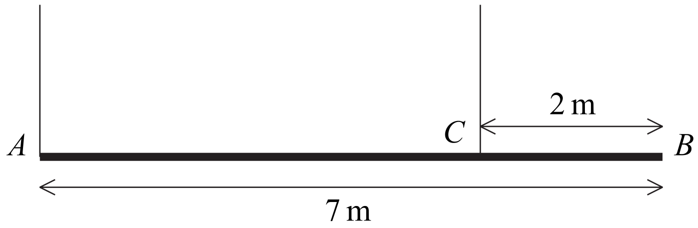
AQA Maths M2

Topic Questions from Papers

Moments and Equilibrium

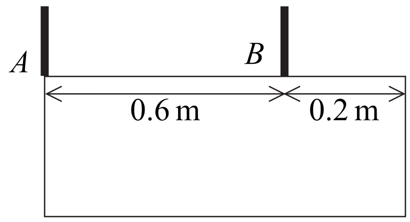
1 A uniform beam, AB, has mass 20 kg and length 7 metres. A rope is attached to the beam at A. A second rope is attached to the beam at the point C, which is 2 metres from B. Both of the ropes are vertical. The beam is in equilibrium in a horizontal position, as shown in the diagram.



Find the tensions in the two ropes. *(6 marks)*

(Q1, Jan 2006)

2 A hotel sign consists of a uniform rectangular lamina of weight W. The sign is suspended in equilibrium in a vertical plane by two vertical light chains attached to the sign at the points A and B, as shown in the diagram. The edge containing A and B is horizontal.



The tensions in the chains attached at A and B are T_A and T_B respectively.

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

(b) Find T_A and T_B in terms of W. *(4 marks)*

(c) Explain how you have used the fact that the lamina is uniform in answering part (b). *(1 mark)*

(Q2, Jan 2007)

3 A uniform plank is 10 m long and has mass 15 kg. It is placed on horizontal ground at the edge of a vertical river bank, so that 2 m of the plank is projecting over the edge, as shown in the diagram below.

(a) A woman of mass 50 kg stands on the part of the plank which projects over the river.

Find the greatest distance from the river bank at which she can safely stand. *(3 marks)*

(b) The woman wishes to stand safely at the end of the plank which projects over the river.

Find the minimum mass which she should place on the other end of the plank so that she can do this. *(4 marks)*

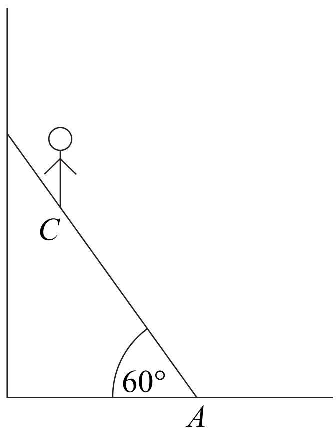
(c) State how you have used the fact that the plank is uniform in your solution. *(1 mark)*

(d) State one other modelling assumption which you have made. *(1 mark)*

(Q4, June 2007)

4 A uniform ladder of length 4 metres and mass 20 kg rests in equilibrium with its foot, A, on a rough horizontal floor and its top leaning against a smooth vertical wall. The vertical plane containing the ladder is perpendicular to the wall and the angle between the ladder and the floor is 60°.

A man of mass 80 kg is standing at point C on the ladder. With the man in this position, the ladder is on the point of slipping. The coefficient of friction between the ladder and the floor is 0.4. The man may be modelled as a particle at C.



