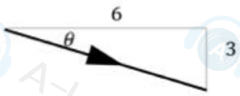
Question Number	Scheme	Marks
3(a)	Velocity $= (14\mathbf{i}-5\mathbf{j})+2(-4\mathbf{i}+\mathbf{j})$	M1
	Speed $= \sqrt{6^2+(-3)^2}$	M1
	Speed $= \sqrt{45} = 3\sqrt{5} = 6.7(\text{ms}^{-1})$ or better	A1 cso
		(3)
3(b)	 $\tan^{-1}\left(\frac{3}{6}\right)$	M1 A1ft
	27° or better **OR** 333° or better 0.46 rads or better **OR** 5.8 rads or better	A1
		(3)
3(c)	$\mathbf{v} = (14\mathbf{i}-5\mathbf{j})+(-4\mathbf{i}+\mathbf{j})T$ (allow t) **OR** $\mathbf{v} = (6\mathbf{i}-3\mathbf{j})+(-4\mathbf{i}+\mathbf{j})t$ ($t = T-2$)	M1
	$\frac{14-4T}{-5+T} = \frac{2}{-3}$	M1 A1
	$T = 3.2$	A1
		(4)
(10)		
	NOTES	
	Accept the use of column vectors throughout	
(a) **M1** **M1** **A1**	Correct use of $t = 2$ to find the velocity (unsimplified). Use of Pythagoras to find the speed when $t = 2$ with <u>their</u> velocity. $\sqrt{45} = 3\sqrt{5} = 6.7(\text{ms}^{-1})$ or better (6.70820…). Must come from correct velocity.	
(b) **M1** **A1ft** **A1**	Use trig to find an equation in a relevant angle e.g. $(90°-\theta)$ for their *velocity*. Correct equation for a relevant angle, ft on their **v** Cao. No isw (A0 for a negative answer)	

(c) **M1** **M1** **A1** **A1**	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}T$ to obtain a velocity vector in T (allow t) Use ratios, using *their* **velocity**, to produce an equation in T only (Allow reciprocal and incorrect sign) Correct equation in T only Cao **N.B.** If they use their answer to (a) instead of $\mathbf{u} = (14\mathbf{i} - 5\mathbf{j})$ but never correct their value of t, can score M1M1A0A0 **N.B.** If they use $\mathbf{v} = k(2\mathbf{i} - 3\mathbf{j})$ to produce 2 simultaneous equations in k and T, and then they use a calculator to solve and get T =3.2, award all the marks, but if they get the wrong answer, they lose the last 3 marks.	

Question Number	Scheme	Marks
7. (a)	$\tan\theta = \frac{9}{13}$ $\theta = 34.7°$	M1 A1 A1 (3)
(b)	$a(2\mathbf{i}-\mathbf{j})+b(\mathbf{i}+3\mathbf{j})=(9\mathbf{i}+13\mathbf{j})$ $2a+b=9$ $-a+3b=13$ $a=2,\ b=5$ $\mathbf{P}=(4\mathbf{i}-2\mathbf{j})\text{N};\ \mathbf{Q}=(5\mathbf{i}+15\mathbf{j})\text{N}$	M1 A2 M1 M1 A1 A1 A1 A1 (9) **12**

Notes	
7. (a)	M1 for $\tan\theta = 9/13$ or $13/9$ First A1 for a correct equation (allowing for a correct adjustment to their angle in the subsequent working) Second A1 for $\theta = 35°$ or better or $325°$ or better
(b)	First M1 for $\mathbf{P}+\mathbf{Q} = 9\mathbf{i} + 13\mathbf{j}$ or $\mathbf{P}+\mathbf{Q}=\mathbf{F}$ (can occur anywhere) First A2; Treat as B1 for $a(2\mathbf{i}-\mathbf{j})$ seen or implied; B1 for $b(\mathbf{i}+3\mathbf{j})$ seen or implied. If they use the same a and b, they lose one of the B marks. Second M1 for equating their **i**- cpts *and* their **j**- cpts to produce two equations in two unknowns Third independent M1 for eliminating one unknown from 2 simultaneous equations Third A1 for $a = 2$ oe Fourth A1 for $b = 5$ oe Fifth A1 for $\mathbf{P}=(4\mathbf{i}-2\mathbf{j})$ (N) Sixth A1 for $\mathbf{Q}=(5\mathbf{i}+15\mathbf{j})$ (N) N.B. Can score all the marks if they 'spot' the answers.

