STATICS – EQUILIBRIUM OF RIGID BODIES

Take g as 9.8 ms^{-2} when required

1. A uniform rod AB is length 4 metres and mass 6kg. It rests on two supports at points C and D, where AC = 1 metre and AD = 2.5 metres.

Find the force exerted on the rod by each support, giving your answers in terms of g.

[8]

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2. A uniform rod AB is of length 4L and weight W. It rests on supports at points C and D, where AC = L and AD = 3L. A force P is applied to the rod vertically downwards at B.

Given that the rod is about to lose contact with its support at C, find the magnitude of P, giving your answer in terms of W.

[3]

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3. Two children make a see-saw from a uniform plank of length 3m. They place a pivot in the middle of the plank. The seesaw rests horizontally in equilibrium with a child of mass 10kg sitting at one end and a child of mass 20kg sitting a distance of x metres from the other end.

a) Find the value of x.

[3]

The children now place the pivot 1.2m from one end of the plank. The see-saw will now rest horizontally in equilibrium with the two children sitting one at each end of the plank.

b) Find the mass of the plank.

[4]

c) State one assumption you have made in your modelling.

[1]

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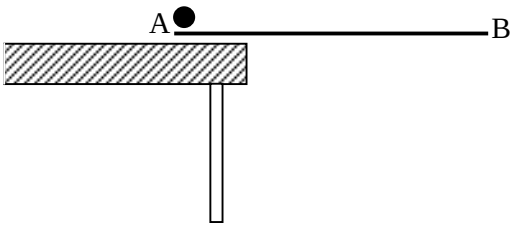
4. A uniform plank AB of length 1 metre and mass 0.5kg is placed as shown with 20cm of it overlapping a smooth table top. A heavy object of mass 4kg is placed on end A of the plank, which rests on the table.



A cat of mass 1kg starts to walk out from the table on the plank. It continues to walk until the plank is about to pivot on the edge of the table. Find the cat's distance from A when it stops walking.

[4]

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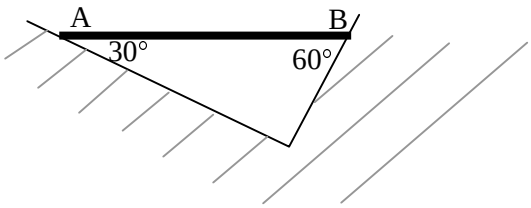
5. A uniform plank AB of length 2L rests horizontally in equilibrium between two smooth surfaces inclined at 30° and 60° to the horizontal, as shown.



The weight of the plank is W.
Find, in terms of W, the normal reaction exerted by the surfaces on the plank at A and at B.

[4]

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6. A plank AB of weight W and length L has strings fastened to ends A and B which are inclined at 30° and 60° to the horizontal respectively, as shown in the diagram.

Find the distance of the plank's centre of mass from A.

[9]

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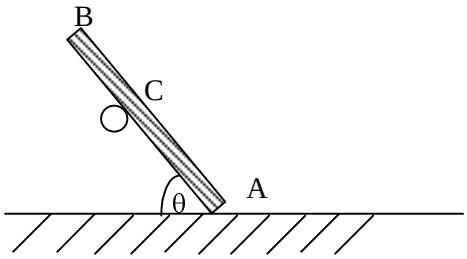
7. A uniform plank AB of length 6L and weight W rests in equilibrium with one end, A, on rough horizontal ground. It is supported by a smooth horizontal rod at point C, where AC = 4L. The angle between the rod and the ground is θ, where $\sin\theta = 0.1$.



Find the coefficient of friction between the plank and the ground, given that the plank is about to slip.

[11]

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8. A uniform ladder of weight W is placed with its foot on rough horizontal ground and its upper end against a smooth vertical wall. The ladder makes an angle of $\cos^{-1}\left(\frac{3}{5}\right)$ with the horizontal and the coefficient of friction between the ground and the ladder is 0.8.

a) A builder of weight 4W climbs up the ladder. Show that he will be able to reach the top without the ladder slipping.

[8]

b) The builder wishes to climb to the top of the ladder carrying bricks of weight W. Find whether he can reach the top safely.

[5]

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9. A uniform ladder of weight W and length 2L stands on rough horizontal ground and rests against a smooth vertical wall. The ladder makes an angle of 60^o with the ground. The magnitude of the reaction between the wall and the ladder is R.

a) Find R in terms of W, leaving your answer in surd form.

[3]

b) Find the minimum possible value of μ, the coefficient of friction between the ground and the ladder.

[5]

c) State one assumption you have used in your modelling.

[1]

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10. A non-uniform ladder AB is of length 3m and weight W newtons. It stands in limiting equilibrium with A on rough horizontal ground, and B resting against a smooth vertical wall. It makes an angle of θ with the horizontal, where $\sin\theta = \frac{4}{5}$. The coefficient of friction between the ground and the ladder is 0.6.

Find the distance of the centre of mass of the ladder from A.

[7]

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11. A uniform ladder has its foot on rough horizontal ground and the other end resting against a smooth vertical wall. The coefficient of friction between the ladder and the ground is 0.2 and the weight of the ladder is 10W.

In order to keep the ladder in limiting equilibrium an external force of W has to be applied horizontally at the base of the ladder. Find the angle that the ladder makes with the ground when it is about to slip.

[9]

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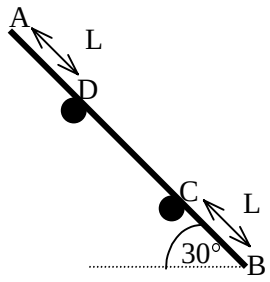
12. A uniform plank AB of weight W and length 4L rests on supports at C and D as shown. The support at C is rough, but the support at D is smooth. AB makes an angle of 30° with the horizontal.



Given that equilibrium is limiting, find μ, the coefficient of friction between the plank and the support at C, giving your answer in surd form.

[8]

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13. A uniform ladder of mass 10kg rests in equilibrium between rough horizontal ground and a rough horizontal wall. The coefficient of friction between the ladder and the ground, and between the ladder and the wall, are μ_1 and μ_2 respectively. The angle between the ladder and the horizontal is θ^o.

Given that equilibrium is limiting at both the ground and the wall, show that $\tan\theta = \dfrac{1-\mu_1\mu_2}{2\mu_1}$

[14]
