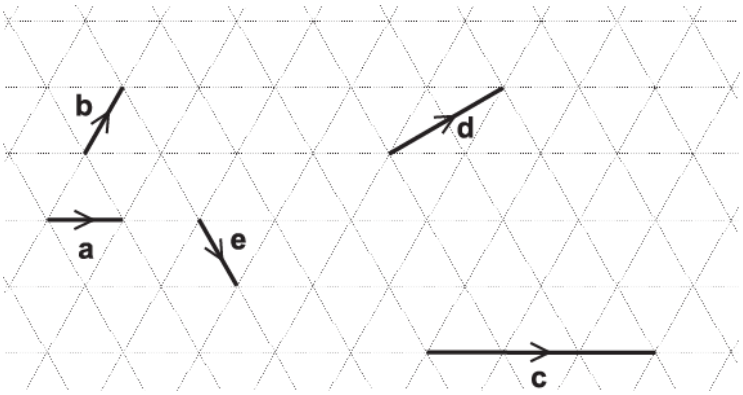
1. Vectors **a**, **b**, **c**, **d** and **e** are drawn on an isometric grid.



Write each of the vectors **c**, **d** and **e** in terms of **a** and / or **b**.

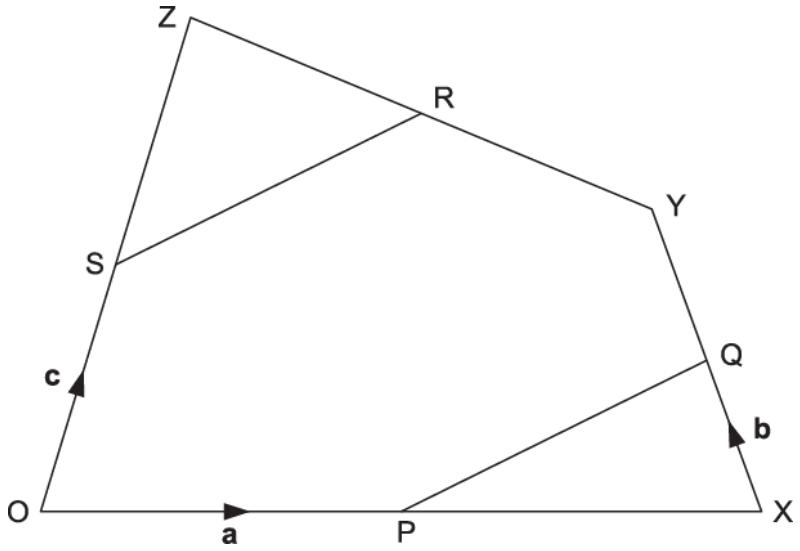
c = _____

d = _____

e = _____

[3]

2. P, Q, R and S are the midpoints of OX, XY, YZ and OZ respectively.



$\overrightarrow{OP} = \mathbf{a}$, $\overrightarrow{XQ} = \mathbf{b}$ and $\overrightarrow{OS} = \mathbf{c}$.

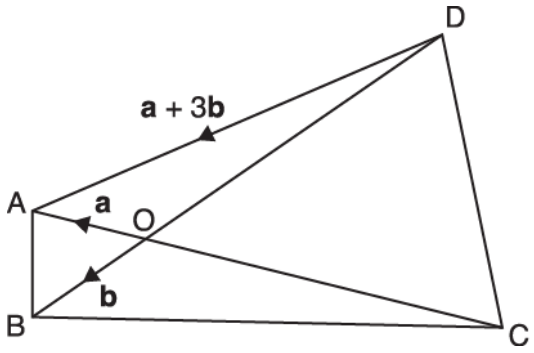
Show that PQ is parallel to SR.

[5]

3(a). ABCD is a quadrilateral.

O is the point on AC where AO = $\frac{1}{4}$ AC.

