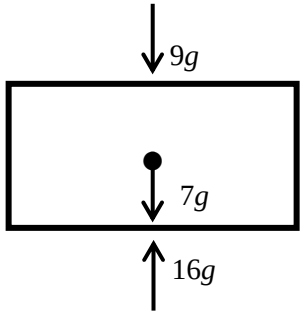
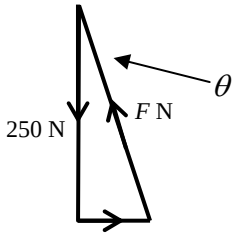
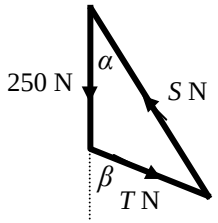
Question			Answer	Marks	Guidance	
1			$P = 8\sqrt{2}\sin 45° + 12\sin 30°$	**M1**	Considering equilibrium in the vertical direction	
				M1	Resolution of forces of 12 N and $8\sqrt{2}$ N in the vertical direction. Do not allow sin-cos interchange for the 30^o angle.	
			$P = 14$	**A1**	Dependent on both M marks	
			$Q + 8\sqrt{2}\cos 45° = 12\cos 30°$	**B1**		
			$Q = 2.39$	**B1** **[5]**		

Question			er	Marks	Guidance
2					One mark for each force with correct magnitude and direction Deduct 1 mark only for *g* missing
				B1	16g ↑
				B	7g ↓
				B	9g ↓
					If all three forces are correct but there is at least one extra force, deduct 1 mark and so give 2 marks. Otherwise ignore extra forces.
					Note For 16*g* ↑ 16*g* ↓ Award B1 B0 B0
				[3]	

Question			Answer	Marks	Guidance
3	(i)		 **Or equivalent**	B1 B1 B1 **[3]**	Shape of triangle; ignore position of θ if marked in diagram 2 marks -1 per error but penalise no arrows only once and penalise no labels only once. Condone *T* written for *F*. In the case of a force diagram showing F, 25 and 250 allow maximum of 2 marks with -1 per error but penalise no arrows only once and penalise no labels only once
	(ii)		$\tan\alpha = \frac{25}{250}$ 25 N $\Rightarrow \alpha = 5.7°$ $F = \sqrt{25^2 + 250^2}$ $F = 251.2$ Distance $= 30\tan\alpha = 30 \times 0.1 = 3$ m	M1 A1 M1 A1 B1 **[5]**	M1 for recognising and using α in the triangle Use of Pythagoras At least 3 significant figures required CAO
			Alternative $F\cos\theta = 250$ $F\sin\theta = 25$ $\tan\theta = \frac{25}{250}$ $\Rightarrow \theta = 5.7°$ $F\cos 5.7° = 250$ $F = 251.2$ Distance $= 30\tan\alpha = 30 \times 0.1 = 3$ m	 M1 A1 M1 A1 B1	 At least 3 significant figures required CAO

Question			Answer	Marks	Guidance
3	(iii)		Vertical equilibrium	M1	M1 for attempt at resolution in an equation involving both S and T; condone sin-cos errors for the M mark only
			$\uparrow \; S\cos\alpha \; = T\cos\beta + 250 \; \downarrow$	A1	
			Horizontal equilibrium $S\sin\alpha = T\sin\beta$	A1	
				[3]	
	(iv)		$S\sin 8.5° = T\sin 35° \Rightarrow S = 3.8805T$	M1	Using one equation to make S or T the subject in terms of the other
			$(3.8805T)\cos 8.5° = T\cos 35° + 250$	M1	Substituting in the other equation
			$T = 82.8$	A1	CAO
			$S = 321.4$	A1	CAO
				[4]	
			Alternative		**Use of linear simultaneous equations**
			$S\sin 8.5° - T\sin 35° = 0$ $S\cos 8.5° - T\cos 35° = 250$		
			$S\sin 8.5°\cos 35° - T\sin 35°\cos 35° = 0$ $S\cos 8.5°\sin 35° - T\cos 35°\sin 35° = 250\sin 35°$		
			$S(-\sin 8.5°\cos 35° + \cos 8.5°\sin 35°) = 250\sin 35°$	M1	Valid method that has eliminated terms in either S or T (execution need not be perfect)
			$S = 321.4$	A1	CAO First answer
			Substituting in either equation	M1	Substituting to find the second answer
			$\Rightarrow T = 82.8$	A1	CAO Second answer

Question			Answer	Marks	Guidance
3	(iv)		Alternative Triangle of forces		
				M1	Either Drawing and using a triangle of forces Or Quo ng and using Lami's Theorem
			$\frac{S}{\sin 145°} = \frac{T}{\sin 8.5°} = \frac{250}{\sin 26.5°}$	M1	Correct form of these equations
			$S = 321.4$	A1	C
			$T = 82.8$	A1	C

