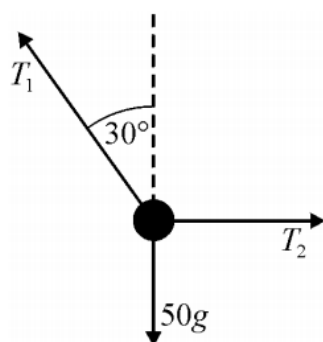# Forces Badge Challenge

Challenge 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)*

Challenge 2

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

(a)   Find $\mathbf{F}$.   (2 marks)

(b)   Find the magnitude of $\mathbf{F}$.   (2 marks)

(c)   Find the acute angle between $\mathbf{F}$ and the unit vector $\mathbf{i}$.   (3 marks)

Challenge 3

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.
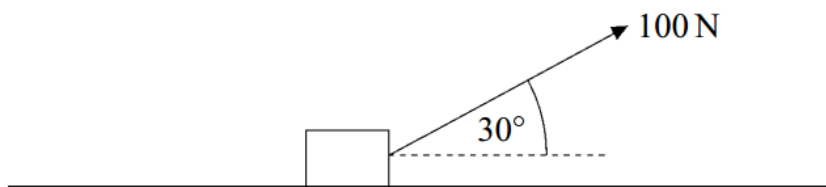

Model the crate as a particle.

(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)*

Final Challenge

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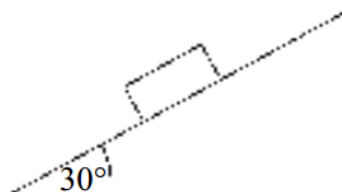
(a) Draw a diagram to show the forces acting on the block. *(1 mark)*

(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)*