			Allow use of column vectors apart from in given answer.
Q	Scheme	Marks	Notes
3a	Use of $\mathbf{v}=\frac{\mathbf{r}-\mathbf{r}_0}{2}$ to find $\mathbf{v}$	M1	Or equivalent, allow difference reversed. Allow 120 min
	$\mathbf{v}=\frac{1}{2}\left((55\mathbf{i}+34\mathbf{j})-(25\mathbf{i}+10\mathbf{j})\right)$ $(=15\mathbf{i}+12\mathbf{j})$	A1	Correct unsimplified expression for $\mathbf{v}$
	$\mathbf{r}_A=25\mathbf{i}+10\mathbf{j}+t(15\mathbf{i}+12\mathbf{j})$	M1	With the correct structure Possible use of $\mathbf{r}_A=(55\mathbf{i}+34\mathbf{j})+(t-2)(15\mathbf{i}+12\mathbf{j})$.
	$(\mathbf{r}_A=)\ (25+15t)\mathbf{i}+(10+12t)\mathbf{j}$ *	A1*	We are looking for the RHS **only** to be correct. Allow order of terms to be reversed in the brackets. **N.B** Use of i's and j's in columns i.e. poor notation, can score Max M1A1M1A0*
		[4]	
3b	$\sqrt{12^2+15^2}$	M1	Correct use of Pythagoras for their $\mathbf{v}$
	$\sqrt{12^2+15^2}\times\frac{1000}{3600}=\frac{5\sqrt{369}}{18}=\frac{5\sqrt{41}}{6}$	A1	5.3 or better (5.3359……)
		[2]	
3c	Position of B at $t=1.5$ (allow t = 1.30)	M1	Correct use of position and direction vectors with correct structure.
	$\mathbf{r}_B=(35\mathbf{i}+51\mathbf{j})+1.5(20\mathbf{i}-6\mathbf{j})$	A1	Correct unsimplified
	$\Rightarrow\begin{pmatrix}65\\42\end{pmatrix}=\begin{pmatrix}25+15t\\10+12t\end{pmatrix}$ oe	M1	Use $\mathbf{r}_P=\mathbf{r}_A$ and use one component to solve for t **N.B.** If they use $\frac{65}{42}=\frac{25+15t}{10+12t}$ oe and solve for t, it's M0 unless they go on and substitute $t=\frac{8}{3}$ into $\mathbf{r}_A$ and obtain $65\mathbf{i}+42\mathbf{j}$, in which case it is M1A1, and could earn the final A1* with a correct conclusion.
	Obtain $t=\frac{8}{3}$ for one component	A1	**N.B.** Allow $t=2.7$ or better for A1 but not for the second A1* but allow 2.6 recurring for both A marks.

	Obtain $t=\frac{8}{3}$ for both components and hence confirm A passes through P **OR** sub $t=\frac{8}{3}$ into $\mathbf{r}_A$ and obtain $65\mathbf{i}+42\mathbf{j}$ and hence confirm A passes through P	A1*	Obtain given result from correct work. **N.B** Use of i's and j's in columns i.e. poor notation, can score Max M1A1M1A1A0* but only penalise ONCE for the whole question.
		[5]	
		(11)	