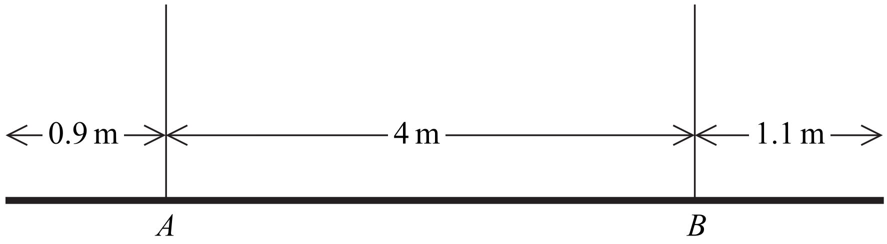
(a) Draw a diagram to show the forces acting on the ladder. *(2 marks)*

(b) Show that the magnitude of the frictional force between the ladder and the ground is 392 N. *(3 marks)*

(c) Find the distance AC. *(6 marks)*

(Q3, Jan 2008)

5 A uniform plank, of length 6 metres, has mass 40 kg. The plank is held in equilibrium in a horizontal position by two vertical ropes attached to the plank at A and B, as shown in the diagram.



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

(b) Show that the tension in the rope attached to the plank at B is $21g$ N. *(3 marks)*

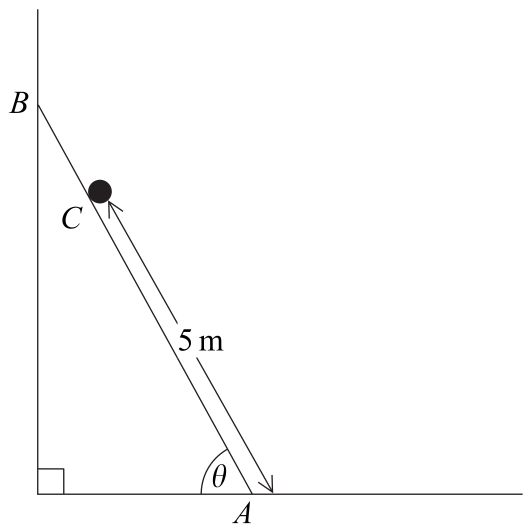
(c) Find the tension in the rope that is attached to the plank at A. *(2 marks)*

(d) State where in your solution you have used the fact that the plank is uniform. *(1 mark)*

(Q2, June 2008)

6 A uniform ladder, of length 6 metres and mass 22 kg, rests with its foot, A, on a rough horizontal floor and its top, B, leaning against a smooth vertical wall. The vertical plane containing the ladder is perpendicular to the wall, and the angle between the ladder and the floor is θ.

A man, of mass 90 kg, is standing at point C on the ladder so that the distance AC is 5 metres. With the man in this position, the ladder is on the point of slipping. The coefficient of friction between the ladder and the horizontal floor is 0.6. The man may be modelled as a particle at C.

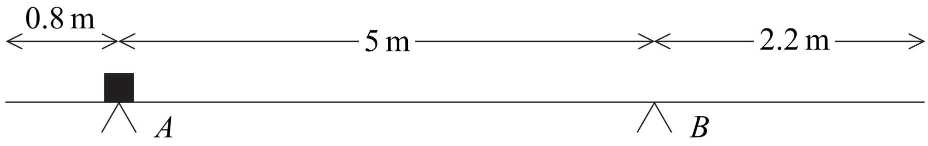


(a) Show that the magnitude of the frictional force between the ladder and the horizontal floor is 659 N, correct to three significant figures. *(4 marks)*

(b) Find the angle θ. *(5 marks)*

(Q3, June 2009)

7 A uniform plank, of length 8 metres, has mass 30 kg. The plank is supported in equilibrium in a horizontal position by two smooth supports at the points A and B, as shown in the diagram. A block, of mass 20 kg, is placed on the plank at point A.