$\overrightarrow{OA}$ = **a**, $\overrightarrow{OB}$ = **b** and $\overrightarrow{DA}$ = **a** + 3**b**.



Not to scale

Find, as simply as possible, in terms of **a** and **b**,

(i) $\overrightarrow{AB}$,

---

[1]

(ii) $\overrightarrow{BD}$.

---

[1]

(b).

(i) Show that DC is parallel to AB.

---

[2]

(ii) Hence prove that triangle OAB is similar to triangle OCD.

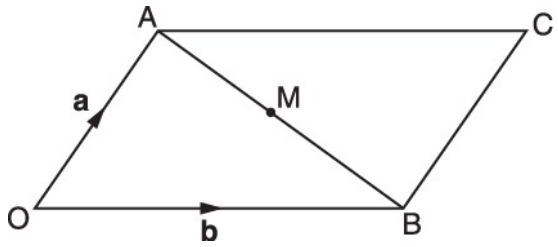
---

[2]

4(a). OACB is a parallelogram.

$\overrightarrow{OA} = \mathbf{a}$ and $\overrightarrow{OB} = \mathbf{b}$.

M is the midpoint of AB.



Not to scale

Find, in terms of **a** and **b**, these vectors.

(i) $\overrightarrow{OC}$

(i) _____ [1]

(ii) $\overrightarrow{AB}$

(ii) _____ [1]

(iii) $\overrightarrow{OM}$

(iii) _____ [2]

(b). Use your answers to write **two** conclusions about points O, M and C.

(1)

---

(2)

---

[2]

5. You are given that $\mathbf{p} + \mathbf{q} = \begin{pmatrix} -1 \\ 3 \end{pmatrix}$.

Write the following as column vectors.

(i) $\left[\begin{pmatrix} 3 \\ 7 \end{pmatrix} + \mathbf{p}\right] + \mathbf{q}$

(i) $\begin{pmatrix} \quad \\ \quad \end{pmatrix}$ [2]

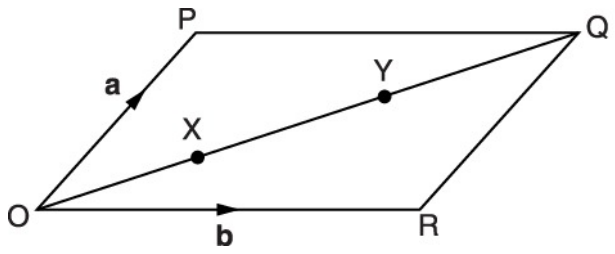
(ii) $-4(q + p)$

(ii) $\begin{pmatrix} \quad \\ \quad \end{pmatrix}$ [2]

6(a). OPQR is a parallelogram.

$\overrightarrow{OP} = \mathbf{a}$ and $\overrightarrow{OR} = \mathbf{b}$.

X and Y are the points on OQ such that OX = XY = YQ.



Not to scale

Find as simply as possible in terms of **a** and **b**,

$\overrightarrow{OQ}$,

_____ [1]

(b). $\overrightarrow{PR}$,

_____ [1]

(c). $\overrightarrow{XY}$,

_____ [1]

(d). $\overrightarrow{XR}$.

_____ [2]

7(a). $\overrightarrow{PQ} = \begin{pmatrix} 3 \\ -2 \end{pmatrix}$

Work out $3\overrightarrow{PQ}$.

_____ [1]

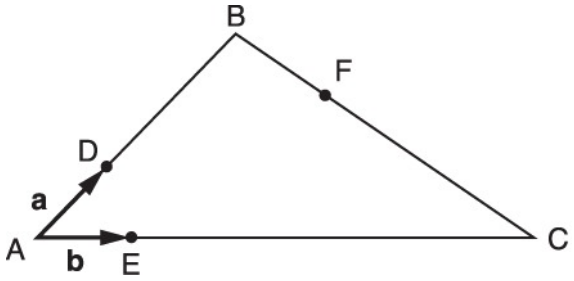
(b). If Q = (7, $^{-}$5), write down the coordinates of P.