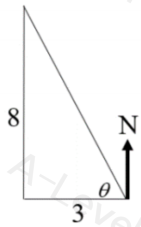
Question Number	Scheme	Marks
7.(i)	$P^2 = 8^2 + 6^2 - 2\times 8\times 6\cos 60^O$	M1A1
	$P = \sqrt{52} = 7.2$ (N) or better	A1
(ii)	$\frac{\sin\alpha}{6} = \frac{\sin 60^O}{\sqrt{52}}$ or $\frac{\sin\beta}{8} = \frac{\sin 60^O}{\sqrt{52}}$ $6^2 = 8^2 + P^2 - 2\times 8\times P\cos\alpha$ or $8^2 = 6^2 + P^2 - 2\times 6\times P\cos\beta$	M1A1 **ft**
	$\alpha = 46.(1..)^o$ $\beta = 73.(897..)$ or $106.(103..)$	A1
	Bearing is 74° to nearest degree	A1 cso
		(7)
	Alternative using column vectors	
(i)	$P^2 = (8\cos 30^0)^2 + (6 - 8\sin 30^0)^2$	M1A1
	$P = \sqrt{52} = 7.2$ (N) or better	A1
(ii)	$\tan\beta = \frac{8\cos 30^0}{6 - 8\sin 30^0}$ or $\sin\beta = \frac{8\cos 30^0}{\sqrt{52}}$ or $\cos\beta = \frac{6 - 8\sin 30^0}{\sqrt{52}}$ or equivalents for $(90^0 - \beta)$	M1A1 **ft**
	$\beta = 73.(897..)^o$ or $(90^0 - \beta) = 16.103\ldots$	A1
	Bearing is 74° to nearest degree	A1
	N.B. If 4 is consistently used instead of 8, max marks are:	
	(i) M1A0A0 (ii) M1A1ftA0A0 i.e. 3/7	
	Notes for qu 7	
7(i)	First M1 for use of the cosine rule (with P, 6, 8 and 60° or their α or (120° – their α).	
	First A1 for a correct equation	
	Second A1 for a correct magnitude	
(ii)	Second M1 for a complete method to find a relevant angle – must be using their P, 60° (or 120°) and either 6 or 8 if using the sine rule or their P, 6, and 8 if using the cosine rule.	
	Third A1 ft for a correct equation, ft on their P	
	Fourth A1 for at least one correct angle, accurate to nearest degree	
	Fifth A1 cso for a correct bearing to nearest degree	
	Alternative using column vectors	
(i)	First M1 for use of Pythagoras with correct structure allowing for sin/cos confusion and sign errors	
	First A1 for a correct equation	
	Second A1 for a correct magnitude	
(ii)	Second M1 for a complete method to find a relevant angle – must be using their P components with correct structure allowing for cos/sin confusion and sign errors	

Question Number	Scheme	Marks
	Third A1 ft for a correct equation, ft on their *P* components	
	Fourth A1 for at least one correct angle, accurate to nearest degree	
	Fifth A1 cso for a correct bearing to nearest degree	

Question Number	Scheme	Marks	Notes
5a	Correct equation for $\mathbf{v}_P$ or find displacement	M1	Use of $\mathbf{r}_P = \mathbf{r}_0 + \mathbf{v}_P t$ to find $\mathbf{v}$. Allow for $\lambda(-\mathbf{i}-5\mathbf{j})$
	$\mathbf{v}_P = 3(6\mathbf{i}-(7\mathbf{i}+5\mathbf{j})) = -3\mathbf{i}-15\mathbf{j}$	A1	
	$\sqrt{(-3)^2+(-15)^2}$	M1	Use of Pythagoras to find magnitude of their $\mathbf{v}$
	$= \sqrt{234} = 15.3\ (\text{km h}^{-1})$ (or better)	A1	CSO $(3\sqrt{26})$ A0 if it comes from $3\mathbf{i}+15\mathbf{j}$
			NB Could score the M marks in reverse order - find displacement in 20 minutes and then multiply by 3
		(4)	
5b	Use of $\mathbf{r}_P = \mathbf{r}_0 + \mathbf{v}_P t$: $\mathbf{r}_P = 7\mathbf{i}+5\mathbf{j}+t(-3\mathbf{i}-15\mathbf{j})$	M1	For their $\mathbf{v}_P$
	$\Rightarrow \mathbf{r}_P = (7-3t)\mathbf{i}+(5-15t)\mathbf{j}$	A1	Obtain **given answer** from correct working
		(2)	
5c	$\frac{(7-3t)}{(5-15t)} = \frac{16}{5}$	M1	Use given answer and direction to form equation in t
		A1	Correct unsimplified equation
	$35-15t = 80-240t$	DM1	Solve for t. Dependent on the previous M1
	$t = 0.2$	A1	
		(4)	
5d	P and Q in the same place at the same time	M1	Equate $\mathbf{i}$ or $\mathbf{j}$ components of position vectors and solve for t
	$\Rightarrow\ 7-3t = 5+2t$ or $5-15t = -3+5t$	A1	Either
	$t = 0.4$	A1	
	Check that the same value of t gives equal values for the other component	DM1	Dependent on the previous M mark
	$\mathbf{r} = (5.8\mathbf{i}-\mathbf{j})$ km	A1	Must be a vector
		(5)	
		[15]	

