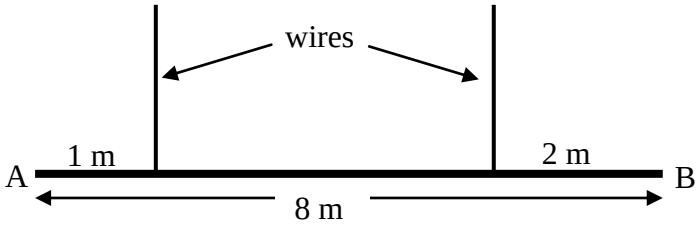
Topic assessment

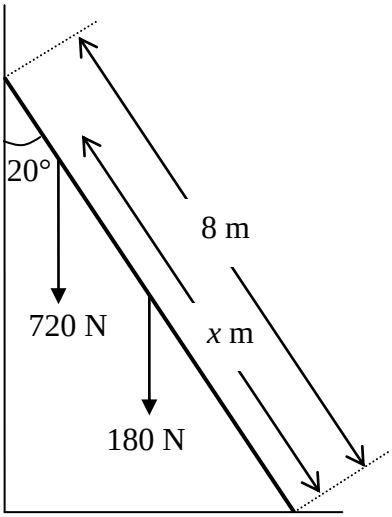
1. A uniform rod AB of length 8 m and weight 180 N is held in horizontal equilibrium by two vertical wires. One wire is 1 m from A and the other 2 m from B.



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

(ii) Calculate the tensions in the wires. [4]

2. A uniform ladder of length 8 m and weight 180 N rests against a smooth, vertical wall and stands on a rough, horizontal surface. A woman of weight 720 N stands on the ladder so that her weight acts at a distance x m from its lower end, as shown in the diagram.



The system is in equilibrium with the ladder at 20° to the vertical.

(i) Show that the frictional force between the ladder and the horizontal surface is F N, where

$$F = 90(1+x)\tan 20°.$$ [5]

(ii) Deduce that F increases as x increases and hence find the values of the coefficient of friction between the ladder and the surface for which the woman can stand anywhere on the ladder without it slipping. [5]

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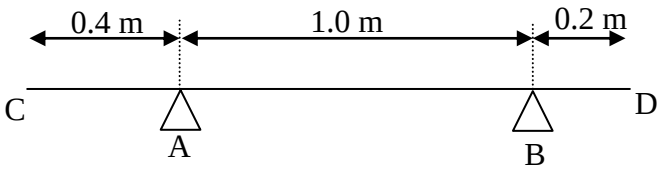
3. A uniform, horizontal, rigid shelf CD has a weight of 40 N and length 1.6 m. It is resting on two thin brackets A and B which are 0.4 m and 0.2 m respectively from C and D, as shown in the diagram below.



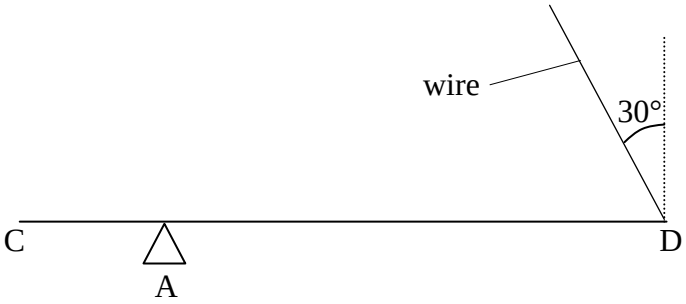
(i) Calculate the reaction forces of the brackets on the shelf. [3]

An object is placed on the shelf so that its weight, W N, acts on the shelf at a distance x m from C.

(ii) Show that the vertical reaction force on the shelf at A is $(24 – W(x – 1.4))$ N.
Find a similar expression for the vertical reaction force on the shelf at B. [3]

(iii) For what values of x will the shelf not tip up if $W = 200$? [3]

The object is removed and the bracket at B is removed for repair. The empty shelf is temporarily held horizontally in equilibrium by a wire attached at D. The wire is inclined at 30° to the vertical and is in the vertical plane containing CD, as shown in the diagram below.



(iv) Calculate the tension in the wire. [2]

(v) Calculate the direction of the supporting force now given to the shelf by bracket A. [4]

4. A packing case in the shape of a cuboid is on a rough plane inclined at an angle α to the horizontal. The packing case is being pushed by a horizontal force of P N applied perpendicular to and in the centre of an edge of the case, as shown in Figure 1 below. Figure 2 below is a side elevation showing the dimensions of the packing case and the position of G, the centre of mass of the packing case and its contents.

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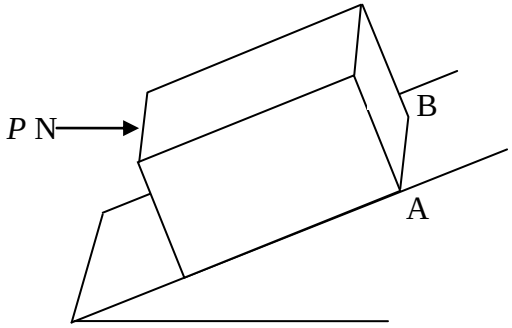

Figure 1

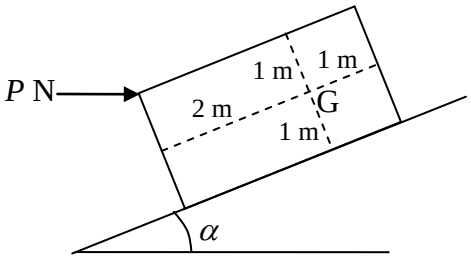

Figure 2

The weight of the packing case and contents is 840 N, $\sin\alpha = \frac{7}{25}$, $\cos\alpha = \frac{24}{25}$ and the coefficient of friction between the packing case and the plane is μ.

(i) Initially $P = 0$ and the packing case is in equilibrium. Show that $\mu \geq \frac{7}{24}$. [4]

(ii) Subsequently $P > 0$. Write down the components of P parallel to and perpendicular to the plane. Show that the moment of the pushing force about the edge AB, shown in Figure 1, is $\frac{27}{25}P$ Nm clockwise. [5]

(iii) The value of P is such that the packing case is in equilibrium but about to turn about the edge AB.
Draw a diagram showing all of the forces acting on the packing case.
Show that $P = 964$, correct to three significant figures. [6]

Total: 45 marks

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