Question Number	Scheme	Marks
	Third A1 for $\quad 4m(0.8u-2u)$ or $-4m(0.8u-2u)$ **OR** $\quad$ for $\quad m(0.8u+4u)$ or $-m(0.8u+4u)$ Fourth A1 for $4.8mu$ (must be positive since magnitude)	
4(i)	$$\left|\mathbf{F}_2\right|^2 = 8^2 + 14^2 - 2 \times 8 \times 14 \cos 30$$	M1 A1
	Solve for $\left|\mathbf{F}_2\right| = 8.1$ (N) or better	M1 A1 (4)
	OR: $\quad \begin{aligned} \left|\mathbf{F}_2\right|\cos\alpha &= 14\cos 30 - 8 \\ \left|\mathbf{F}_2\right|\sin\alpha &= 14\sin 30 \end{aligned}$	M1 A1
	Solve for $\left|\mathbf{F}_2\right| = 8.1$ (N) or better	M1 A1 (4)
4(ii)	$$\frac{\sin\theta}{8} = \frac{\sin 30}{8.12467} \quad \text{or} \quad \frac{\sin\phi}{14} = \frac{\sin 30}{8.12467}$$	M1 A1
	Solve: $\quad \theta = 29.49^o \quad$ or $\quad \phi = 120.51^o$	M1 A1
	Bearing is 149° (nearest degree)	A1 (5)
	OR: $\quad \begin{aligned} \left|\mathbf{F}_2\right|\cos\alpha &= 14\cos 30 - 8 = 4.124(355.) \\ \left|\mathbf{F}_2\right|\sin\alpha &= 14\sin 30 \end{aligned}$	M1 A1
	Solve: $\quad \alpha = 59.49^o$	M1 A1
	Bearing is 149° (nearest degree)	A1 (5)
	Notes	
4(i)	First M1 for use of cos rule with 30° First A1 for a correct equation **OR:** First M1 for 'resolving' in 2 directions with $30^o / 60^o$ (**N.B.** M0 here if cos/sin confused) First A1 for TWO correct equations Second M1 for solving for $\left|\mathbf{F}_2\right|$, <u>independent</u> *but* must be solving a 'correct cosine formula but with wrong angle' if using method 1 **OR** for eliminating α from two equations, <u>independent</u> *but* equations must have the correct structure if using method 2 Second A1 for 8.1 (N) or better	
4(ii)	First M1 for use of sin rule with 30° First A1 for a correct equation (<u>allow 8.12 or better</u>) **OR:** First M1 for 'resolving' in 2 directions with $30^o / 60^o$	

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Question Number	Scheme	Marks
	First A1 for TWO correct equations (<u>allow 4.12 or better</u>) Second M1, <u>independent,</u> for solving a 'correct sine formula' for θ or ϕ **OR** <u>independent</u> for solving two equations, with correct structure, for α Second A1 for $\theta =$ **AWRT** 29° or $\phi =$ **AWRT** 121° **OR** $\alpha =$ **AWRT** 59°	
	Third A1 for Bearing is 149° (nearest degree)	
	N.B. First M1A1 Could use cos rule to find an angle	
	N.B. If the resolving method is used and there are no (i) or (ii) labels, only award M1A1 in both cases when an answer is reached.	
5a	$0 = 14.7^2 - 2 \times 9.8h$	M1A1
	$h = 11.025$	A1
	$\text{max ht} = 13.5$ or 14 (m)	A1 (4)
5b	$-1.5 = 14.7t - 4.9t^2$	M1A1
	$4.9t^2 - 14.7t - 1.5 = 0$	
	$t = \dfrac{14.7 \pm \sqrt{14.7^2 + 6 \times 4.9}}{9.8}$	**DM**1
	$t = 3.1$ or 3.10 (s)	A1 (4)
5c	$v^2 = 14.7^2 + 2 \times (-9.8) \times (-2.5)$	M1 A1
	$v = 16.3$ or 16 (m s^{-1})	A1 (3)
		11
	Notes	
5a	**N.B.** If they use $g = 9.81$, lose first A mark (once for whole question) but all other A marks can be scored. First M1 for a complete method to find the height (Could involve two *suvat* equations) condone sign errors. First A1 for a correct equation (or equations) Second A1 for $h = 11$ (may be unsimplified) or better (For other methods, give this A1 for any correct (may be unsimplified) intermediate answer) Third A1 for 13.5 or 14 (m)	
5b	First M1 for a complete method to find the required time (they may find the time up (1.5 s) and then add on the time down. Condone sign errors First A1 for a correct equation or equations Second DM1, dependent, for solving to find required time Second A1 for 3.1 or 3.10 (s)	

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)	$\dfrac{\sin \alpha}{6} = \dfrac{\sin 60^o}{\sqrt{52}}$ or $\dfrac{\sin \beta}{8} = \dfrac{\sin 60^o}{\sqrt{52}}$ $6^2 = 8^2 + P^2 - 2 \times 8 \times P \cos \alpha$ 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)	$\tan \beta = \dfrac{8 \cos 30^0}{6 - 8 \sin 30^0}$ or $\sin \beta = \dfrac{8 \cos 30^0}{\sqrt{52}}$ or $\cos \beta = \dfrac{6 - 8 \sin 30^0}{\sqrt{52}}$ 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 $\alpha)$.	
