Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Vectors

Time allowed: 1 hour 50 minutes

Subject code **0606**

Additional Mathematics

Questions from Paper 1 and Paper 2

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.
Questions 1-2, 6, 10 (Paper 1): no calculator.
Questions 3-5, 7-9 (Paper 2): calculator allowed.

Total marks

/ 71

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.
- Unless a question says otherwise, give answers that are not exact to 3 significant figures, and angles in degrees to 1 decimal place.

Information

- This paper has 10 questions worth 71 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 The point A has position vector $\begin{pmatrix} 2 \\ -6 \end{pmatrix}$. The point B has position vector $\begin{pmatrix} -3 \\ 6 \end{pmatrix}$.

(a) Find, in vector form, the displacement of B from A. [2]

(b) Find the distance AB. [1]

The point X is such that $3\overrightarrow{AB} = 2\overrightarrow{AX}$.

(c) Find the position vector of X. [2]

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Vectors: position, magnitude and geometry Click for more variations

1(a)	$\pm\begin{pmatrix}-5\\12\end{pmatrix}$	**B1**	
	$\begin{pmatrix}-5\\12\end{pmatrix}$	**B1**	
1(b)	13	**B1**	**FT** on *their* (a)
1(c)	$3\left(\text{their } \overrightarrow{AB}\right)=2\overrightarrow{OX}-2\begin{pmatrix}2\\-6\end{pmatrix}$	**M1**	Condone $3\left(\text{their } \overrightarrow{AB}\right)=2\begin{pmatrix}2\\-6\end{pmatrix}-2OX$
	$\begin{pmatrix}-\frac{11}{2}\\12\end{pmatrix}$	**A1**	

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2 **(a)** The vector **v** has a magnitude of 39 units and is in the same direction as $\begin{pmatrix} -12 \\ 5 \end{pmatrix}$. Write **v** in the form $\begin{pmatrix} a \\ b \end{pmatrix}$, where a and b are constants. [2]

(b) Vectors **p** and **q** are such that $\mathbf{p} = \begin{pmatrix} r+s \\ r+6 \end{pmatrix}$ and $\mathbf{q} = \begin{pmatrix} 5r+1 \\ 2s-1 \end{pmatrix}$, where r and s are constants. Given that $2\mathbf{p}+3\mathbf{q} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$, find the value of r and of s. [4]

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2(a)	$\left\|\begin{pmatrix}-12\\5\end{pmatrix}\right\| = 13$	**B1**	For magnitude, may be implied by a correct **v**
	$\mathbf{v} = \begin{pmatrix}-36\\15\end{pmatrix}$ or $3\begin{pmatrix}-12\\5\end{pmatrix}$	**B1**	Must be a vector
2(a) Alternative	If $t\left\|\begin{pmatrix}-12\\5\end{pmatrix}\right\| = 39$, $t = 3$	**B1**	For value of t, may be implied by a correct **v**
	$\mathbf{v} = \begin{pmatrix}-36\\15\end{pmatrix}$ or $3\begin{pmatrix}-12\\5\end{pmatrix}$	**B1**	
2(b)		**M1**	For equating like vectors at least once
	$17r + 2s + 3 = 0$ $2r + 6s + 9 = 0$	**M1**	**Dep** For solution of resulting equations to obtain 2 solutions
	$r = 0$	**A1**	
	$s = -\frac{3}{2}$ oe	**A1**	

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3 Vectors **i** and **j** are vectors parallel to the x-axis and y-axis respectively.

Given that $\mathbf{a} = 2\mathbf{i} + 3\mathbf{j}$, $\mathbf{b} = \mathbf{i} - 5\mathbf{j}$ and $\mathbf{c} = 3\mathbf{i} + 11\mathbf{j}$, find

(i) the exact value of $|\mathbf{a} + \mathbf{c}|$, [2]

(ii) the value of the constant m such that $\mathbf{a} + m\mathbf{b}$ is parallel to **j**, [2]

(iii) the value of the constant n such that $n\mathbf{a} - \mathbf{b} = \mathbf{c}$. [2]

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Vectors: position, magnitude and geometry Click for more variations

