3.(a)	$\tan\alpha = 1/3 \Rightarrow \alpha = 18.4^{o}$	M1 A1
	Bearing is 288° (nearest degree)	A1 (3)
(b)	$\mathbf{r} = (21\mathbf{i} + 5\mathbf{j}) + t(-6\mathbf{i} + 2\mathbf{j})$	B1 (1)
(c)	$21 - 6t = -(5 + 2t)$	M1 A1
	$t = 6.5$	A1 (3)
		7

NOTES

Question 3(a)

First M1 for $\arctan(\frac{\pm 2}{\pm 6})$

First A1 for a correct value from their expression, usually 18.4^{o} or 71.6^{o}

Second A1 for 288 (nearest degree)

Question 3(b)

B1 for $(21\mathbf{i} + 5\mathbf{j}) + t(-6\mathbf{i} + 2\mathbf{j})$

Question 3(c)

M1 for equating the negative of their **i**-component to their **j**-component oe

Allow equating the components for the M mark.

First A1 for a correct equation.

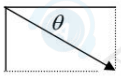
Second A1 for $t = 6.5$

Question Number	Scheme	Marks
4.(a)	$\mathbf{p} = (-5\mathbf{i} + 9\mathbf{j}) + t(\mathbf{i} - 2\mathbf{j})$	M1 A1 (2)
(b)	$2 = 9 - 2t$ $t = 3.5$ $\mathbf{p} = (-5\mathbf{i} + 9\mathbf{j}) + 3.5(\mathbf{i} - 2\mathbf{j}) = (-1.5\mathbf{i} + 2\mathbf{j})$	M1 A1 M1 A1 (4)
(c)	$\frac{2b-1}{5-2b} = \frac{1}{-2}$ $b = -1.5$	M1 A1 **DM1** A1 (4) **10**
	Notes	
4.(a)	M1 for clear attempt at $\mathbf{p} = (-5\mathbf{i} + 9\mathbf{j}) + t(\mathbf{i} - 2\mathbf{j})$ (allow slips but must be ' + ') A1 if correct	
(b)	First M1 for equating the **j** *component* of their **p** to 2 First A1 for $t = 3.5$ Second M1 (independent) for substituting their t value into their **p** Second A1 for $(-1.5\mathbf{i} + 2\mathbf{j})$	
(c)	First M1 for $\frac{2b-1}{5-2b} = \pm\frac{1}{2}$ or $\frac{2b-1}{5-2b} = \pm\frac{2}{1}$ (must be in b only but allow slips) First A1 for a correct equation in b only Second M1 (dependent on first M1) for solving for b Second A1 for $b = -1.5$	

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)	(**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	
	$(-840)^2 - 4\times720\times325$ $(= -230,400)$ < 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 $\mathbf{r}-\mathbf{s}$. $\mathbf{r}$ and $\mathbf{s}$ 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
6a	Resultant force $=(2\mathbf{i}+3\mathbf{j})+(4\mathbf{i}-5\mathbf{j})=6\mathbf{i}-2\mathbf{j}$ (N)	M1
	Use of $\mathbf{F}=m\mathbf{a}$: $6\mathbf{i}-2\mathbf{j}=2\mathbf{a}$, $\mathbf{a}=3\mathbf{i}-\mathbf{j}$	M1
	Magnitude: $\lvert a\rvert=\sqrt{3^2+1^2}=\sqrt{10}\,(=3.2 \text{ or better})$ (ms^{-2})	M1A1
		(4)
6b	$(10\mathbf{i}+2\mathbf{j})=(-u\mathbf{i}+u\mathbf{j})+T(3\mathbf{i}-\mathbf{j})$	M1
	$10=-u+3T$ and $2=u-T$	**DM**1A1**ft**
	$T=6$	A1
	(i) $u=8$	A1
	(ii)	(5)
		[9]
	Notes for question 6	
6a	First M1 for adding forces – must collect **i**'s and **j**'s	
	Second M1 for use of $\mathbf{F}=m\mathbf{a}$ or $F=ma$	
	Third M1 for finding a magnitude	
	A1 for $\sqrt{10}\,(=3.2 \text{ or better})$	
6b	First M1 for use of $\mathbf{v}=\mathbf{u}+\mathbf{a}t$ with their **a** (M0 if clearly using **F** instead of **a**)	
	Second **DM**1, dependent on previous M, for equating cpts of **i** and **j**	
	First A1**ft** for two correct equations following their **a**	
	Second A1 for $T=6$	
	Third A1 for $u=8$	

Question Number	Scheme	Marks	Notes
5 (a)	Speed = $\sqrt{3^2+(-2)^2}$ or $\sqrt{3^2+2^2}$ $=\sqrt{13}$ 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 $\mathbf{r}=4\mathbf{i}-2\mathbf{j}+3\left(\frac{5}{3}\mathbf{i}+2\mathbf{j}\right)=(9\mathbf{i}+4\mathbf{j})$ m	A1 (6)	Final answer. Accept with no units. Do not ignore subsequent working.
		[11]	