt{3^2+(-3)^2+2^2} = \sqrt{22}$ and so $22 = 29 + 29 - 2\sqrt{29}\sqrt{29}\cos SPQ$	M1	3.1a
	$\cos PQR = -\frac{18}{29}$ or $\cos SPQ = \frac{18}{29}$ Condone angles in degrees 51.6, 128.4 (1dp) or radians 2.24, 0.901 (3sf) here	A1	1.1b
	Correct method for area *PQRS*. E.g. $PQ \times QR \sin PQR = \sqrt{2^2+3^2+(-4)^2} \times \sqrt{5^2+(-2)^2} \times \frac{\sqrt{517}}{29}$	dM1	2.1
	$= \sqrt{517}$	A1	1.1b
		(4)	

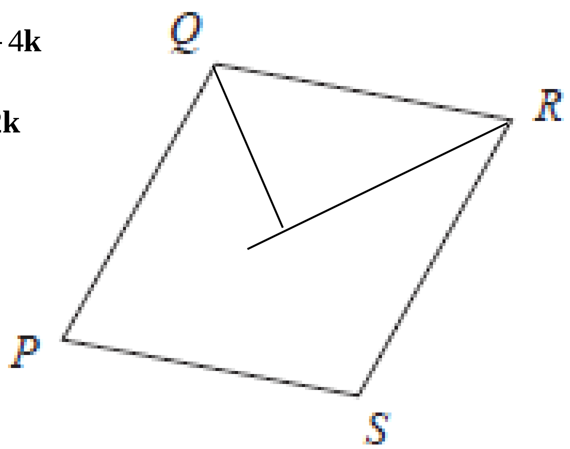
FYI

$\overrightarrow{QR} = 5\mathbf{i} + 0\mathbf{j} - 2\mathbf{k}$

$\overrightarrow{PQ} = 2\mathbf{i} + 3\mathbf{j} - 4\mathbf{k}$

$\overrightarrow{SQ} = -3\mathbf{i} + 3\mathbf{j} - 2\mathbf{k}$

$\overrightarrow{MQ} = -1.5\mathbf{i} + 1.5\mathbf{j} - 1\mathbf{k}$



$\overrightarrow{PR} = 7\mathbf{i} + 3\mathbf{j} - 6\mathbf{k}$

M

$\overrightarrow{PM} = 3.5\mathbf{i} + 1.5\mathbf{j} - 3\mathbf{k}$

(a) Do not award marks in part (a) from work in part (b).

M1: Attempts both $\lvert\overrightarrow{PQ}\rvert = \sqrt{2^2+3^2+(\pm4)^2}$ and $\lvert\overrightarrow{QR}\rvert = \sqrt{5^2+(\pm2)^2}$ or PQ^2 and QR^2. For this mark only, condone just the correct answers $\lvert\overrightarrow{PQ}\rvert = \sqrt{29}$ and $\lvert\overrightarrow{QR}\rvert = \sqrt{29}$. Alternatively attempts $\overrightarrow{PR} \bullet \overrightarrow{QS}$ or PM^2, MQ^2 and PQ^2 where *M* is the mid point of *PR*

A1: Shows that $\lvert\overrightarrow{PQ}\rvert = \lvert\overrightarrow{QR}\rvert = \sqrt{29}$ (with calculations) and states *PQRS* is a rhombus.

Condone poor notation such as $\overrightarrow{PQ}=\sqrt{29}$ here, So $\overrightarrow{PQ}=\overrightarrow{QR}=\sqrt{29}$ hence rhombus.
Requires both a reason and a conclusion. The reason may be given at the start of their solution.
In the alternatives $\overrightarrow{PR}\bullet\overrightarrow{QS}=(7\mathbf{i}+3\mathbf{j}-6\mathbf{k})\bullet(3\mathbf{i}-3\mathbf{j}+2\mathbf{k})=21-9-12=0$ so diagonals cross at $90°$ so *PQRS* is a rhombus or $PM^2+MQ^2=PQ^2=23.5+5.5=29\Rightarrow\angle PMQ=90°\Rightarrow$ Rhombus

(b) **Candidates can transfer answers from (a) to use in part (b) to find the area**
Look through their complete solution first. The first two marks are for finding the elements that are required to calculate the area. The second set of two marks is for combining these elements correctly. If the method is NOT shown on how to find vector it can be implied by two correct components. Allow as column vectors.