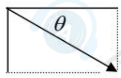
Question Number	Scheme	Marks	Notes
1.	$(2\mathbf{i}+3a\mathbf{j})+(2a\mathbf{i}+b\mathbf{j})+(b\mathbf{i}+4\mathbf{j}) = \mathbf{0}$	M1	Use of resultant force = 0 (Seen or implied)
	$2a+b+2=0;\ 3a+b+4=0$	M1	In an equation involving all three forces once and once only, compare $\mathbf{i}$ or $\mathbf{j}$ components to form an equation in a and b. Allow with $\mathbf{i}$ or $\mathbf{j}$. $\lambda\mathbf{i} = \mu\mathbf{j}$ is M0
		A1	Two correct scalar equations. No i/j
	$a=-2; b=2$	DM1	Solve simultaneous equations to find a or b. Dependent on the previous M1
		A1	a correct
		A1	b correct
		6	
2(a)	$2mu - km3u = -2m\frac{1}{2}u + kmv$	M1	Conservation of momentum. Must have all four terms but condone sign errors and consistent omission of m or g included in all terms
	$(3u = kv + 3ku)$	A2,1,0	-1 for each error. All correct A1A1, one error A1A0, two or more errors A0A0
	$v = (1-k)\frac{3u}{k}$ or $k = \frac{3u}{v+3u}$	A1	Correct expression for v or for kv or for k
	$v > 0 \Rightarrow$	M1	Correct inequality for their v
	$\Rightarrow k < 1$ *	A1	Reach **given answer** correctly
		(6)	
(b)	$I = 2m(\frac{1}{2}u - -u)$	M1	Impulse = <u>change</u> in momentum for A or for B. Condone sign errors.
		A1	Correct unsimplified expression in terms of m and u. Allow +/-
	$= 3mu$	A1	Correct answer only.
		(3)	
		9	

QUESTION NUMBER	SCHEME	MARKS
6(a)	$\dfrac{(20\mathbf{i}+34\mathbf{j})-(15\mathbf{i}+36\mathbf{j})}{0.5}$ oe	M1
	$(10\mathbf{i}-4\mathbf{j})$ *	A1*
		(2)
6(b)	$(15\mathbf{i}+36\mathbf{j})+t(10\mathbf{i}-4\mathbf{j})$	M1 A1
		(2)
6(c)(i)	Verify using $t=1.5$ in **p or q** $\mathbf{p}=(15\mathbf{i}+36\mathbf{j})+1.5(10\mathbf{i}-4\mathbf{j})=30\mathbf{i}+30\mathbf{j}$ $\mathbf{q}=(42-8\times1.5)\mathbf{i}+(9+14\times1.5)\mathbf{j}=30\mathbf{i}+30\mathbf{j}$	M1 A1 A1
(ii)	$30\mathbf{i}+30\mathbf{j}$	A1 (B1)
	N.B. The A mark for (ii) is now to be treated as a B mark.	
		(4)
ALT1 (i)	Find t by equating **i or j** components of **p** and **q** Equate **i**'s $15+10t=42-8t \rightarrow t=1.5$ **j**'s $36-4t=9+14t \rightarrow t=1.5$	M1 A1 A1
(ii)	$30\mathbf{i}+30\mathbf{j}$	A1 (B1)
ALT2 (i)	Uses ratio: $\dfrac{15+10t}{36-4t}=\dfrac{42-8t}{9+14t}$ $\rightarrow t=1.5$ or -8.5 verifies that components are both 30 at $t=1.5$	M1 A1 A1
(ii)	$30\mathbf{i}+30\mathbf{j}$	A1 (B1)
		(4)
6(d)	Position of P at 14:30 is $40\mathbf{i}+26\mathbf{j}$	B1
	Position of Q when $t=0.5$ $\mathbf{q}=(42-8\times0.5)\mathbf{i}+(9+14\times0.5)\mathbf{j}$ $(=(38\mathbf{i}+16\mathbf{j}))$	M1
	$15\mathbf{j}$ seen or implied	B1
	New position of Q at time 14:30 $\mathbf{q}=(38\mathbf{i}+16\mathbf{j})+2(15\mathbf{j})$ **N.B.** M0 if 2.5 is used.	M1
	$\mathbf{q}=38\mathbf{i}+46\mathbf{j}$	A1
	$\lvert PQ\rvert=\sqrt{(40-38)^2+(26-46)^2}$	dM1
	$=\sqrt{404}$ or $2\sqrt{101}$ (km)	A1
		(7)
		(15)