3(i)	$\lvert their(\mathbf{a}+\mathbf{c})\rvert = \sqrt{their(5^2+14^2)}$	**M1**	
	$\sqrt{221}$	**A1**	mark final answer
3(ii)	$[(2+m)\mathbf{i}+(3-5m)\mathbf{j}$ therefore] *their* $(2+m)=0$	**M1**	for attempting to form $\mathbf{a}+m\mathbf{b}$ and equate the scalar of the **i** component to 0
	$m=-2$ only	**A1**	implies **M1**
3(iii)	$[(2n-1)\mathbf{i}+(3n+5)\mathbf{j}=3\mathbf{i}+11\mathbf{j}$ or $n(2\mathbf{i}+3\mathbf{j})=(3\mathbf{i}+11\mathbf{j})+(\mathbf{i}-5\mathbf{j})$ oe leading to] $2n-1=3$ or $3n+5=11$ oe, soi	**M1**	
	$n=2$ only	**A1**	implies **M1**

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4 A plane, which can travel at a speed of $300\,\text{km}\,\text{h}^{-1}$ in still air, heads due north. The plane is blown off course by a wind so that it travels on a bearing of 010° at a speed of $280\,\text{km}\,\text{h}^{-1}$.

(i) Find the speed of the wind. [3]

(ii) Find the direction of the wind as a bearing correct to the nearest degree. [3]

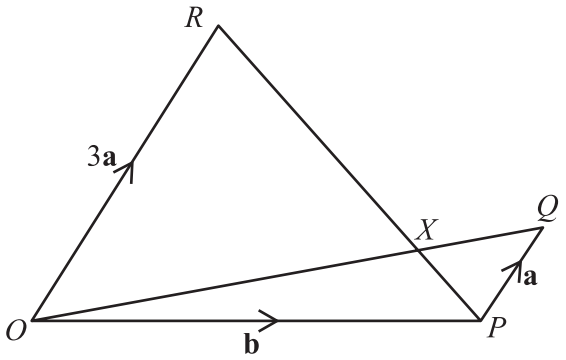
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Velocity vectors and relative motion Click for more variations

4(i)	Uses correct triangle with v_w opposite 10° Sides of 300 and 280 include 10°	**M1**	
	Use cosine rule	**M1**	$v_w^{\,2} = 300^2 + 280^2 - 2\times 300\times 280\cos 10$
	$v_w = 54.3$	**A1**	
4(ii)	Use sine rule	**M1**	$\frac{280}{\sin\alpha} = \frac{54.3}{\sin 10°}$
	$\alpha = 63°$ or $64°$	**A1**	
	Bearing 117° or 116°	**A1**	

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5



In the diagram $\overrightarrow{OP} = \mathbf{b}$, $\overrightarrow{PQ} = \mathbf{a}$ and $\overrightarrow{OR} = 3\mathbf{a}$. The lines OQ and PR intersect at X.

(i) Given that $\overrightarrow{OX} = \mu\overrightarrow{OQ}$, express $\overrightarrow{OX}$ in terms of μ, $\mathbf{a}$ and $\mathbf{b}$. [1]

(ii) Given that $\overrightarrow{RX} = \lambda\overrightarrow{RP}$, express $\overrightarrow{OX}$ in terms of λ, $\mathbf{a}$ and $\mathbf{b}$. [2]

(iii) Hence find the value of μ and of λ and state the value of the ratio $\frac{RX}{XP}$. [3]

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Vectors: position, magnitude and geometry Click for more variations

5 **(i)**	$\overrightarrow{OX} = \mu(a+b)$	**B1**	
(ii)	$\overrightarrow{RP} = b-3a$ or $\overrightarrow{RX} = \lambda(b-3a)$ oe	**B1**	
	$\overrightarrow{OX} = 3a+\lambda(b-3a)$	**B1**	
(iii)	$\overrightarrow{OX} = \overrightarrow{OX}$ and equate both coefficients $\mu = 3-3\lambda$ $\mu = \lambda$	**M1**	
	$\mu = \lambda = 0.75$	**A1**	
	$\frac{RX}{XP} = 3$ or 3:1	**A1ft**	$\frac{\lambda}{1-\lambda}$

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6 A particle P is moving with a velocity of $20\,\text{ms}^{-1}$ in the same direction as $\begin{pmatrix}3\\4\end{pmatrix}$.

(i) Find the velocity vector of P. [2]

At time $t = 0$ s, P has position vector $\begin{pmatrix}1\\2\end{pmatrix}$ relative to a fixed point O.

(ii) Write down the position vector of P after t s. [2]

A particle Q has position vector $\begin{pmatrix}17\\18\end{pmatrix}$ relative to O at time $t = 0$ s and has a velocity vector $\begin{pmatrix}8\\12\end{pmatrix}\,\text{ms}^{-1}$.

