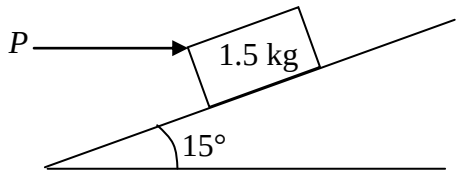
Topic assessment

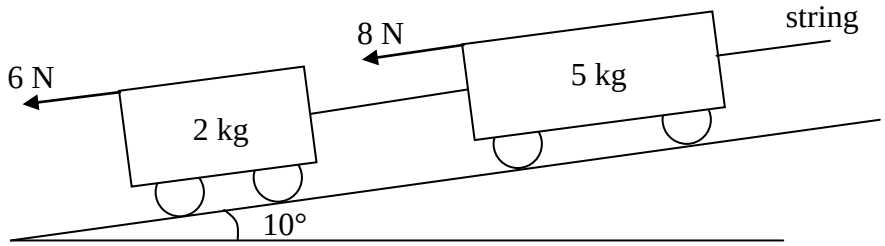
1. A book of mass 1.5 kg is at rest on a smooth plane at 15° to the horizontal. It is held in equilibrium by a horizontal force P, as shown in the diagram below.



(i) Write down an equation for the equilibrium of the book parallel to the plane. Hence calculate the value of P. [3]

(ii) Calculate the value of the normal reaction of the plane on the book. [3]

2. A model truck of mass 5 kg is being pulled by a light string along a straight path. The resistance to its motion is 8 N. A second truck is attached to the first by a light, rigid coupling. The mass of the second truck is 2 kg and the resistance to its motion is 6 N. The two trucks are pulled up a slope at 10° to the horizontal, as shown below, with the coupling and the pulling string both parallel to the slope.

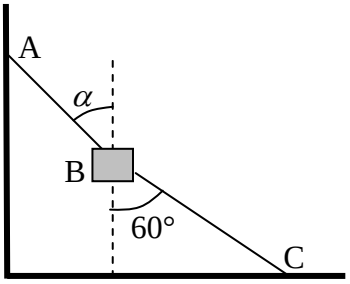


(i) In a case where the acceleration of the two trucks is 2.5 ms^{-2}, show that the tension in the string is 43.4 N, correct to three significant figures.

Calculate also the tension in the coupling. [7]

(ii) Show that, while the trucks are moving up the slope, the coupling remains in tension whatever the tension in the string. [4]

3. A small box B of weight 400 N is held in equilibrium by two light strings AB and BC. The string BC is fixed at C. The end A of string AB is fixed so that AB is at an angle α to the vertical where $\alpha < 60°$. String BC is at 60° to the vertical. This information is shown in the diagram below.



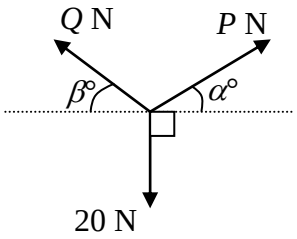
(i) Draw a labelled diagram showing all the forces acting on the box. [1]

(ii) In one situation, the tension in the string BC is 200 N.
By resolving horizontally and vertically, or otherwise, calculate α and the tension in string AB. [7]

(iii) In a new situation, string AB is fixed so that $\alpha = 30°$ and BC remains at 60° to the vertical.
Calculate the tension in the string BC and the tension in the string AB. [4]

(iv) Show briefly that the box cannot be in equilibrium if $\alpha = 60°$ and BC remains at 60° to the vertical. [2]

4. (a) Three forces act on a small object: its weight of 20 N and forces P N and Q N. These forces are shown in the force diagram (below left). They are represented as vectors in the triangle of forces (below right).



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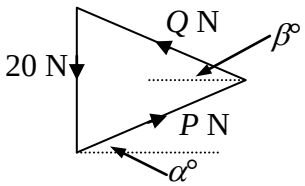

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(i) How does the triangle of forces show that the object is in equilibrium? [2]

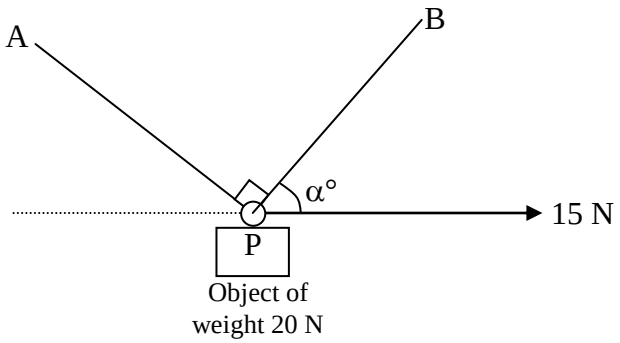
A block of weight 20 N is in equilibrium on a plane inclined at 20° to the horizontal. The frictional force is F N and the normal reaction of the plane on the block is R N.

(ii) Sketch a force diagram for the block, labelling each of the forces. [1]

(iii) Sketch also a triangle of forces for this situation. Mark in the angles and again label each of the forces. [2]

(iv) Calculate the values of R and F. [2]

(b) The diagram below shows an object of weight 20 N. It is supported by a light string AB that passes through a small smooth ring attached to the object at P. A further horizontal force of 15 N acts at P. The string section PB is inclined at $\alpha°$ to the horizontal and at 90° to PA.

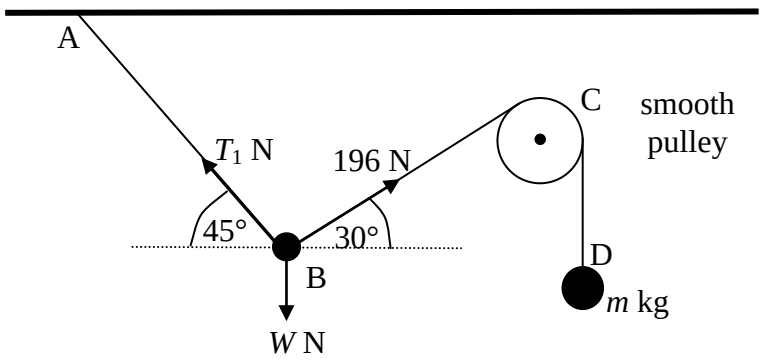


(v) Draw a labelled diagram of all the forces acting at P. [1]

(vi) Why is the tension the same in the string sections PA and PB? Explain briefly how you know that $\alpha \neq 45$. [3]

(vii) Verify that, correct to four significant figures, $\alpha = 81.87$ and the tension in the string is 17.68 N. [3]

5.



The diagram shows a load of weight W N at B in equilibrium. The load is attached by one light string to the ceiling at A and by a second light string that passes over a smooth pulley at C to an object of mass m kg hanging freely at D. The angles of the strings and the tensions T_1 N and 196 N acting at B are shown in the diagram.

(i) Write down the numerical value of the tension in string section CD, giving a reason for your answer.

By considering the equilibrium of the object at D, calculate the value of m. [3]

(ii) Calculate the value of T_1. [3]

(iii) Calculate the value of W. [3]

(iv) Calculate the magnitude of the total force exerted on the pulley at C by the string passing over it. [3]

(v) An additional mass, M kg, is now added at D. Explain why the system cannot be in equilibrium with ABC in a straight line no matter what the value of M. [3]

Total 60 marks