M1: For a key step in solving the problem. It is scored for attempting to find both key vectors.
Attempts both $\overrightarrow{PR}=\overrightarrow{PQ}+\overrightarrow{QR}=(7\mathbf{i}+3\mathbf{j}-6\mathbf{k})$ **AND** $\overrightarrow{QS}=-\overrightarrow{PQ}+\overrightarrow{PS}=(3\mathbf{i}-3\mathbf{j}+2\mathbf{k})$

You may see $\overrightarrow{PM}=\frac{1}{2}\overrightarrow{PQ}+\frac{1}{2}\overrightarrow{QR}=\left(\frac{7}{2}\mathbf{i}+\frac{3}{2}\mathbf{j}-3\mathbf{k}\right)$ **AND** $\overrightarrow{QM}=-\frac{1}{2}\overrightarrow{PQ}+\frac{1}{2}\overrightarrow{PS}=\left(\frac{3}{2}\mathbf{i}-\frac{3}{2}\mathbf{j}+1\mathbf{k}\right)$

A1: Accurately finds both key vectors whose lengths are required to solve the problem.
Score for both $\overrightarrow{PR}=7\mathbf{i}+3\mathbf{j}-6\mathbf{k}$ and $\overrightarrow{QS}=3\mathbf{i}-3\mathbf{j}+2\mathbf{k}$ (Allow either way around.)
or both $\overrightarrow{PM}=\frac{7}{2}\mathbf{i}+\frac{3}{2}\mathbf{j}-3\mathbf{k}$ and $\overrightarrow{QM}=\frac{3}{2}\mathbf{i}-\frac{3}{2}\mathbf{j}+1\mathbf{k}$ (Allow either way around.)

dM1: Constructs a rigorous method leading to the area *PQRS*. Dependent upon previous M.
E.g. See scheme. Alt: the sum of the area of four right angled triangles e.g. $4\times\frac{1}{2}\times\left|\overrightarrow{PM}\right|\times\left|\overrightarrow{QM}\right|$,

A1: $\sqrt{517}$

Alternatives for (b). Two such ways are set out below

Alt 1-Examples via cosine rule but you may see use of scalar product via a Further Maths method.

M1: For a key step in solving the problem. In this case it for an attempt at cos *PQR* or cos *SPQ*.
Don't be too concerned with the labelling of the angle which may appear as θ.

Attempts $\pm\begin{pmatrix}2\\3\\-4\end{pmatrix}\bullet\pm\begin{pmatrix}5\\0\\-2\end{pmatrix}=\sqrt{2^2+3^2+(-4)^2}\times\sqrt{5^2+(-2)^2}\cos PQR$

A1: Finds the cosine of one of the angles in the Figure.
Look for $\cos\ldots=-\frac{18}{29}$ or $\cos\ldots=\frac{18}{29}$ which may have been achieved via the cosine rule.

Accept rounded answers and the angles in degrees 51.6, 128.4 (1dp) or radians 2.24, 0.901 (3sf) here.

dM1: Constructs a rigorous method leading to the area *PQRS*. Implied by awrt 22.7
E.g. $PQ\times QR\sin PQR=\sqrt{2^2+3^2+(-4)^2}\times\sqrt{5^2+(-2)^2}\times\frac{\sqrt{517}}{29}$

A1: $\sqrt{517}$

Alt 2-Example via vector product via a Further Maths method.