(iii) Given that P and Q collide, find the value of t when they collide and the position vector of the point of collision. [3]

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Velocity vectors and relative motion Click for more variations

6(i)	$v = 20 \times \frac{1}{\sqrt{3^2 + 4^2}} \begin{pmatrix} 3 \\ 4 \end{pmatrix}$ oe	**M1**	finding and using the magnitude of $\begin{pmatrix} 3 \\ 4 \end{pmatrix}$
	$v = \begin{pmatrix} 12 \\ 16 \end{pmatrix}$	**A1**	
6(ii)	$\boldsymbol{r}_p = \begin{pmatrix} 1 \\ 2 \end{pmatrix} + \begin{pmatrix} 12 \\ 16 \end{pmatrix} t$	**M1**	correct use of position vector and *their* velocity vector
		A1	

6(iii)	$\begin{pmatrix} 17 \\ 18 \end{pmatrix} + \begin{pmatrix} 8 \\ 12 \end{pmatrix} t = \begin{pmatrix} 1 \\ 2 \end{pmatrix} + \begin{pmatrix} 12 \\ 16 \end{pmatrix} t$ Leading to $17 + 8t = 1 + 12t$ or $18 + 12t = 2 + 16t$	**M1**	equating position vectors of both particles at time t and solve either equation for t
	$t = 4$	**A1**	
	Position vector of collision $\begin{pmatrix} 49 \\ 66 \end{pmatrix}$	**A1**	

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7 Relative to an origin O, the position vectors of the points A, B, C and D are

$$\overrightarrow{OA} = \begin{pmatrix} 6 \\ -5 \end{pmatrix}, \quad \overrightarrow{OB} = \begin{pmatrix} 10 \\ 3 \end{pmatrix}, \quad \overrightarrow{OC} = \begin{pmatrix} x \\ y \end{pmatrix} \text{ and } \overrightarrow{OD} = \begin{pmatrix} 12 \\ 7 \end{pmatrix}.$$

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

(b) The point A is the mid-point of BC. Find the value of x and of y. [2]

(c) The point E lies on OD such that $OE : OD$ is $1 : 1 + \lambda$. Find the value of λ such that $\overrightarrow{BE}$ is parallel to the x-axis. [3]

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Vectors: position, magnitude and geometry Click for more variations

7(a)	$\overrightarrow{AB} = \begin{pmatrix} 4 \\ 8 \end{pmatrix}$	**B1**	
	$\sqrt{4^2 + 8^2}$	**M1**	**FT** *their* $\begin{pmatrix} 4 \\ 8 \end{pmatrix}$
	$\frac{1}{\sqrt{80}}\begin{pmatrix} 4 \\ 8 \end{pmatrix}$ oe isw	**A1**	**FT** provided working shown
7(b)	$\begin{pmatrix} 6 \\ -5 \end{pmatrix} = \frac{1}{2}\begin{pmatrix} 10+x \\ 3+y \end{pmatrix}$ oe	**M1**	
	$x = 2,\ y = -13$	**A1**	

7(c)	$\overrightarrow{OE} = \frac{1}{1+\lambda}\begin{pmatrix} 12 \\ 7 \end{pmatrix}$ oe seen	**B1**	
	Solves *their* $\frac{7}{1+\lambda} = 3$	**M1**	
	$\lambda = \frac{4}{3}$ oe	**A1**	
	Alternative $\overrightarrow{OE} = \begin{pmatrix} x \\ 3 \end{pmatrix}$ $\frac{12}{7} = \frac{x}{3}$ $x = \frac{36}{7}$	**(B1)**	
	$\frac{1+\lambda}{1} = \frac{12}{36/7}$	**(M1)**	**FT** *their x*
	$\lambda = \frac{4}{3}$	**(A1)**	

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8 **(a)** The four points O, A, B and C are such that

$$\overrightarrow{OA} = 5\mathbf{a}, \qquad \overrightarrow{OB} = 15\mathbf{b}, \qquad \overrightarrow{OC} = 24\mathbf{b} - 3\mathbf{a}.$$

Show that B lies on the line AC. [3]

(b) Relative to an origin O, the position vector of the point P is $\mathbf{i} - 4\mathbf{j}$ and the position vector of the point Q is $3\mathbf{i} + 7\mathbf{j}$. Find

(i) $|\overrightarrow{PQ}|$, [2]

