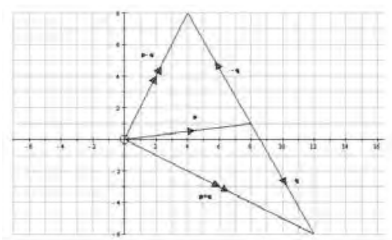
		mark		**Sub**
1(i)	**R** + $\begin{pmatrix}-3\\4\end{pmatrix}+\begin{pmatrix}21\\-7\end{pmatrix}=\begin{pmatrix}0\\0\end{pmatrix}$	M1	Sum to zero	
	R = $\begin{pmatrix}-18\\3\end{pmatrix}$	A1	Award if seen here or in (ii) or used in (ii).	
			[SC1for $\begin{pmatrix}18\\-3\end{pmatrix}$]	2
(ii)	$\mid \mathbf{R} \mid = \sqrt{18^2+3^2}$	M1	Use of Pythagoras	
	= 18.248… so 18.2 N (3 s. f.)	A1	Any reasonable accuracy. FT **R** (with 2 non-zero cpts)	
	angle is $180-\arctan\left(\frac{3}{18}\right)$ = 170.53…°	M1	Allow arctan $\left(\frac{\pm 3}{\pm 18}\right)$ or arctan $\left(\frac{\pm 18}{\pm 3}\right)$	
	so 171° (3 s. f.)	A1	Any reasonable accuracy. FT **R** provided their angle is obtuse but not 180°	4
	total	6		

		mark		**Sub**
2(i)	$x = 2 \Rightarrow t = 4$ $t = 4 \Rightarrow y = 16 - 1 = 15$	B1 F1	cao FT **their** *t* and *y*. Accept 15 **j**	2
(ii)	$x = \frac{1}{2}t$ and $y = t^2 - 1$ Eliminating *t* gives $y = \left((2x)^2 - 1\right) = 4x^2 - 1$	M1 E1	Attempt at elimination of expressions for *x* and *y* in terms of *t* Accept seeing $(2x)^2\text{-}1 = 4x^2 - 1$	2
(iii)	**either** We require $\frac{\mathrm{d}y}{\mathrm{d}x} = 1$ so $8x = 1$ $x = \frac{1}{8}$ and the point is $\left(\frac{1}{8}, -\frac{15}{16}\right)$ **or** Differentiate to find **v** equate **i** and **j** cpts so $t = \frac{1}{4}$ and the point is $\left(\frac{1}{8}, -\frac{15}{16}\right)$	 M1 B1 A1 M1 M1 A1	 This may be implied Differentiating correctly to obtain $8x$ Equating the **i** and **j** cpts of **their v**	3
	total	7		

3	(i)		$\lvert\mathbf{p}\rvert = \sqrt{8^2 + 1^2}$ $\lvert\mathbf{p}\rvert = \sqrt{65}$ $\lvert\mathbf{q}\rvert = \sqrt{4^2 + (-7)^2} = \sqrt{65}$ They are equal	M1 A1 A1 **[3]**	For applying Pythagoras theorem Condone no explicit statement that they are equal	
	(ii)		$\mathbf{p} + \mathbf{q} = 12\mathbf{i} - 6\mathbf{j}$ $\mathbf{p} + \mathbf{q} = 6(2\mathbf{i} - \mathbf{j})$ so $\mathbf{p} + \mathbf{q}$ is parallel to $2\mathbf{i} - \mathbf{j}$	M1 E1 **[2]**	Accept argument based on gradients being equal. “Parallel” may be implied	
	(iii)		 The angle is 90°	B1 B1 B1 **[3]**	One mark for each of $\mathbf{p} + \mathbf{q}$ and $\mathbf{p} - \mathbf{q}$ drawn correctly SC1 if arrows missing or incorrect from otherwise correct vectors Cao	