QUESTION NUMBER	SCHEME	MARKS
4(a)	$(5\mathbf{i}-8\mathbf{j})+5(-\lambda\mathbf{i}+2\lambda\mathbf{j})$ (m s^{-1}) isw	M1 A1
		(2)
4(b)	$13=\sqrt{(5-5\lambda)^2+(-8+10\lambda)^2}$	M1 A1
	$169=25-50\lambda+25\lambda^2+64-160\lambda+100\lambda^2$	
	$25\lambda^2-42\lambda-16=0$ *	A1* cso
		(3)
4(c)	$(-2\mathbf{i}+4\mathbf{j})$ seen or implied	B1
	$(5\mathbf{i}-8\mathbf{j})+(-2\mathbf{i}+4\mathbf{j})4$	M1A1
	 e.g. $\tan^{-1}\left(\pm\frac{8}{3}\right)$, $\tan^{-1}\left(\pm\frac{3}{8}\right)$, $\sin^{-1}\left(\pm\frac{8}{\sqrt{73}}\right)$,...	M1
	339°	A1
		(5)
		(10)
	Notes for question 4	
(a) **M1** **A1** **(b)** **M1** **A1** **A1*** **(c)** **B1** **M1** **A1** **M1** **A1**	 Use of **v**=**u**+**a***t* to form a vector expression in λ and t Correct unsimplified expression with $t=5$ **N.B.** Allow use of column vectors for the M mark but not for the A mark. Collect **i**'s and **j**'s and correct use of Pythagoras to form an equation in λ Correct equation cso. Expand brackets and correctly reach the GIVEN answer. **N.B.** Allow $0=25\lambda^2-42\lambda-16$ Or column vector Complete method to find the velocity when $t=4$. Correct unsimplified expression. Note the correct velocity is $\mathbf{v}=-3\mathbf{i}+8\mathbf{j}$ Use **their** velocity vector **at *t* = 4** with trig to find a relevant angle. Cao. Degrees sign not required. **N.B.** if they work with both values of λ, can score max all the marks except the last one.	