(ii) the unit vector in the direction $\overrightarrow{PQ}$, [1]

(iii) the position vector of M, the mid-point of PQ. [2]

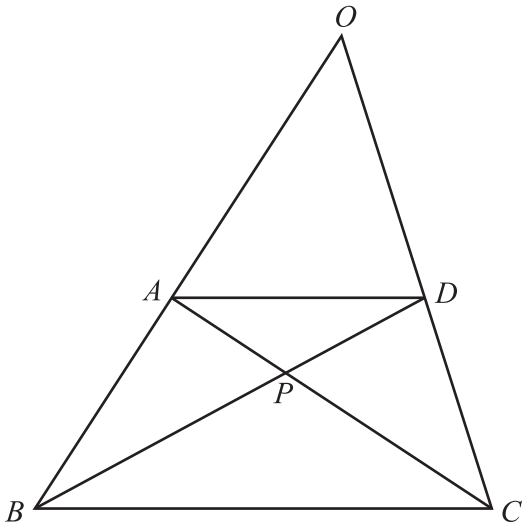
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Vectors: position, magnitude and geometry Click for more variations

8	**(a)**	$\overrightarrow{AB} = 15\mathbf{b} - 5\mathbf{a} = 5(3\mathbf{b} - \mathbf{a})$ or $\overrightarrow{BC} = 24\mathbf{b} - 3\mathbf{a} - 15\mathbf{b} = 3(3\mathbf{b} - \mathbf{a})$ or $\overrightarrow{AC} = 24\mathbf{b} - 3\mathbf{a} - 5\mathbf{a} = 8(3\mathbf{b} - \mathbf{a})$	B1 B1	Any correct simplified vector Any second simplified vector
		Comment: e.g. the vectors are scalar multiples of each other AND they have a common point (A, B or C as appropriate)	B1dep	Dep on both B marks being awarded.
	(b) (i)	$2\mathbf{i} + 11\mathbf{j}$ soi $\Rightarrow \sqrt{2^2 + 11^2}$	B1	
		$\sqrt{125}$ or $5\sqrt{5}$ or 11.2 (3 s.f.) or better)	B1fT	ft *their* $2\mathbf{i} + 11\mathbf{j}$ (not $\overrightarrow{OP}$ or $\overrightarrow{OQ}$)
	(ii)	$\frac{1}{5\sqrt{5}}(2\mathbf{i} + 11\mathbf{j})$ isw	B1fT	ft *their* answers from **(i)**
	(iii)	$\frac{\mathbf{i} - 4\mathbf{j} + 3\mathbf{i} + 7\mathbf{j}}{2}$ or $\mathbf{i} - 4\mathbf{j} + \frac{2\mathbf{i} + 11\mathbf{j}}{2}$ or $3\mathbf{i} + 7\mathbf{j} - \frac{2\mathbf{i} + 11\mathbf{j}}{2}$	M1	
		$2\mathbf{i} + 1.5\mathbf{j}$	A1	

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9



The diagram shows a triangle OBC.
$OA : OB = 4 : 7$ and $OD : OC = 4 : 7$.

$$\overrightarrow{OB} = \mathbf{b} \text{ and } \overrightarrow{OC} = \mathbf{c}$$

The point P is the point of intersection of AC and BD such that $\overrightarrow{AP} = \lambda\overrightarrow{AC}$ and $\overrightarrow{BP} = \mu\overrightarrow{BD}$ where λ and μ are scalars.

(a) Find two expressions for $\overrightarrow{OP}$, each in terms of **b**, **c** and a scalar, and hence show that P divides both AC and DB in the ratio 4 : 7. [7]

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(b) The point Q is such that $\overrightarrow{OQ} = \frac{2}{7}\mathbf{b} + \frac{2}{7}\mathbf{c}$.

Use a vector method to show that O, Q and P are collinear. Justify your answer. [2]