(_____,_____) [1]

8(a). In the diagram below, ABC is a triangle.

$\overrightarrow{AD} = \mathbf{a}$ and $\overrightarrow{AE} = \mathbf{b}$

- D is a point on AB such that AB = 4AD
- E is a point on AC such that AC = 4AE
- F is a point on BC such that BC = 4BF



Not to scale

Write these vectors in terms of **a** and **b** in their simplest form.

(i) $\overrightarrow{AB}$

(i) _____ [1]

(ii) $\overrightarrow{BC}$

(ii) _____ [1]

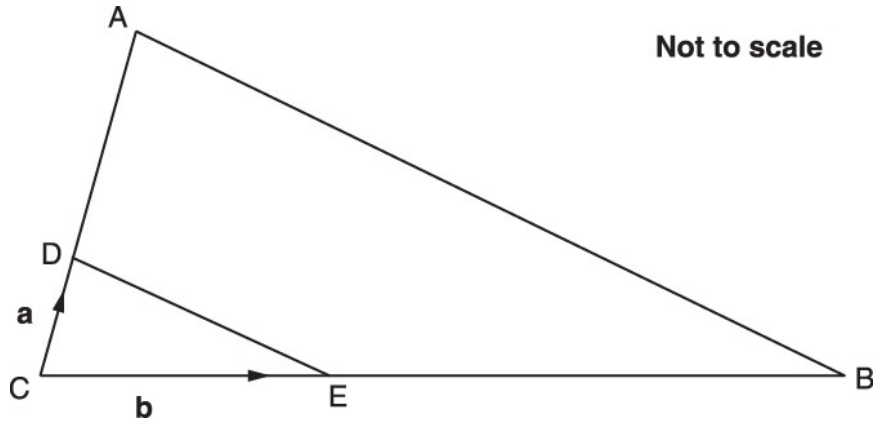
(iii) $\overrightarrow{EF}$

(iii) _____ [2]

(b). What do your answers from **(a)(i)** and **(a)(iii)** tell you about AB and EF?

_____ [1]

9. In the diagram ABC is a triangle.



D is a point on CA such that CA = 4CD.

E is a point on CB such that CB = 4CE.

$\overrightarrow{CD} = \mathbf{a}$ and $\overrightarrow{CE} = \mathbf{b}$.

Show that lines DE and AB are parallel.

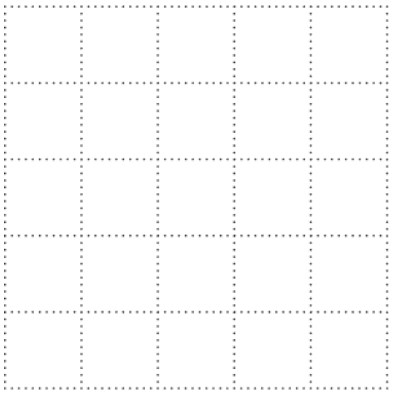
[4]

10(a) .

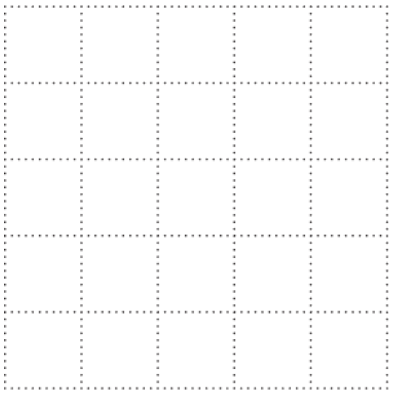
Vector $\mathbf{a} = \begin{pmatrix} 2 \\ 1 \end{pmatrix}$, vector $\mathbf{b} = \begin{pmatrix} -2 \\ 1 \end{pmatrix}$.

On each grid below, draw a vector to represent

(i) 2a,



(ii) a + b.