4 (i)	$\lvert\mathbf{F}\rvert = \sqrt{(-1)^2 + 5^2}$	M1	Accept $\sqrt{-1^2 + 5^2}$ even if taken to be $\sqrt{24}$	
	$= \sqrt{26} = 5.0990...$ = 5.10 (3 s. f.)	A1		
	Angle with **j** is $\arctan(0.2)$	M1	accept arctan(p) where $p = \pm 0.2$ or ± 5 o.e.	
	so 11.309… so 11.3° (3 s. f.)	A1	cao	4
(ii)	$\begin{pmatrix} -2 \\ 3b \end{pmatrix} = 4\begin{pmatrix} -1 \\ 5 \end{pmatrix} + \begin{pmatrix} 2a \\ a \end{pmatrix}$	M1	**H** = 4**F** + **G** soi	
		M1	Formulating at least 1 scalar equation from **their** vector equation soi	
	$a = 1$, $b = 7$	A1	a correct **or G** follows from their wrong a	
	so **G** = $\begin{pmatrix} 2 \\ 1 \end{pmatrix}$ and **H** = $\begin{pmatrix} -2 \\ 21 \end{pmatrix}$	A1	**H** cao	
	or **G** = 2 **i** + **j** and **H** = – 2 **i** + 21 **j**			4
				8

		Mark	Comment	Sub
5(i)	$\mathbf{F}+\begin{pmatrix}-4\\8\end{pmatrix}=6\begin{pmatrix}2\\3\end{pmatrix}$	M1	N2L. $F = ma$. All forces present	
		B1 B1	Addition to get resultant. May be implied. For $\mathbf{F} \pm\begin{pmatrix}-4\\8\end{pmatrix}=6\begin{pmatrix}2\\3\end{pmatrix}$.	
	$\mathbf{F}=\begin{pmatrix}16\\10\end{pmatrix}$	A1	SC4 for $\mathbf{F}=\begin{pmatrix}16\\10\end{pmatrix}$ WW. If magnitude is given, final mark is lost unless vector answer is clearly intended.	4
(ii)	$\arctan\left(\frac{16}{10}\right)$	M1	Accep equivalent and FT **their F** only. Do not accept wrong angle. Accept 360 - $\arctan\left(\frac{16}{10}\right)$	
	57.994… so 58.0° (3 s. f.)	A1	cao. Accept 302º (3 s f.)	2
		6		

6 (i)	$\begin{pmatrix}6\\9\end{pmatrix}=1.5\mathbf{a}$ giving $\mathbf{a}=\begin{pmatrix}4\\6\end{pmatrix}$ so $\begin{pmatrix}4\\6\end{pmatrix}$ m s $^{-2}$	M1 A1	Use of N2L with an attempt to find **a**. Condone spurious notation. Must be a vector in proper form. Penalise only once in paper.	2
(ii)	Angle is $\arctan\left(\frac{6}{4}\right)$ = 56.309… so 56.3° (3 s. f.)	M1 F1	Use of arctan with **their** $\frac{6}{4}$ or $\frac{4}{6}$ or equiv. May use **F**. FT **their a** provided both cpts are +ve and non-zero.	2
(iii)	Using $\mathbf{s}\ = t\mathbf{u}+0.5t^2\mathbf{a}$ we have $\mathbf{s}=2\begin{pmatrix}-2\\3\end{pmatrix}+0.5\times4\begin{pmatrix}4\\6\end{pmatrix}$ so $\begin{pmatrix}4\\18\end{pmatrix}$ m	M1 A1 A1 7	Appropriate single ***uvast*** (or equivalent sequence of ***uvast***). If integration used twice condone omission of **r**(0) but not **v**(0). FT **their a** only cao. isw for magnitude subsequently found. Vector must be in proper form (penalise only once in paper).	3

		mark		**Sub**
7(i)	$\lvert \mathbf{F} \rvert = 12.5$ so 12.5 N bearing is $90 - \arctan \frac{12}{3.5}$ = (0)16.260… so (0)16.3° (3 s. f.)	B1 M1 A1	 Use of arctan with 3.5 and 12 or equiv May be obtained directly as $\arctan \frac{3.5}{12}$	3
(ii)	24/7 = 12/3.5 or …. **G** = 2**F** so $\lvert \mathbf{G} \rvert = 2\lvert \mathbf{F} \rvert$	E1 B1	Accept **statement** following **G** = 2**F** shown. Accept equivalent in words.	2
(iii)	$\frac{9+12}{3.5} = \frac{-18+q}{12}$ so $q = 6 \times 12 + 18 = 90$	M1 A1	Or equivalent or in scalar equations. Accept $\frac{21}{q-18}$ or $\frac{q-18}{21}$ = tan (i) or tan(90 - (i)) Accep 90**j**	2
				7