(a) Draw a diagram to show the forces acting on the plank. *(2 marks)*

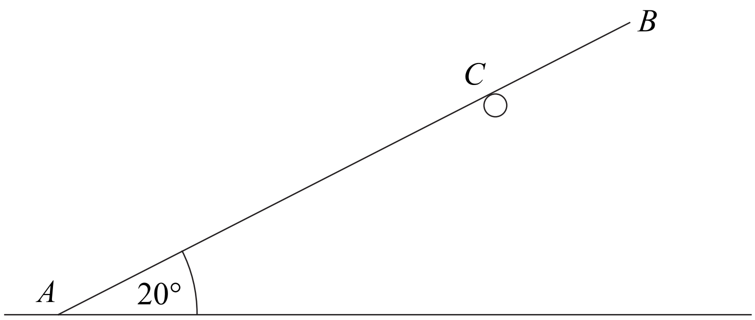
(b) Show that the magnitude of the force exerted on the plank by the support at B is $19.2g$ newtons. *(3 marks)*

(c) Find the magnitude of the force exerted on the plank by the support at A. *(2 marks)*

(d) Explain how you have used the fact that the plank is uniform in your solution. *(1 mark)*

(Q3, Jan 2010)

8 A uniform rod AB, of length 4 m and mass 6 kg, rests in equilibrium with one end, A, on smooth horizontal ground. The rod rests on a rough horizontal peg at the point C, where AC is 3 m. The rod is inclined at an angle of 20° to the horizontal.



(a) Draw a diagram to show the forces acting on the rod. *(2 marks)*

(b) Find the magnitude of the normal reaction force between the rod and the ground. *(3 marks)*

(c) (i) Find the normal reaction acting on the rod at C.

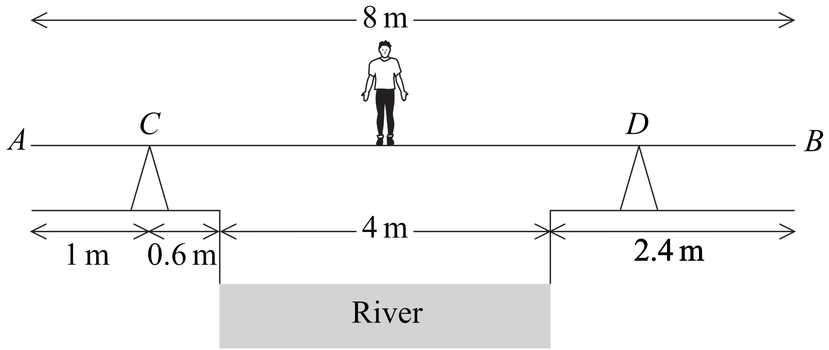
(ii) Find the friction force acting on the rod at C. *(5 marks)*

(d) In this position, the rod is on the point of slipping.

Calculate the coefficient of friction between the rod and the peg. *(2 marks)*

(Q7, June 2010)

9 Ken is trying to cross a river of width 4 m. He has a uniform plank, AB, of length 8 m and mass 17 kg. The ground on both edges of the river bank is horizontal. The plank rests at two points, C and D, on fixed supports which are on opposite sides of the river. The plank is at right angles to both river banks and is horizontal. The distance AC is 1 m, and the point C is at a horizontal distance of 0.6 m from the river bank. Ken, who has mass 65 kg, stands on the plank directly above the middle of the river, as shown in the diagram.



(a) Draw a diagram to show the forces acting on the plank. *(2 marks)*

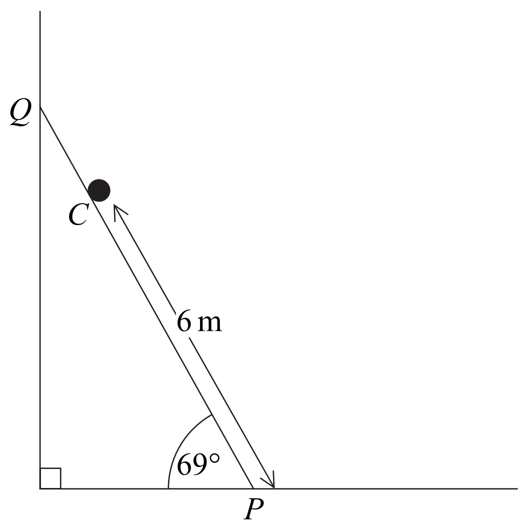
(b) Given that the reaction on the plank at the point D is $44g$ N, find the horizontal distance of the point D from the nearest river bank. *(4 marks)*