Question			Answer	Marks	Guidance
3	(v)		Abi's weight is $40g = 392$ N	M1	Consideration of Abi's weight
			When $\alpha = 60°$, $S\cos 60° > 250 \Rightarrow S > 500$	M1	Consideration of vertical forces on the object. Condone no mention of Bob's rope
			The tension in rope A would be greater than Abi's weight and so she would be lifted off the ground	A1	The argument must be of high quality and must include consideration of the tension in Bob's rope
				[3]	
			Alternative		
			If Abi is on the ground, the maximum possible tension in rope A is Abi's weight of 392 N	M1	Consideration of Abi's weight
			So the maximum upward force on the object is $392 \times \cos 60° = 192$ N		
			This is less than the weight of the object, and the tension in Bob's rope is pulling the box down.	M1	Consideration of vertical forces on the object. Condone no mention of Bob's rope Or the box accelerated downwards
			So Abi would be lifted off the ground	A1	The argument must be of high quality and must include consideration of the tension in Bob's rope

4		mark	Comment
(i)		B1 B1 2	Any one force in correct direction correctly labelled with arrow **or** all forces with correct directions and arrows. A force may be replaced by its components if labelled correctly eg *m*gcos20°, *m*gsin20°. All correct (Accept words for labels and weight as *W*, *mg*, 147 (N)) No extra or duplicate forces. Do not allow force **and** its components unless components are clearly distinguished, eg by broken lines.
(ii)	**Either** Up the plane $P\cos 20 - 15 \times 9.8 \times \sin 20 = 0$ $P = 53.50362\ldots$ so 53.5 (3 s. f.)	M1 A1 A1 3	Attempt to resolve at least one force up plane. Accept mass not weight. No extra forces. If other directions used, all forces must be present but see below for resolving vertically and horizontally. Accept only error as consistent $s \leftrightarrow c$. Cao
	Or Vertically and horizontally $R\cos 20° = 15g, \quad R\sin 20° = P$ Eliminate R $P = \dfrac{15g}{\cos 20°} \times \sin 20°$ $P = 53.5$ (3.s f.)	 M1 A1 A1 3	Attempt to resolve all forces both horizontally and vertically and attempt to combine into a single equation. No extra forces. Accept $s \leftrightarrow c$. Accept mass not weight. Accept only error as consistent $s \leftrightarrow c$. Cao
	Or Triangle of forces Triangle drawn and labelled $\dfrac{P}{15g} = \tan 20°$ $P = 53.5$ (3.s f.)	 M1 A1 A1 3	All sides must be labelled and in correct orientation; three forces only; condone no arrows Oe Cao
		5	

5		mark	notes
(i)	$v^2 = 0^2 + 2\times 9.8\times 0.75$	M1	Use of $v^2 = u^2 + 2as$ with u = 0 and $a = \pm g$. Accept muddled units and sign errors.
		A1	Allow wrong or wrongly converted units not sign errors
	$v = \pm 3.8340...$ so 3.83 m s^{-1} (3. s. f.)	A1	cao [SC2 for 38.3… seen WWW and SC3 for 3.83… seen WWW]
		3	
		3	

6				
(i)	$\rightarrow \quad 40 - P\cos 60 = 0$ $P = 80$	M1 A1 A1	For any resolution in an equation involving P. Allow for $P = 40\cos 60$ or $P = 40\cos 30$ or $P = 40\sin 60$ or $P = 40\sin 30$ Correct equation cao	3
(ii)	$\downarrow \quad Q + P\cos 30 = 120$ $Q = 40\left(3 - \sqrt{3}\right) = 50.7179\ldots$ so 50.7 (3 s. f.)	M1 A1	Resolve vert. All forces present. Allow $\sin \leftrightarrow \cos$ No extra forces. Allow wrong signs. cao	2
				5

7				
	Take F +ve up the plane $F + 40\cos 35 = 100\sin 35$ $F = 24.5915\ldots$ so 24.6 N (3 s. f.) up the plane	M1 B1 A1 A1	Resolve // plane (or horiz or vert). All forces present. At least one resolved. Allow $\sin \leftrightarrow \cos$ and sign errors. Allow $100g$ used. Either $\pm 40\cos 35$ or $\pm 100\sin 35$ or equivalent seen Accept $\pm 24.5915\ldots$ or $\pm 90.1237\ldots$ even if inconsistent or wrong signs used. 24.6 N up the plane (specified or from diagram) or equiv all obtained from consistent and correct working.	4
				4