[2]

(b). Emma says that if she draws vector **a** and vector **b** they will be the same.

Explain why this is incorrect.

_____ [1]

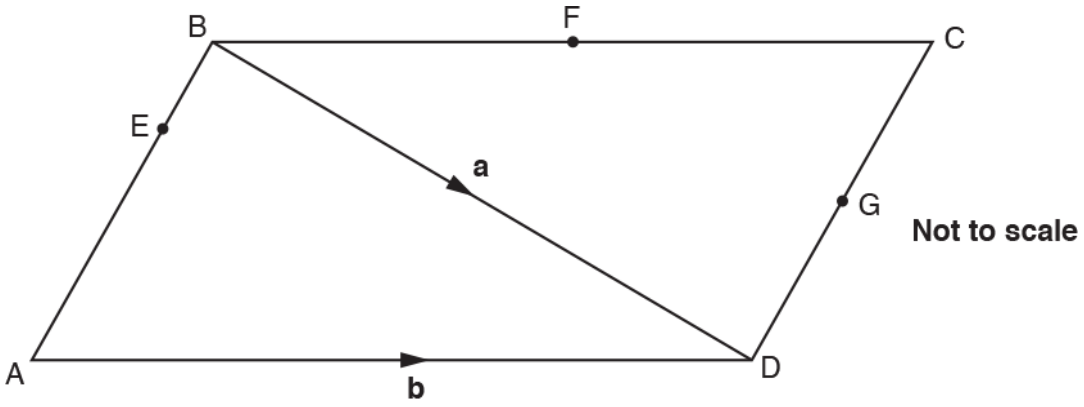
(c). $\mathbf{c} = \begin{pmatrix} -12 \\ 0 \end{pmatrix}$.

Find the value k so that $k(\mathbf{a} - \mathbf{b}) = \mathbf{c}$.

$k =$ _____ [2]

11(a) ABCD is a parallelogram.

.



$\overrightarrow{BD} = \mathbf{a}$ and $\overrightarrow{AD} = \mathbf{b}$

F is the midpoint of BC.

G is the midpoint of DC.

AE = 3EB.

Write down simplified expressions in terms of **a** and **b** for

(i) $\overrightarrow{AB}$,

---------- [1]

(ii) $\overrightarrow{EB}$.

---------- [1]

(b).

Show that $\overrightarrow{EF} = \frac{1}{4}(3\mathbf{b} - \mathbf{a})$. [2]

(c). Prove that $\overrightarrow{EF}$ and $\overrightarrow{AG}$ are parallel.

---

[3]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Part marks and guidance	
1			$\mathbf{c} = 3\mathbf{a}$ $\mathbf{d} = \mathbf{a} + \mathbf{b}$ $\mathbf{e} = \mathbf{a} - \mathbf{b}$	3	**B1** for each	
			Total	3		
2			$\vec{ZY} = -2\mathbf{c} + 2\mathbf{a} + 2\mathbf{b}$ $\vec{SR} = \mathbf{c} + (-\mathbf{c} + \mathbf{a} + \mathbf{b})$ so $\vec{SR} = \mathbf{a} + \mathbf{b}$ $\vec{PQ} = \mathbf{a} + \mathbf{b}$ $\vec{SR} = \vec{PQ}$ so they are parallel	5	**M1** for $\vec{ZY} = -2\mathbf{c} + 2\mathbf{a} + 2\mathbf{b}$ **M1** for $\vec{SR} = \mathbf{c} + (-\mathbf{c} + \mathbf{a} + \mathbf{b})$ **M1** for $\vec{SR} = \mathbf{a} + \mathbf{b}$ **M1** for $\vec{PQ} = \mathbf{a} + \mathbf{b}$	
			Total	5		
3	a	i	$\mathbf{b} - \mathbf{a}$ or $-\mathbf{a} + \mathbf{b}$ final answer	1		Condone $\mathbf{b} + -\mathbf{a}$ Examiner's Comments Candidates who had some understanding of vectors often reached the correct answer in (i), although answers of $\mathbf{a} + \mathbf{b}$ and $\mathbf{a} - \mathbf{b}$ were also common.