Question Number	Scheme	Marks
	N.B. Answers to (a) and (b) should be in terms of **i** and **j**, but only penalise once. Column vectors can be used in working.	
7(a)	$\mathbf{v}_B = (20\sin\alpha)\mathbf{i} + (20\cos\alpha)\mathbf{j}$ oe e.g. use of Pythagoras but must get to an answer	M1
	$= 16\mathbf{i} + 12\mathbf{j}$ (km h^{-1})	A1 (2)
7(b)	$(\mathbf{s} =)\ (10\mathbf{i} + 5\mathbf{j}) + t(16\mathbf{i} + 12\mathbf{j})$ or $(10 + 16t)\mathbf{i} + (5 + 12t)\mathbf{j}$	M1 A1 **ft** (2)
7(c)	$\overrightarrow{AB} = \mathbf{s} - \mathbf{r} = (10\mathbf{i} + 5\mathbf{j}) + t(16\mathbf{i} + 12\mathbf{j}) - [20\mathbf{j} + 40t\mathbf{i}]$	M1
	$\overrightarrow{AB} = [(10 - 24t)\mathbf{i} + (12t - 15)\mathbf{j}]$ km *	A1* (2)
7(d)	$10 - 24t = 0$ and $12t - 15 = 0$ **OR** $40t = 10 + 16t$ and $20 = 5 + 12t$	M1
	$t = \frac{5}{12}$ and $\frac{5}{4}$ or one correct t value which is then used in the other equation **correctly** to show that the equation is not true.	A1
	Different *t* values oe so never collide*	A1* (3)
	ALT 1:	
	$(10 - 24t)^2 + (12t - 15)^2 = 0$ (i.e. $720t^2 - 840t + 325 = 0$) M1	
	$(-840)^2 - 4 \times 720 \times 325$ $(= -230,400)$ < 0 A1 Or roots $\frac{7 \pm 4i}{12}$ (calculator)	
	No real roots oe so never collide* A1* **N.B.** Must see justification for 'no real roots' to score either of the A marks.	
	ALT 2:	
	Finds minimum value of $720t^2 - 840t + 325$ or its square root using derivative or completing the square or calculator M1	
	80 or $\sqrt{80}$ or $\overrightarrow{AB} = -4\mathbf{i} - 8\mathbf{j}$ (at $t = \frac{7}{12}$) A1	
	so never collide* A1*	
7(e)	$10 - 24t = 12t - 15$ oe	M1
	$t = \frac{25}{36}$ or 0.69 or better	A1
	$\overrightarrow{AB} = \left[(10 - 24 \times \frac{25}{36})\mathbf{i} + (12 \times \frac{25}{36} - 15)\mathbf{j}\right]$ (km)	M1
	$AB = 20\frac{\sqrt{2}}{3}$, 9.4 or better (km)	A1 (4)
		(13)

	Notes	
7(a)	M1: Condone sign errors and sin/cos confusion but both components must be resolved. Allow if they use $\cos(\frac{3}{5})$ or similar. If $12\mathbf{i}+16\mathbf{j}$ appears without working, award M1A0.	
	A1: cao	
7(b)	M1: Correct structure, condone slips	
	A1**ft**: ft on their answer to (a)	
7(c)	M1: Allow $\mathbf{r}-\mathbf{s}$. **r** and **s** must be substituted.	
	A1*: Correct given answer, correctly obtained **N.B.** Need to see $\overrightarrow{AB}$ at the start or finish for the A1* and answer must be **exactly** as printed, ignoring [] and km.	
7(d)	M1: They may use $\mathbf{r}=\mathbf{s}$ with both **i** and **j** cpts equated.	
	A1: Need both t values. Accept 0.42 or better and 1.25.	
	A1*: Correct conclusion	
7(e)	M1: Correct method	
	A1: cao	
	M1: Sub their calculated t value into $\overrightarrow{AB}$ or $\overrightarrow{BA}$, seen or implied, oe. Note that this is an independent M mark.	
	A1: cao	

Question Number	Scheme	Marks	Notes
5 (a)	Speed = $\sqrt{3^2+(-2)^2}$ or $\sqrt{3^2+2^2}$ $=\sqrt{13}\text{ m s}^{-1}$	M1 A1(2)	Use Pythagoras Accept 3.6 or better Ignore their diagram if it does not support their working
(b)			
	$\tan\theta=\frac{2}{3}$, $\theta=33.7$ OR $\tan\theta=\frac{3}{2}$, $\theta=56.3$	M1	Find a relevant angle
	OR find another useful angle	A1	Their angle correct (seen or implied)
	Bearing = 124	A1 (3)	Correct bearing. Accept 124° or awrt 124/124° Accept N 124 E or S 56 E
(c)	$\mathbf{r}_B=10\mathbf{j}+t(3\mathbf{i}-2\mathbf{j})$	M1 A1	Find the position vector of *B* or *G* at time *t* Correct for *B*
	$\mathbf{r}_G=4\mathbf{i}-2\mathbf{j}+t\left(\frac{5}{3}\mathbf{i}+2\mathbf{j}\right)$	A1	Correct for *G*
	$3t=4+\frac{5}{3}t$ OR $10-2t=-2+2t$	DM1	Compare coefficients of **i** or of **j** to form an equation in *t*.
	(i) $t=3$ s	A1	Correct unambiguous conclusion.
	(ii) $\mathbf{r}=10\mathbf{j}+3(3\mathbf{i}-2\mathbf{j})=(9\mathbf{i}+4\mathbf{j})$ m		
	OR $\mathbf{r}=4\mathbf{i}-2\mathbf{j}+3\left(\frac{5}{3}\mathbf{i}+2\mathbf{j}\right)=(9\mathbf{i}+4\mathbf{j})\text{ m}$	A1 (6)	Final answer. Accept with no units. Do not ignore subsequent working.
		[11]	