M1: For a key step in solving the problem. In this case it for an attempt at $\pm\overrightarrow{PQ}\times\overrightarrow{QR}$

E.g. $\overrightarrow{PQ}\times\overrightarrow{QR}=\begin{vmatrix}\mathbf{i}&\mathbf{j}&\mathbf{k}\\2&3&-4\\5&0&-2\end{vmatrix}=(3\times-2-0\times-4)\mathbf{i}-(2\times-2-5\times-4)\mathbf{j}+(2\times0-3\times5)\mathbf{k}$

A1: E.g. $\overrightarrow{PQ}\times\overrightarrow{QR}=-6\mathbf{i}-16\mathbf{j}-15\mathbf{k}$

dM1: Constructs a rigorous method leading to the area *PQRS*. In this case $\left|\overrightarrow{PQ}\times\overrightarrow{QR}\right|$

A1: $=\sqrt{(-6)^2+(-16)^2+(-15)^2}=\sqrt{517}$

Question	Scheme	Marks	AOs
6(a)	$\left(\lvert\overrightarrow{OA}\rvert=\right)\sqrt{5^2+3^2+2^2}=\sqrt{38}$ *	B1*	1.1b
		(1)	
(b)	$\lvert\overrightarrow{OB}\rvert=\sqrt{2^2+4^2+a^2}=\sqrt{20+a^2}$ so when $a=5$ $\lvert\overrightarrow{OB}\rvert=\sqrt{20+25}=\sqrt{45}$	M1	1.1b
	$=5$	A1cso	2.3
		(2)	
			(3 marks)

Notes

(a)

B1*: Shows the magnitude of $\lvert\overrightarrow{OA}\rvert$ is $\sqrt{38}$. Must see $\sqrt{5^2+3^2+2^2}$ or e.g. $\sqrt{25+9+4}$. We need to see how the value 38 or $\sqrt{38}$ is formed using the three components. Withhold this mark for incorrect working such as $\lvert\overrightarrow{OA}\rvert=5^2+3^2+2^2=38\Rightarrow\lvert\overrightarrow{OA}\rvert=\sqrt{38}$ but do not penalise poor notation to denote vectors or the magnitude as long as the intention is clear as to what they are finding (OA instead of $\lvert\overrightarrow{OA}\rvert$ is fine). Do not penalise if their square root does not go fully over all three terms as long as the intention is clear. May find $\lvert\overrightarrow{AO}\rvert$ instead which is acceptable.

$\left(\lvert\overrightarrow{OA}\rvert^2=\right)25+9+4=38\Rightarrow\left(\lvert\overrightarrow{OA}\rvert=\right)\sqrt{38}$ scores B1 (we see how 38 is found)

$\left(\lvert\overrightarrow{OA}\rvert^2=\right)25+9+4\Rightarrow\sqrt{38}$ scores B1 (we see how 38 is found)

$25+9+4=\sqrt{38}$ scores B0 (they are not equal)

$\left(\lvert\overrightarrow{OA}\rvert^2=\right)38\Rightarrow\left(\lvert\overrightarrow{OA}\rvert=\right)\sqrt{38}$ scores B0 (no method seen to show how 38 is found)

(b)

M1: Attempts to find $\lvert\overrightarrow{OB}\rvert$ (or $\lvert\overrightarrow{OB}\rvert^2$) in terms of a and substitutes in a positive integer for a to find a value for $\lvert\overrightarrow{OB}\rvert$ (or $\lvert\overrightarrow{OB}\rvert^2$). e.g. $\lvert\overrightarrow{OB}\rvert=\sqrt{20+a^2}\Rightarrow$ when $a=2\Rightarrow\sqrt{24}$. Also accept e.g. $\lvert\overrightarrow{BO}\rvert$ (or $\lvert\overrightarrow{BO}\rvert^2$).

Alternatively sets up an equation or an inequality e.g. $\sqrt{20+a^2}>\sqrt{38}$ and proceeds to $a^2>...$ (or $a^2=...$). Condone sign slips in their rearrangement only.

Allow the use of =, < or > for this mark. $"20"+a^2...38\Rightarrow a^2..."18"$

(may be implied by sight of $\sqrt{18}=4.24...$)

A1: 5 cso (answer on its own with no incorrect working seen scores M1A1). Withhold this mark if $\lvert\overrightarrow{OB}\rvert$ (or $\lvert\overrightarrow{OB}\rvert^2$) is incorrect (or $\lvert\overrightarrow{BO}\rvert$ or $\lvert\overrightarrow{BO}\rvert^2$). Do not be concerned with the notation as long as the intention is clear or implied as to what they are trying to calculate (the calculations must be correct)