Question			Answer/Indicative content	Marks	Part marks and guidance	
		ii	$-4\mathbf{b}$ oe	1		ISW for incorrect simplification Accept $\mathbf{a} - \mathbf{b} - (\mathbf{a} + 3\mathbf{b})$ or equivalent Examiner's Comments Far fewer correct answers were seen in (ii) because the directions of the vectors created problems for candidates. Many identified that they needed to combine BA and AD, but they did not understand that BA is not the same as AB. The most common answers were $2\mathbf{b} - 2\mathbf{a}$ from $\mathbf{b} - \mathbf{a} - \mathbf{a} + 3\mathbf{b}$ and $2\mathbf{b}$ from $\mathbf{a} - \mathbf{b} - \mathbf{a} + 3\mathbf{b}$, where a bracket had been omitted from $(\mathbf{a} + 3\mathbf{b})$.
	b	i	$\overrightarrow{DC} = 3\mathbf{b} - 3\mathbf{a}$ and $\overrightarrow{DC}$ is a multiple of $\overrightarrow{AB}$ or $\overrightarrow{DC} = 3\overrightarrow{AB}$ oe	2	B1 for $3\mathbf{a}$ and $3\mathbf{b}$ seen	Condone missing vector arrows For 2 marks, must relate DC and AB Condone AB is a factor of DC For B1 condone $-3\mathbf{a}$, $-3\mathbf{b}$ Examiner's Comments The candidates were usually successful in finding $\overrightarrow{DC}$ in terms of $\mathbf{a}$ and $\mathbf{b}$ to give the correct conclusion. Some candidates found $\overrightarrow{DC} = 3\mathbf{b} - 3\mathbf{a}$ but did not then relate this to $\overrightarrow{AB}$. A mark was available to those who ignored the directions for reaching $3\mathbf{a}$ and $3\mathbf{b}$ in their working. Some candidates simply defined parallel lines.

Question			Answer/Indicative content	Marks	Part marks and guidance	
		ii	Two pairs of equal angles stated with reasons OR Three pairs of proportional sides DC = 3AB, CO = 3OA **and** DO = 3OB OR Two pairs of proportional sides and included pair of angles with reason	2	**M1** for one correct pair of angles with reason or for two correct pairs of angles with no/incorrect reason or for one pair of proportional sides from DC = 3AB, CO = 3OA and DO = 3OB or scale factor 3 soi	Pairs of angles and reasons: ∠AOB = ∠DOC, [vertically] opposite ∠OAB = ∠OCD, alternate [angles] ∠OBA = ∠ODC, alternate [angles] Accept OA = a and OC = 3a etc as pairing sides <u>Examiner's Comments</u> Proving the triangles were similar was most successfully done through pairing sides. Referring to angles accurately was not well done and reasons for equal angles often omitted. Despite the fact that the parallel lines had been identified in the previous part, few candidates identified that angles OAB and OCD or ABO and CDO were equal because they were alternate angles. Many candidates gained a mark for mentioning the scale factor of 3, although some candidates misunderstood the information in the question and thought that the scale factor was 4. Some candidates stated as many facts about the sides or angles as they could without linking them in a way that would show that the triangles were similar.
			Total	6		

