Problem Solving with Moments in 1 and 2 Dimensions (From OCR 4762)

Q1, (Jan 2006, Q2)

A uniform beam, AB, is 6 m long and has a weight of 240 N.

Initially, the beam is in equilibrium on two supports at C and D, as shown in Fig. 2.1. The beam is horizontal.

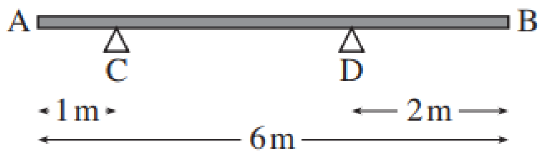

Fig. 2.1

(i) Calculate the forces acting on the beam from the supports at C and D. [4]

A workman tries to move the beam by applying a force T N at A at 40° to the beam, as shown in Fig. 2.2. The beam remains in horizontal equilibrium but the reaction of support C on the beam is zero.

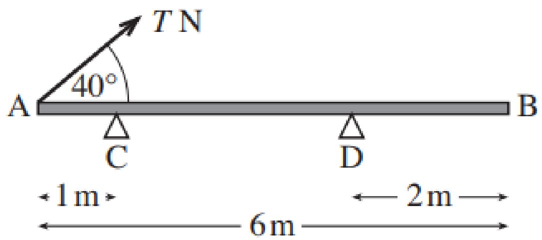

Fig. 2.2

(ii) (*A*) Calculate the value of T. [4]

(*B*) Explain why the support at D cannot be smooth. [1]

The beam is now supported by a light rope attached to the beam at A, with B on rough, horizontal ground. The rope is at 90° to the beam and the beam is at 30° to the horizontal, as shown in Fig. 2.3. The tension in the rope is P N. The beam is in equilibrium on the point of sliding.

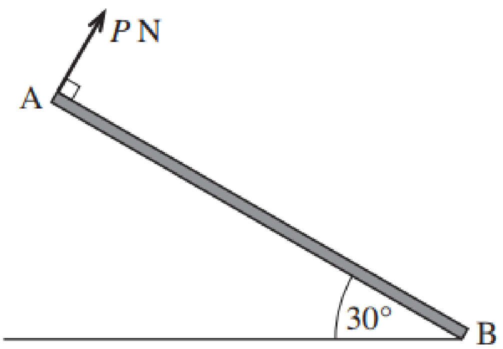

Fig. 2.3

(iii) (*A*) Show that $P = 60\sqrt{3}$ and hence, or otherwise, find the frictional force between the beam and the ground. [5]

(*B*) Calculate the coefficient of friction between the beam and the ground. [5]

Q2, (Jun 2007, Q3)

A uniform plank is 2.8 m long and has weight 200 N. The centre of mass is G.

(i) Fig. 3.1 shows the plank horizontal and in equilibrium, resting on supports at A and B.

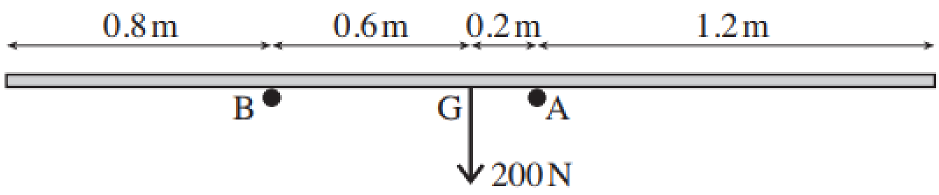

Fig. 3.1

Calculate the reactions of the supports on the plank at A and at B. [4]

(ii) Fig. 3.2 shows the plank horizontal and in equilibrium between a support at C and a peg at D.

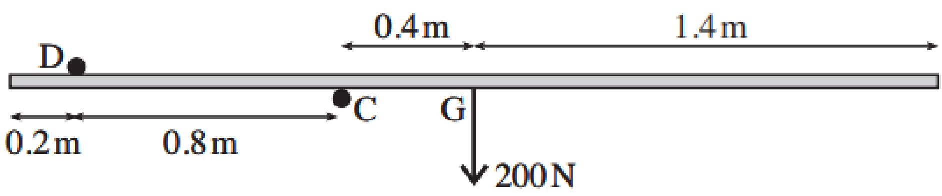

Fig. 3.2

Calculate the reactions of the support and the peg on the plank at C and at D, showing the directions of these forces on a diagram. [5]

Fig. 3.3 shows the plank in equilibrium between a support at P and a peg at Q. The plank is inclined at α to the horizontal, where $\sin\alpha = 0.28$ and $\cos\alpha = 0.96$.

