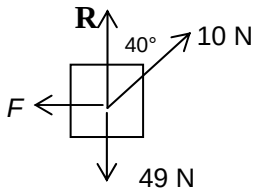
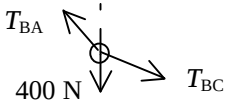
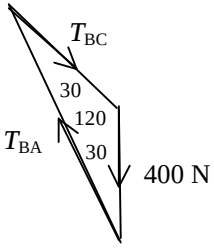
1		mark	notes
(i)	$\mathbf{F} = (10 - 8\cos 50)\mathbf{i} + 8\sin 50\mathbf{j}$ $= 4.85769\ldots\mathbf{i} + 6.128355\ldots\ \mathbf{j}$ so $4.86\mathbf{i} + 6.13\mathbf{j}$ (3 s. f.)	M1 A1 A1 3	Resolution. Accept $s \leftrightarrow c$. Condone resolution in only one direction. Award for a vector with either component correct or consistent $s \leftrightarrow c$ error is only mistake in the vector. Need not be evaluated. cao. Must be in $a\mathbf{i} + b\mathbf{j}$ or column format. Must be correct to 3 s. f.
(ii)	$\lvert\mathbf{F}\rvert = \sqrt{4.85769...^2 + 6.12835...^2} = 7.820101...$ so 7.82 (3 s. f.) angle is $\arctan\dfrac{4.857...}{6.128...}$ $= 38.40243\ldots$ so 38.4° (3 s. f.)	 B1 M1 F1 3	 FT **their F** Or equivalent. FT **their F.** Accept $\arctan\dfrac{6.128...}{4.857...}$. Accept complementary angle and ± signs FT only **their** *F*.
		6	

2		Mark	Comment	
(i)	Resultant is $\begin{pmatrix}4\\1\\2\end{pmatrix}+\begin{pmatrix}-6\\2\\4\end{pmatrix}=\begin{pmatrix}-2\\3\\6\end{pmatrix}$ Magnitude is $\sqrt{(-2)^2+3^2+6^2}=\sqrt{49}=7$ N	M1 A1 M1 F1	Adding the vectors. Condone spurious notation. Vector must be in proper form (penalise only once in the paper). Accept clear components. Pythagoras on **their** 3 component vector. Allow e.g. -2^2 for $(-2)^2$ even if evaluated as -4. FT **their** resultant.	4
(ii)	**F** + 2**G** + **H** = **0** So **H** = - 2**G** - **F** = $-\begin{pmatrix}-12\\4\\8\end{pmatrix}-\begin{pmatrix}4\\1\\2\end{pmatrix}$ = $\begin{pmatrix}8\\-5\\-10\end{pmatrix}$	M1 A1 A1	Either **F** + 2**G** + **H** = **0** or **F** + 2**G** = **H** Must see attempt at **H** = – 2 **G** – **F** cao. Vector must be in proper form (penalise only once in the paper).	3
		7		

3		mark		sub
(i)	$R = mg$ so 49 N	B1	Equating to weight. Accept $5g$ (but not mg)	1
(ii)		B1 B1	All except F correct (arrows and labels) (Accept mg, W etc and no angle). Accept cpts instead of 10N. No extra forces. F clearly marked and labelled	2
(iii)	↑ $R + 10\cos 40 - 49 = 0$ R = 41.339… so 41.3 N (3 s. f.) $F = 10\sin 40$ = 6.4278… so 6.43 N (3 s. f.)	M1 B1 A1 B1	Resolve vertically. All forces present and 10N resolved Resolution correct and seen in an equation. (Accept $R = \pm 10\cos 40$ as an equation) Allow –ve if consistent with the diagram.	4
				7

4		mark		sub
(i)	$\downarrow \quad 20+16\cos 60=28$	B1		1
(ii)	**either** $\rightarrow 16\sin 60$ Mag $\sqrt{28^2+192}=31.2409...$ so 31.2 N (3 s.f.) **or** Cos rule $\text{mag}^2=16^2+20^2-2\times16\times20\times\cos120$ 31.2 N (3 s. f.)	B1 M1 F1 M1 A1 A1	Any form. May be seen in (i). Accept any appropriate equivalent resolution. Use of Pythag with 2 distinct cpts (but not 16 and $\pm$ 20) Allow 34.788… only as FT Must be used with 20 N, 16 N and 60° or 120° Correct substitution	3
(iii)	Magnitude of accn is 15.620… m s^{-2} so 15.6 m s^{-2} (3 s. f.) angle with 20 N force is $\arctan\left(\frac{16\sin 60}{28}\right)$ so 26.3295… so 26.3° (3 s. f.)	B1 M1 A1	Award only for **their** $F\div2$ Or equiv. May use force or acceleration. Allow use of sine or cosine rules. FT only $s\leftrightarrow c$ and sign errors. Accept reciprocal of the fraction. cao	3
				7

5		mark		
(i)	$\begin{pmatrix} x \\ -7 \\ z \end{pmatrix} + \begin{pmatrix} 4 \\ y \\ -5 \end{pmatrix} + \begin{pmatrix} 5 \\ 4 \\ -7 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$ Equating components gives x = -9, y = 3, z = 12	M1 A1 A1 A1	[Allow SC 2/4 if 9, -3, -12 obtained]	4
(ii)	We need $\sqrt{5^2 + 4^2 + (-7)^2}$ = $\sqrt{90}$ or 9.48683… so 9.49 (3 s. f.)	M1 A1	Any reasonable accuracy	2
	total	6		

6		mark		
(i)		B1	Different labels. All forces present with arrows in correct directions. Condone no angles.	1
(ii)	Using triangle of forces  Triangle isosceles so tension in BC is 400 N Tension in BA is $2\times400\times\cos 30 = 400\sqrt{3}$ N (693 N, (3 s. f.))	M1 B1 A1 F1	Attempt at triangle of forces. Ignore angles and arrows. Accept 90, 60, 30 triangle. Triangle, arrows, labels and angles correct cao FT BC only [If resolution used, M1 for 1 equn; M1 for 2nd equn + attempt to elim; A1; F1. For M marks all forces present but allow $s \leftrightarrow c$ and sign errors. No extra forces. If Lami used: M1 first pair of equations in correct format, condone wrong angles. A1. M1 second pair in correct format, with **correct** angles.F1 FT their first answer if necessary.]	4
(iii)	Resolve at B perpendicular to the line ABC Weight has unbalanced component in this direction	E1 E1	Attempt to argue unbalanced force Complete, convincing argument. [**or** Resolve horiz and establish tensions equal E1 Resolve vert to show inconsistency. E1]	2
	total	7		