Question			Answer/Indicative content	Marks	Part marks and guidance	
4	a	i	**a** + **b** or **b** + **a**	1		Capitals, eg A and B, do not score
		ii	**b** – **a** or $^{-}$**a** + **b**	1		
		iii	$\frac{1}{2}\mathbf{a}+\frac{1}{2}\mathbf{b}$ oe	2	M1 for $\overrightarrow{OA}+\frac{1}{2}\overrightarrow{AB}$ Examiner's Comments The majority of candidates could score well on this question with only a few writing their answers as column vectors.	eg 2 for **a** + $\mathbf{a}+\frac{1}{2}(\mathbf{b}-\mathbf{a})$
	b		O, M, C collinear/all on a line M is midpoint of OC oe	1 1	Examiner's Comments The weaker candidates gave conclusions about the vectors or the parallelogram, rather than about the *points*, hence failing to score.	It is an equal distance from O to M as from M to C OC is double OM OM is half of OC
			Total	6		

Question			Answer/Indicative content	Marks	Part marks and guidance	
5		i	$\begin{pmatrix} 2 \\ 10 \end{pmatrix}$	2	Or **M1** for $\begin{pmatrix} 3 \\ 7 \end{pmatrix} + \begin{pmatrix} -1 \\ 3 \end{pmatrix}$	
		ii	$\begin{pmatrix} 4 \\ -12 \end{pmatrix}$	2	Or **M1** for $-4\begin{pmatrix} -1 \\ 3 \end{pmatrix}$ **Examiner's Comments** Most candidates knew that the resultant of the two vectors involved addition and answered part (a) correctly. Part (b)(i) was more problematic with many not understanding the associative law for this addition. Common errors were the inability to add negative numbers or to add the vector **p + q** twice. Part (b)(ii) was found easier than part (i) with many correct answers from multiplying the vector by a constant. The errors came from an inability to multiply by a negative number. Answer: $\begin{pmatrix} 6 \\ -6 \end{pmatrix}$, $\begin{pmatrix} 2 \\ 10 \end{pmatrix}$, $\begin{pmatrix} 4 \\ -12 \end{pmatrix}$	
			Total	4		

Question			Answer/Indicative content	Marks	Part marks and guidance	
6	a		$\mathbf{a} + \mathbf{b}$ final answer	1		
	b		$\mathbf{b} - \mathbf{a}$ final answer	1	Examiner's Comments The basic processes of adding or subtracting two vectors seemed to be reasonably well understood and many candidates gave the correct answers in parts (a) and (b).	Condone $\mathbf{b} + {}^{-}\mathbf{a}$
	c		$\frac{1}{3}(\mathbf{a} + \mathbf{b})$ or $\frac{1}{3}\mathbf{a} + \frac{1}{3}\mathbf{b}$ final answer	1	FT $\frac{1}{3}$ (*their* '$\mathbf{a} + \mathbf{b}$')	

Question			Answer/Indicative content	Marks	Part marks and guidance	
	d		$\frac{1}{3}(2\mathbf{b}-\mathbf{a})$ or $\frac{2}{3}\mathbf{b}-\frac{1}{3}\mathbf{a}$ final answer	2	M1 for $-\frac{1}{3}(\mathbf{a}+\mathbf{b})+\mathbf{b}$ oe or for $\mathbf{b} \pm$ *their* $\frac{1}{3}(\mathbf{a}+\mathbf{b})$' or for $\overrightarrow{XO}+\overrightarrow{OR}$ or $\overrightarrow{XQ}+\overrightarrow{QR}$ soi Examiner's Comments Candidates found more difficulty with parts (c) and (d), where more interpretation of the diagram was required. Many candidates identified that part (c) required a fraction of the answer to part (a), but $\frac{1}{3}$ was not always correctly identified and $\frac{1}{2}$ was not uncommon. Some careless notation was seen, with answers such as $\frac{1}{3}\mathbf{a}+\mathbf{b}$ instead of $\frac{1}{3}$#x00A0;($\mathbf{a}+\mathbf{b}$). Few correct, fully simplified answers were seen in part (d), although some candidates were given credit for identifying that the required vector was $\mathbf{b}-$ their answer to part (c), or twice their answer to part (c) $-\mathbf{a}$.	
			Total	5		