	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
2(a)	$\mathbf{F_3} + (3c\mathbf{i} + 4c\mathbf{j}) + (-14\mathbf{i} + 7\mathbf{j}) = \mathbf{0}$ oe	M1
	$\mathbf{F_3} = (14 - 3c)\mathbf{i} + (-7 - 4c)\mathbf{j}$	A1
		(2)
2(b)	Resultant force $\mathbf{F_1} + \mathbf{F_2} = (6 - 14)\mathbf{i} + (8 + 7)\mathbf{j}$ $(= -8\mathbf{i} + 15\mathbf{j})$	M1
	 Find any relevant angle for **their (even if they've subtracted)** resultant (need not be acute nor positive)	M1
	any of $\tan^{-1}\left(\pm\frac{8}{15}\right), \tan^{-1}\left(\pm\frac{15}{8}\right), \sin^{-1}\left(\pm\frac{8}{17}\right), \cos^{-1}\left(\pm\frac{8}{17}\right), \dots$	A1ft
	$120°$ or better ($118.0724\dots$) **OR** $240°$ or better ($241.9276\dots$) In radians 2.1 or better ($2.0607\dots$) **OR** 4.2 or better ($4.2224\dots$)	A1
		(4)
2(c)	Use of Pythagoras on their resultant : $\sqrt{(-8)^2 + 15^2}$ **or** their acceleration: $\sqrt{\left(\frac{-8}{m}\right)^2 + \left(\frac{15}{m}\right)^2}$	M1
	Use of $\lvert$their $\mathbf{R}\rvert = 8.5m$ **or** their Resultant $= m\mathbf{a}$	M1
	A correct equation in m only eg $17 = m \times 8.5$	A1ft
	$m = 2$	A1
	N. B. $\sqrt{\left(\frac{-8}{8.5}\right)^2 + \left(\frac{15}{8.5}\right)^2}$ M1 $-8\mathbf{i} + 15\mathbf{j} = 8.5m$ M1 $\sqrt{\left(\frac{-8}{8.5}\right)^2 + \left(\frac{15}{8.5}\right)^2} = m$ A1ft $2 = m$ A1	
		(4)
		(10)
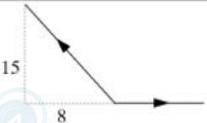
		Notes
		Accept column vectors throughout apart from answer for (a)
(a)		
	M1	Uses the vector **sum** of all 3 forces being equal to zero oe **N.B.** $\mathbf{F}_3 = \mathbf{F}_1 + \mathbf{F}_2$ is M0
	A1	cao Must be in terms of c, **i** and **j** but allow uncollected **i**'s and **j**'s and apply isw if necessary.
(b)		
	M1	Finds the resultant using $\mathbf{F}_1 + \mathbf{F}_2$ or $-$ their $\mathbf{F}_3$
	M1	Uses trig to find a relevant angle **for their resultant**
	A1ft	Any **correct** relevant angle (does not need to be acute), ft on their resultant
	A1	Cso.
(c)		
	M1	Use of Pythagoras to find the magnitude of their resultant force **or** their acceleration
	M1	Allow their $\mathbf{R} = 8.5\,m$
	A1ft	A correct scalar equation in m only eg $17 = m \times 8.5$, ft on their resultant
	A1	cso