Withhold this mark if at any point they set $\lvert\overrightarrow{OB}\rvert<\lvert\overrightarrow{OA}\rvert$ but accept an argument leading to an answer of 5 from either $\lvert\overrightarrow{OB}\rvert>\lvert\overrightarrow{OA}\rvert$ or $\lvert\overrightarrow{OB}\rvert=\lvert\overrightarrow{OA}\rvert$

Question	Scheme	Marks	AOs
7(a)	$\overrightarrow{AD} = 10\mathbf{i} + 24\mathbf{j}$ and $\overrightarrow{BC} = 50\mathbf{i} + 120\mathbf{j}$	M1	1.1b
	$\overrightarrow{AD} = \frac{1}{5}\overrightarrow{BC}$ therefore AD is parallel to BC *	A1*cso	2.2a
		(2)	
(b)	Attempt to find at least two lengths between AB, BC, CD and AD $\lvert\overrightarrow{BC}\rvert = \sqrt{50^2 + 120^2} = 130$, $\lvert\overrightarrow{DA}\rvert = \sqrt{10^2 + 24^2} = 26$	M1	1.1b
	$\lvert\overrightarrow{AB}\rvert = \sqrt{12^2 + 16^2} = 20$, $\lvert\overrightarrow{CD}\rvert = \sqrt{28^2 + 112^2} = 28\sqrt{17}$ (awrt 115 m)	A1	1.1b
	Average speed $= \dfrac{2(26+130+20+28\sqrt{17})/1000}{5/60}$	dM1	3.1b
	awrt $= 6.99$ (km/h)	A1	3.2a
		(4)	
			(6 marks)

Notes

(a)

M1: Attempts to find both $\overrightarrow{AD} = \pm(10\mathbf{i} + 24\mathbf{j})$ and $\overrightarrow{BC} = \pm(50\mathbf{i} + 120\mathbf{j})$.

May be seen as column vectors.

Condone poor notation with column vectors e.g. $\begin{pmatrix} 10\mathbf{i} \\ 24\mathbf{j} \end{pmatrix}$ or $\begin{matrix} 10 \\ 24 \end{matrix}$ for $\begin{pmatrix} 10 \\ 24 \end{pmatrix}$

This mark can be scored for at least one correct component for each vector if no method is shown.

May be implied if they go straight for ratios (gradients) e.g. $\pm\frac{24-0}{22-12}$, $\pm\frac{16-136}{0-50}$, $\pm\frac{0-50}{16-136}$

Some candidates use distances in an attempt to prove part (a) e.g. finding $10^2 + 24^2$ and $50^2 + 120^2$ in which case the M1 can be implied. Adding vectors scores M0

A1*cso: This mark requires

- correct work showing AD is parallel to BC by showing that e.g. $\overrightarrow{AD} = \pm\frac{1}{5}\overrightarrow{BC}$ or equivalent e.g. $\overrightarrow{BC} = \pm 5\overrightarrow{AD}$ or e.g. $\overrightarrow{AD} = 2(5\mathbf{i} + 12\mathbf{j})$ $\overrightarrow{BC} = 10(5\mathbf{i} + 12\mathbf{j})$ or e.g. $BC = \pm 5AD$ (i.e. the vector arrows are not required) or by showing the ratio/gradient of the lines through AD and BC are equal e.g. $\frac{24}{10} = \frac{120}{50}$. Condone e.g. $\frac{50\mathbf{i} + 120\mathbf{j}}{10\mathbf{i} + 24\mathbf{j}} = 5$
- a (minimal) conclusion e.g. ✓, hence shown, etc. which may be in a preamble e.g. if they are parallel then $AD = kBC$…etc. If using ratios/gradients they need to say that they are parallel.
- vectors correctly calculated but allow e.g. $\overrightarrow{AD} = -10\mathbf{i} - 24\mathbf{j}$ and allow poor column vector notation as above

Using reciprocal gradients for both is acceptable for A1 even if they call them "gradients".

Do not credit work in part (b) in part (a) unless used in part (a)

(b)

M1: Attempts to use Pythagoras to find **at least two** of the lengths of the quadrilateral.