Question			Answer/Indicative content	Marks	Part marks and guidance	
7	a		$\begin{pmatrix} 9 \\ -6 \end{pmatrix}$	1	Examiner's Comments This was usually answered correctly, although some fraction lines were seen and some left out the vector brackets.	there should be no fraction line
	b		4 ¯3	1	Examiner's Comments The correct method was to subtract the vector but some added them to give (10, –7) and others seem to guess as they had no perceivable method to solve this problem.	watch out for –4, 3 which scores **0**
			Total	2		

Question			Answer/Indicative content	Marks	Part marks and guidance	
8	a	i	$4\boldsymbol{a}$	1		
		ii	$4\boldsymbol{b} - 4\boldsymbol{a}$	1	allow any equivalent simplified expression	
		iii	$3\boldsymbol{a}$	2	**M1** for $-\boldsymbol{b} + 4\boldsymbol{a} + ¼(4\boldsymbol{b} - 4\boldsymbol{a})$ or EA + AB + BF or 3b – ¾ (4b –4a) **oe**	Note: EA (etc) does not need arrows
	b		parallel	1	accept AB is 1– times longer **Examiner's Comments** Vectors is clearly one topic which many candidates did not study as can be seen by the number who did not attempt this question in its entirety. These parts are all linked by the same theory so it was usual to see some candidates answer it all correctly whilst others answer it all wrongly. Part (a)(i) did offer the opportunity for some to get at least 1 mark, although some wrote $3\boldsymbol{a}$. In (a)(ii) the most common incorrect answer was $4\boldsymbol{a} + 4\boldsymbol{b}$. Part (a)(iii) was only correctly answered by a few and yet in (b) there were more correct answers presumably by interpreting the diagram.	see accepted list and choose the best if more than one comment **Exemplar Response** parallel (1) AB is 1⅓ times longer (1) They are parallel and multiples of each other (1) EF is ¾ of AB (1) They are multiples of each other (0)
			Total	5		

Question			Answer/Indicative content	Marks	Part marks and guidance	
9			$\overrightarrow{DE} = \mathbf{b} - \mathbf{a}$ oe	B1	could be $\overrightarrow{ED}$	Could be on diagram
			$\overrightarrow{CA} = 4\mathbf{a}$ **and** $\overrightarrow{CB} = 4\mathbf{b}$	B1	soi by correct $\overrightarrow{AB}$ or $\overrightarrow{BA}$	condone omission of arrows
			$\overrightarrow{AB} = 4\mathbf{b} - 4\mathbf{a}$ oe	B1	could be $\overrightarrow{BA}$	
			$\overrightarrow{AB} = 4\overrightarrow{DE}$ oe	B1	dep on **B3**	
					Examiner's Comments Those who used vectors gained three marks showing DE and AB correctly. However, very few were able to make the correct final statement of AB = 4DE or something equivalent. Many thought that it was sufficient to have the answers $\mathbf{b}-\mathbf{a}$ and $4\mathbf{b}-4\mathbf{a}$ without making a statement or a factorisation attempt. The most common mistake was writing DE as $\mathbf{a} + \mathbf{b}$, not recognising the change of direction, and then AB as $4\mathbf{a} + 4\mathbf{b}$. Often only comments such as 'they are going in the same direction' or 'one is four times longer than the other' were seen. Some did not use vectors and saw this as similar triangles or enlargement with sides in the ratio of 1 : 4 leading to AB being 4 times longer than DE and parallel to it. This was a more difficult strategy but would gain credit if the reasoning was correct.	
			Total	4		

Question			Answer/Indicative content	Marks	Part marks and guidance	
10	a	i	Draws vector $\begin{pmatrix}4\\2\end{pmatrix}$	2	B1 for each In (a), penalise first instance only where direction arrow is omitted Condone good freehand mark intention Examiner's Comments This was a weak area for many and very few candidates earned the 2 marks for representing the two vectors correctly on the grid. Some omitted the direction arrows from one or both diagrams or omitted the enclosing side of the vector triangle in the second diagram. The majority of candidates scored 0 with many axes seen with points plotted or objects translated or rectangles drawn. There were a significant number of candidates giving no response to this question.	
		ii	and Draws vector $\begin{pmatrix}0\\2\end{pmatrix}$		Could be part of correct vector triangle	