(c) State how you have used the fact that the plank is uniform in your solution. *(1 mark)*

(Q4, June 2011)

10 A uniform ladder PQ, of length 8 metres and mass 28 kg, rests in equilibrium with its foot, P, on a rough horizontal floor and its top, Q, leaning against a smooth vertical wall. The vertical plane containing the ladder is perpendicular to the wall and the angle between the ladder and the floor is 69°.

A man, of mass 72 kg, is standing at the point C on the ladder so that the distance PC is 6 metres. The man may be modelled as a particle at C.



(a) Draw a diagram to show the forces acting on the ladder. *(2 marks)*

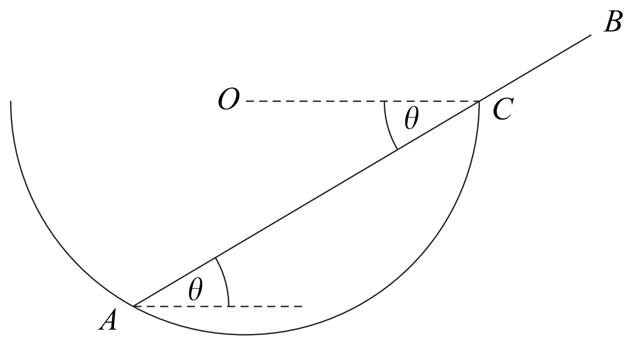
(b) With the man standing at the point C, the ladder is on the point of slipping.

(i) Show that the magnitude of the reaction between the ladder and the vertical wall is 256 N, correct to three significant figures. *(4 marks)*

(ii) Find the coefficient of friction between the ladder and the horizontal floor. *(4 marks)*

(Q3, Jan 2012)

11 A smooth hollow hemisphere, of radius a and centre O, is fixed so that its rim is in a horizontal plane. A smooth uniform rod AB, of mass m, is in equilibrium, with one end A resting on the inside of the hemisphere and the point C on the rod being in contact with the rim of the hemisphere. The rod, of length l, is inclined at an angle θ to the horizontal, as shown in the diagram.



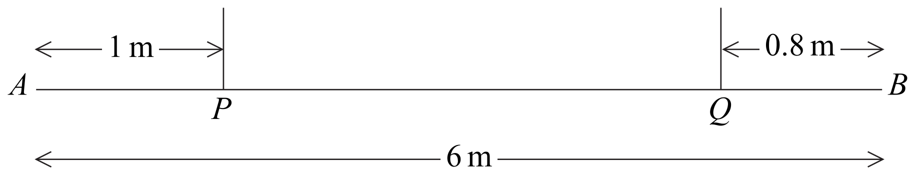
(a) Explain why the reaction between the rod and the hemisphere at point A acts through O. *(1 mark)*

(b) Draw a diagram to show the forces acting on the rod. *(2 marks)*

(c) Show that $l = \dfrac{4a\cos 2\theta}{\cos\theta}$. *(5 marks)*

(Q9, Jan 2013)

12 A uniform plank AB, of length 6 m, has mass 25 kg. It is supported in equilibrium in a horizontal position by two vertical inextensible ropes. One of the ropes is attached to the plank at the point P and the other rope is attached to the plank at the point Q, where $AP = 1$ m and $QB = 0.8$ m, as shown in the diagram.



(a) (i) Find the tension in each rope. *(5 marks)*

(ii) State how you have used the fact that the plank is uniform in your solution. *(1 mark)*

(b) A particle of mass m kg is attached to the plank at point B, and the tension in each rope is now the same.

Find m. *(6 marks)*

(Q4, June 2013)