	Allow column vectors throughout apart from in the answers to (b) and (c).		
7a	$\lvert\mathbf{a}\rvert = \sqrt{1^2+(-4)^2}$ or $\sqrt{1^2+4^2}$	M1	Complete method to find the magnitude using the correct vector or the correct vector with just a sign error. They may use $\mathbf{a} = \dfrac{\mathbf{v}_p - \mathbf{v}_q}{p-q}$ for two specific times p and q, allow subtraction either way round and slips in arithmetic
	$=\sqrt{17}$. Accept $4.1\left(\text{km h}^{-2}\right)$ or better	A1	$=4.123105\ldots\ \left(\text{km h}^{-2}\right)$ Must come from a correct **a** (if seen.)
		(2)	
7b	$\dfrac{(\mathbf{i}-5\mathbf{j})-(4\mathbf{i}+\mathbf{j})}{3}$	M1	Condone subtraction the wrong way round
	$=-\mathbf{i}-2\mathbf{j}\quad\left(\text{km h}^{-2}\right)$	A1	Must be in **i** and **j**
		(2)	
7c	$4\mathbf{i}+\mathbf{j}-2(-\mathbf{i}-2\mathbf{j})$ **OR** $\mathbf{i}-5\mathbf{j}-5(-\mathbf{i}-2\mathbf{j})$	M1	Or equivalent for their **a**
	$=6\mathbf{i}+5\mathbf{j}\quad\left(\text{km h}^{-1}\right)$	A1	Must be in **i** and **j**. Isw if they find the speed.
			N.B. In (b) and (c), penalise the use of column vectors in the answers ONCE.
		(2)	
7d	Express both velocities in component form, with **i**'s and **j**'s collected, using their answers to (b) and (c) for $\mathbf{v}_B$.	M1	$\mathbf{v}_A = (2+t)\mathbf{i}+(3-4t)\mathbf{j}$ $\mathbf{v}_B = (6-t)\mathbf{i}+(5-2t)\mathbf{j}$ Seen or implied. Allow slips. **N.B.** This mark can be earned in part (e).
	Correct use of Pythagoras to form an equation in T_1 (or t) only, with or without square roots.	M1	For given $\mathbf{v}_A$ and their $\mathbf{v}_B$
	$(6-T_1)^2+(5-2T_1)^2=(2+T_1)^2+(3-4T_1)^2$ $\left(T_1^2+T_1-4=0\right)$	A1ft	Correct unsimplified equation in T_1 (or t), without square roots. Follow their answers from (b) and (c)
	$\dfrac{-1+\sqrt{17}}{2}$ only	A1	cao accept exact equivalent
		(4)	
7e	Use ratios to form an equation in T_2 (or t) only	M1	Allow reciprocal on one side **N.B.** Allow if **i**'s and **j**'s are left in

	$\Rightarrow \frac{5-2T_2}{6-T_2} = \frac{3-4T_2}{2+T_2}$ (allow t at this stage)	A1**ft**	Or equivalent ft on their $\mathbf{v}_B$
	$\Rightarrow 3T_2^2 - 14T_2 + 4 = 0$ *	A1*	Obtain **correct answer** from full and correct working with no errors. Must see at least $10 + 5T_2 - 4T_2 - 2T_2^2 = 18 - 24T_2 - 3T_2 + 4T_2^2$ **OR** $10 + T_2 - 2T_2^2 = 18 - 27T_2 + 4T_2^2$ (Allow t at this stage but must be T_2 in final answer) $\Rightarrow 3T_2^2 - 14T_2 + 4 = 0$ *
		(3)	
		(13)	