Question			Answer/Indicative content	Marks	Part marks and guidance		
	b		They are different in direction oe	1	Accept correct comments that mention the directions of the vectors	Accept any comment implying the directions of the 2 vectors are different e.g. 'They are not parallel' 'They are going in different directions' 'They are going in opposite x -directions' 'Vector A is a [vertical] reflection of vector B' 'One goes left, the other goes right' 'One goes in positive direction the other goes in negative direction' 'One has –2 and the other has 2' Condone 'They are going in opposite directions' Do not accept mention of just 1 vector	

Question			Answer/Indicative content	Marks	Part marks and guidance	
					only unless the reason clearly implies a comparison e.g. Do not accept 'Vector **a** goes right' 'One of them has a minus sign' **Examiner's Comments** In part (b), many candidates recognized that the vectors were in different directions, but some thought that vector **a** was going left and vector **b** was going right or that **a** was up and **b** was down. A few candidates did not make a comparison, making a statement about only vector **b**.	
	c		–3	2	**M1** for $k\left(\begin{pmatrix}2\\1\end{pmatrix}-\begin{pmatrix}-2\\1\end{pmatrix}\right)=\begin{pmatrix}-12\\0\end{pmatrix}$ oe M1 implied by answer $\begin{pmatrix}-3\\0\end{pmatrix}$ **Examiner's Comments** Only the strongest candidates gained marks in part (c). Vector notation was rarely consistently used and the negative sign was often omitted from –12, resulting in the common incorrect answer of 3.	
			Total	5		

Question			Answer/Indicative content	Marks	Part marks and guidance	
11	a	i	$\mathbf{b} - \mathbf{a}$	1	Examiner's Comments Many candidates appeared unfamiliar with vector notation and the question was frequently omitted by the weaker candidates. Most of those making an attempt ignored the instruction for answers to be in terms of **a** and **b**, leaving their responses rather meaningless and of no use in the subsequent parts. Unsurprisingly as a consequence, only a very small number of candidates were able to prove that $\overrightarrow{EF}$ and $\overrightarrow{EF}$ were parallel.	
		ii	$\frac{1}{4}(\mathbf{b} - \mathbf{a})$ o $\frac{1}{4}\mathbf{b} - \frac{1}{4}\mathbf{a}$ r	1	FT from (a)(i)	
	b		$\overrightarrow{EF} = \overrightarrow{EB} + \overrightarrow{BF} = \frac{1}{4}(\mathbf{b} - \mathbf{a}) + \frac{1}{2}\mathbf{b}$ leading to $\frac{1}{4}(3\mathbf{b} - \mathbf{a})$ as given.	2	M1 for *their* part (a) $+\frac{1}{2}$b oe (ii)	(a)(ii) must be in terms of **a** and b

Question			Answer/Indicative content	Marks	Part marks and guidance		
	c		$\overrightarrow{AG} = \frac{3}{2}\mathbf{b} - \frac{1}{2}\mathbf{a}$ $\overrightarrow{AG} = 2\overrightarrow{EF}$ oe so are parallel.	3	B2 for $\overrightarrow{AG} = \frac{3}{2}\mathbf{b} - \frac{1}{2}\mathbf{a}$ or M1 for **b** + $\frac{1}{2}$ (*their* part (a)(i)) oe	Allow vectors found in reverse throughout eg. $\overrightarrow{GA}$ instead of $\overrightarrow{AG}$ Condone "AG and EF are multiples of each other" Full marks dependent on both AG and EF in correct simplified forms	
			Total	7			