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9(a)	$\overrightarrow{OP} = \frac{4}{7}\mathbf{b} + \lambda\left(\mathbf{c} - \frac{4}{7}\mathbf{b}\right)$ and $\overrightarrow{OP} = \mathbf{b} + \mu\left(\frac{4}{7}\mathbf{c} - \mathbf{b}\right)$	**B3**	**B2** for $\overrightarrow{OP} = \frac{4}{7}\mathbf{b} + \lambda\left(\mathbf{c} - \frac{4}{7}\mathbf{b}\right)$ or $\overrightarrow{OP} = \mathbf{b} + \mu\left(\frac{4}{7}\mathbf{c} - \mathbf{b}\right)$ oe or **B1** for $\overrightarrow{OP} = \left(their\frac{4}{7}\right)\mathbf{b} + \lambda\left(\mathbf{c} - \left(their\frac{4}{7}\right)\mathbf{b}\right)$ or $\overrightarrow{OP} = \mathbf{b} + \mu\left(\left(their\frac{4}{7}\right)\mathbf{c} - \mathbf{b}\right)$ or
	Equates components e.g.: $\left(their\frac{4}{7}\right)(1-\lambda) = (1-\mu)$ or $\lambda = their\frac{4}{7}\mu$	**M1**	**FT** providing at least **B1** awarded and two expressions for $\overrightarrow{OP}$ in terms of **b, c**, λ and μ found
	$\frac{4}{7}(1-\lambda) = (1-\mu) \quad \lambda = \frac{4}{7}\mu$ oe	**A1**	
	$\lambda = \frac{4}{11}$ and $\mu = \frac{7}{11}$ oe and conclusion $AP : AC = 4 : 11$ therefore $AP : PC = 4 : 7$ $BP : BD = 7 : 11$ therefore $DP : PB = 4 : 7$ oe	**A2**	**A1** for $\lambda = \frac{4}{11}$ or $\mu = \frac{7}{11}$ oe

9(b)	$\overrightarrow{OP} = \frac{4}{11}(\mathbf{b} + \mathbf{c})$ or $\overrightarrow{OP} = \frac{4}{11}\mathbf{b} + \frac{4}{11}\mathbf{c}$ and $\overrightarrow{OP}$ and $\overrightarrow{OQ}$ are scalar multiples of each other and have a point in common oe	**2**	**M1** for $\overrightarrow{OP} = \frac{4}{11}(\mathbf{b} + \mathbf{c})$ or $\overrightarrow{OP} = \frac{4}{11}\mathbf{b} + \frac{4}{11}\mathbf{c}$

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10 In this question, all distances are in metres and time, t, is in seconds.

A particle P moves with a speed of 14.5 parallel to the vector $\begin{pmatrix} -20 \\ 21 \end{pmatrix}$.

(a) Find the velocity vector of P. [2]

Initially, P has position vector $\begin{pmatrix} 3 \\ 5 \end{pmatrix}$.

(b) Write down the position vector of P at time t. [2]

A second particle Q has position vector $\begin{pmatrix} -1 \\ 3 \end{pmatrix} + \begin{pmatrix} -5 \\ 7.5 \end{pmatrix} t$ at time t.

(c) Find, in terms of t, the distance between P and Q at time t. Simplify your answer. [4]

(d) Hence show that P and Q never collide. [2]

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10(a)	Velocity vector = $\begin{pmatrix}-10\\10.5\end{pmatrix}$ or $\frac{1}{2}\begin{pmatrix}-20\\21\end{pmatrix}$	**B2**	**B1** for $\left\|\begin{pmatrix}-20\\21\end{pmatrix}\right\| = 29$ soi or one correct element
10(b)	$\begin{pmatrix}3\\5\end{pmatrix}+\begin{pmatrix}-10\\10.5\end{pmatrix}t$ oe	**2**	**M1 FT** on *their* velocity vector from part (a) if not correct.
10(c)	$\overrightarrow{PQ} = \begin{pmatrix}5t-4\\-3t-2\end{pmatrix}$ oe	**2**	**Dep M1** must have **M1** in part (b) for $\left(\begin{pmatrix}-1\\3\end{pmatrix}+\begin{pmatrix}-5\\7.5\end{pmatrix}t\right)$ – *their* answer to part (b) or *their* answer to part b $-\left(\begin{pmatrix}-1\\3\end{pmatrix}+\begin{pmatrix}-5\\7.5\end{pmatrix}t\right)$
	$PQ = \sqrt{(5t-4)^2+(-3t-2)^2}$	**M1**	**Dep** on previous **M** mark for using *their* $\overrightarrow{PQ}$
	$PQ = \sqrt{34t^2-28t+20}$	**A1**	
10(d)	For collision $34t^2-28t+20=0$ soi	**M1**	Need to be using *their* quadratic PQ^2 from part (c) or forming a quadratic from their $\overrightarrow{PQ}$ from part (c)
	Discriminant = -1936 So no real roots so no collision oe	**A1**	Discriminant must be correct, but allow unsimplified

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