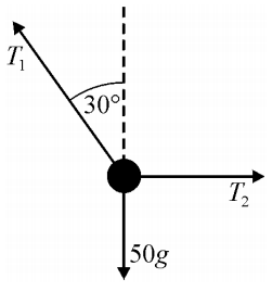
1 A load of mass 50 kg is supported, in equilibrium, by two ropes. One is at an angle of 30° to the vertical and the other is horizontal, as shown in the diagram. The tensions in these ropes are T_1 newtons and T_2 newtons respectively.



(a) Show that $T_1 = 566$, correct to 3 significant figures. *(3 marks)*

(b) Find T_2. *(4 marks)*

Question Number and part	Solution	Marks	Total Marks	Comments
1 (a)	$T_1 \cos 30° = 50 \times 9.8$	M1		Resolving vertically with 2 forces
		A1		Correct equation (allow $g = 10$)
	$T_1 = \dfrac{490}{\cos 30°} = 566$	A1	3	**ag** Correct value from correct working
(b)	$T_2 = T_1 \sin 30°$	M1 A1		Resolving horizontally with 2 forces oe Correct equation
	$= \dfrac{490}{\cos 30°} \sin 30°$	m1		Substituting for T_1 and solving for T_2
	$= 283$	A1	4	Correct value cao
	Total		**7**	

3 Two forces, $\mathbf{F}_1 = (3\mathbf{i} + 4\mathbf{j})$ N and $\mathbf{F}_2 = (6\mathbf{i} - 8\mathbf{j})$ N, act on a particle. The resultant of these two forces is **F**. The unit vectors **i** and **j** are perpendicular.

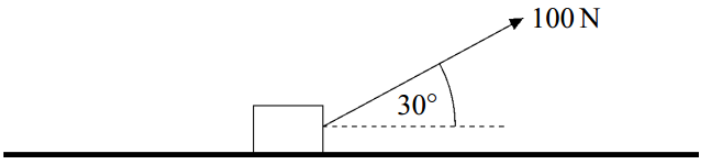
(a) Find **F**. *(2 marks)*

(b) Find the magnitude of **F**. *(2 marks)*

(c) Find the acute angle between **F** and the unit vector **i**. *(3 marks)*

Q	Solution	Marks	Total	Comments
3(a)	$\mathbf{F} = (3\mathbf{i} + 4\mathbf{j}) + (6\mathbf{i} - 8\mathbf{j})$	M1	2	Addition of the two forces
	$= 9\mathbf{i} - 4\mathbf{j}$	A1		Correct resultant
(b)	$F = \sqrt{9^2 + 4^2} = 9.85$ N	M1 A1	2	Finding magnitude Correct magnitude
(c)	$\tan\alpha = \frac{4}{9}$	M1 A1		Using tan to find the angle Correct equation
	$\alpha = 24.0°$	A1	3	Correct angle
	Total		**7**	

5 A crate, of mass 50 kg, is at rest on a warehouse floor. The floor is rough and horizontal. The coefficient of friction between the crate and the floor is μ. A rope is attached to the crate at an angle of 30° to the horizontal. The tension in the rope is 100 N. The crate is shown in the diagram.

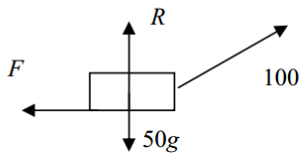


Model the crate as a particle.

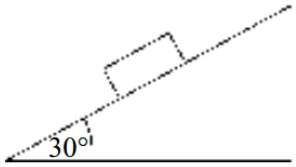
(a) Draw and label a diagram to show the forces acting on the crate. *(1 mark)*

(b) Show that the magnitude of the normal reaction force acting on the crate is 440 N. *(3 marks)*

(c) If the crate remains at rest, μ must satisfy the inequality $\mu \geqslant k$. Find k. *(3 marks)*

5(a)		B1	1	Correct force diagram
(b)	$50\times9.8 = R + 100\sin 30°$	M1		Resolving vertically
		A1		Correct equation
	$R = 440$ N	A1	3	Correct R from correct working
(c)	$100\cos 30° \leq \mu \times 440$ $\therefore k = 0.197$	M1		Use of $F \leq \mu R$ or $F = \mu R$
	$\mu \geq 0.197$	A1		Correct equation
		A1	3	Correct k from correct working

4 A block, of mass 7 kg, is placed on a rough slope that is inclined at 30° to the horizontal, as shown in the diagram. The block remains at rest in this position.



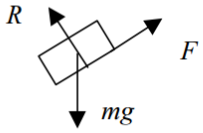
(a) Draw a diagram to show the forces acting on the block. *(1 mark)*

(b) Find the magnitude of the normal reaction force acting on the block. *(2 marks)*

(c) Find the magnitude of the friction force acting on the block. *(2 marks)*

(d) The coefficient of friction between the block and the plane is μ. Find an inequality that μ must satisfy. *(2 marks)*

(e) A similar block, of mass 14 kg, is placed on the slope. Does this block remain at rest or slide? Give a reason for your answer. *(2 marks)*

Question Number and part	Solution	Marks	Total marks	Comments
4(a)		B1	1	Correct force diagram
(b)	$R = 7\times9.8\cos30° = 59.4$ N	M1 A1	2	Resolving perpendicular to plane Correct force
(c)	$F = 7\times9.8\sin30° = 34.3$ N	M1 A1	2	Resolving parallel to plane Correct force
(d)	$34.3 \le \mu\times59.4$ $\mu \ge 0.577$	M1 A1	2	Using $F = \mu R$ or $F \le \mu R$ Correct inequality
(e)	Remains at rest, as mass appears in both F and R, so inequality unchanged.	B1 B1	2	Conclusion Reason
	Total		**9**	