May be implied by at least 2 correct lengths.

For reference $\pm\overrightarrow{AB} = \pm(-12\mathbf{i} + 16\mathbf{j})$, $\pm\overrightarrow{BC} = \pm(50\mathbf{i} + 120\mathbf{j})$, $\pm\overrightarrow{CD} = \pm(-28\mathbf{i} - 112\mathbf{j})$, $\pm\overrightarrow{DA} = \pm(10\mathbf{i} + 24\mathbf{j})$

Allow ft if using their vectors from part (a) provided subtraction was used. Do not be concerned about the signs of individual components but must be using subtraction (but condone $\pm\overrightarrow{AB} = \pm(12\mathbf{i} + 16\mathbf{j})$) to find the vectors and then squaring and adding components and then taking the square root.

A1: At least 2 lengths correct: If units are given they must be correct.

$\left|\overrightarrow{AB}\right| = \sqrt{12^2 + 16^2} = 20,$ $\left|\overrightarrow{CD}\right| = \sqrt{28^2 + 112^2} = 28\sqrt{17}$ (allow awrt 115 m)

$\left|\overrightarrow{BC}\right| = 10\sqrt{5^2 + 12^2} = 130,$ $\left|\overrightarrow{DA}\right| = 2\sqrt{5^2 + 12^2} = 26$

Allow if they are working in km e.g. $\left|\overrightarrow{AB}\right| = 0.02$ etc.

M1A1 is implied by a total distance of awrt 291 (m) or possibly a multiple of this if they are doubling (awrt 583) or e.g. multiplying by 24 (awrt 6990) etc.

dM1: For an attempt at an average speed ignoring any attempt to get the correct units.
They must have attempted all 4 lengths for this mark.
There must be some indication that they have divided by 5 but this may be implied.
Allow this mark if they calculate the average speed for 2 laps or 1 lap e.g.
$\frac{\text{"291"}\times 2}{5}, \frac{\text{"291"}}{5}, \text{"291"}\times 12, \text{"291"}\times 2\times 12$ or e.g. if they divide by 2.5 or multiply by 24.

A1: awrt 6.99 (km/h). or anything which truncates to 6.99 e.g. 6.995. Units are **not** required but if they are given they must be correct. Isw once a correct answer is seen.

An exact answer is acceptable for the final A1 in (b): $4.224 + 0.672\sqrt{17}$

Special Case:

Some candidates are misinterpreting/misreading the position vector for *B* as 16**i** rather than 16**j**
This is usually implied by their vectors/ratios e.g.

$$\overrightarrow{AD} = \pm(10\mathbf{i} + 24\mathbf{j}) \quad \text{and} \quad \overrightarrow{BC} = \pm(34\mathbf{i} + 136\mathbf{j})$$

or e.g.

$$\pm\frac{24-0}{22-12}, \pm\frac{50-16}{136-0}$$

For part (a), the maximum possible score is **M1A0** with the conditions for the M mark as described in the main scheme.

For part (b) the maximum possible score is **M1A1M1A0** as follows:

M1: Attempts to use Pythagoras to find **at least two** of the lengths of the quadrilateral as defined in the main scheme.

For reference $\pm\overrightarrow{AB} = \pm 4\mathbf{i}, \pm\overrightarrow{BC} = \pm(34\mathbf{i} + 136\mathbf{j}), \pm\overrightarrow{CD} = \pm(-28\mathbf{i} - 112\mathbf{j}), \pm\overrightarrow{DA} = \pm(10\mathbf{i} + 24\mathbf{j})$

A1: Correct lengths for *AD* and *CD*. If units are given they must be correct.
This may **not** be scored for correct ft lengths for *AB* or *BC*
So requires both:

$$\left|\overrightarrow{CD}\right| = \sqrt{28^2 + 112^2} = 28\sqrt{17} \text{ (allow awrt 115 m)}$$
$$\left|\overrightarrow{DA}\right| = \sqrt{10^2 + 24^2} = 26$$

dM1: As above for an attempt at an average speed ignoring any attempt to get the correct units.
A0: Not available

If the position vector for *B* is not misinterpreted/misread in part (b) then full marks are available.