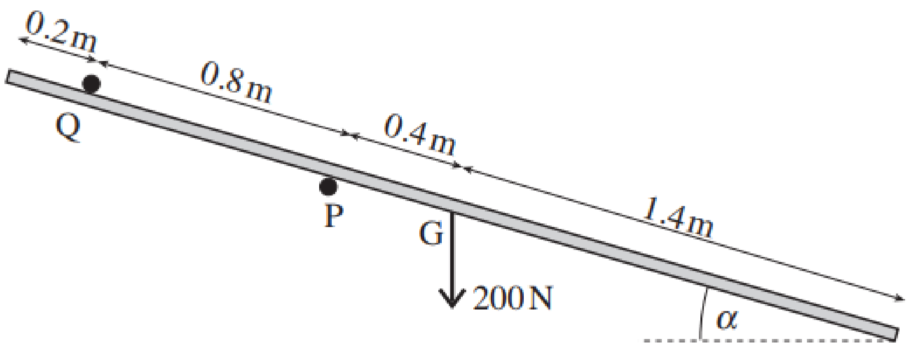

Fig. 3.3

(iii) Calculate the normal reactions at P and at Q. [6]

(iv) Just one of the contacts is rough. Determine which one it is if the value of the coefficient of friction is as small as possible. Find this value of the coefficient of friction. [4]

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Q3, (Jan 2013, Q4)

A rigid thin uniform rod AB with length 2.4 m and weight 30 N is used in different situations.

(i) In the first situation, the rod rests on a small support 0.6 m from B and is held horizontally in equilibrium by a vertical string attached to A, as shown in Fig. 4.1.

Fig. 4.1

Calculate the tension in the string and the force of the support on the rod. **[4]**

(ii) In the second situation, the rod rests in equilibrium on the point of slipping with end A on a horizontal floor and the rod resting at P on a fixed block of height 0.9 m, as shown in Fig. 4.2. The rod is perpendicular to the edge of the block on which it rests and is inclined at θ to the horizontal.

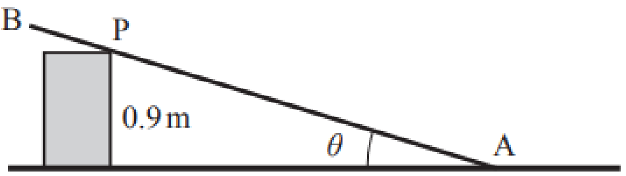

Fig. 4.2

(*A*) Suppose that the contact between the block and the rod is rough with coefficient of friction 0.6 and contact between the end A and the floor is smooth.

Show that $\tan\theta = 0.6$. **[5]**

(*B*) Suppose instead that the contact between the block and the rod is smooth and the contact between the end A and the floor is rough. The rod is now in limiting equilibrium at a different angle θ such that the distance AP is 1.5 m.

Calculate the normal reaction of the block on the rod.

Calculate the coefficient of friction between the rod and the floor. **[9]**

Q4, (Jun 2015, Q1)

A thin uniform rigid rod JK of length 1.2 m and weight 30 N is resting on a rough circular cylinder which is fixed to a floor. The axis of symmetry of the cylinder is horizontal and at all times the rod is perpendicular to this axis.

Initially, the rod is horizontal and its point of contact with the cylinder is 0.4 m from K. It is held in equilibrium by resting on a small peg at J. This situation is shown in Fig. 1.1.

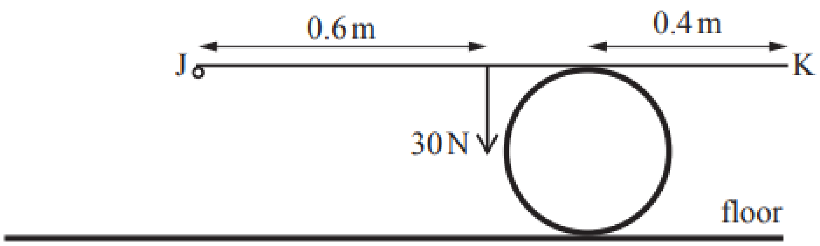

Fig. 1.1

(i) Calculate the force exerted by the peg on the rod and also the force exerted by the cylinder on the rod. **[3]**

A small object of weight W N is attached to the rod at K.

(ii) Find the greatest value of W for which the rod maintains its contact at J. **[2]**

The object at K is removed. Fig. 1.2 shows the rod resting on the cylinder with its end J on the floor, which is smooth and horizontal. The point of contact of the rod with the cylinder is 0.3 m from K. Fig. 1.2 also shows the normal reaction, S N, of the floor on the rod, the normal reaction, R N, of the cylinder on the rod and the frictional force F N between the cylinder and the rod.

Suppose the rod is in equilibrium at an angle of $\theta°$ to the horizontal, where $\theta < 90$.

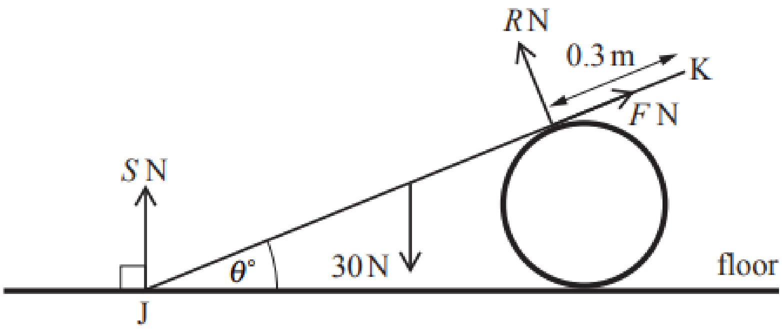

Fig. 1.2

(iii) Find S. Find also expressions in terms of θ for R and F. **[8]**

The coefficient of friction between the cylinder and the rod is μ.

(iv) Determine a relationship between μ and θ. **[3]**