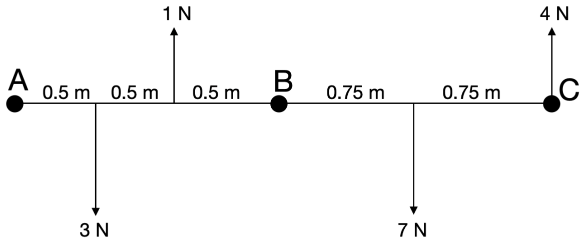
A#56 MOMENTS

AEM questions are taken from past exam papers - they have been carefully chosen to represent a typical exam question at each level of difficulty. If you can do these questions, you're ready to move onto past papers for this topic.

APPRENTICE

Typical moments problems lead to a force diagram like this:



All forces acting on the horizontal light rod are shown.
Find the moment of the system of forces:

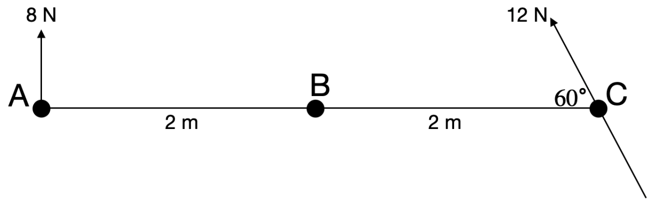
a. about A

b. about B

c. about C

EXPERT

Slightly harder moments problems lead to a force diagram like this:



All forces acting on the horizontal light rod are shown.
Find the moment of the system of forces:

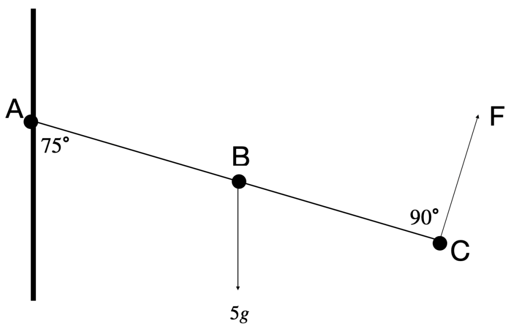
a. about A

b. about B

c. about C

MASTER

Hinges problems lead to a force diagram like this:



AC is a uniform rod with mass 5 kg and length $2l$ metres.
B is the midpoint of AC.
The rod is smoothly hinged at A on a vertical wall.
The rod is in equilibrium.

There is a reaction force at A not shown on this force diagram.
All other forces acting on the rod are shown.

Find the value of the force F

A#57 BEAMS - PARALLEL FORCES

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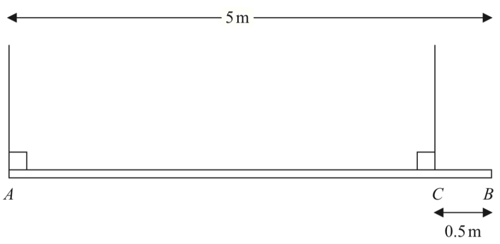
APPRENTICE



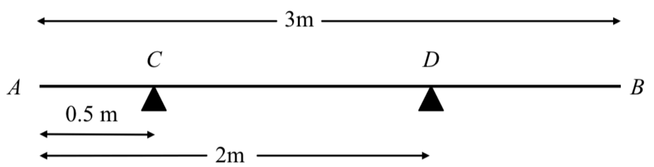
A beam AB has length 5m and mass 25kg. The beam is suspended in equilibrium in a horizontal position by two vertical ropes. One rope is attached to the beam at A and the other rope is attached to the point C on the beam where $CB = 0.5\text{m}$, as shown in Figure 3. A particle P of mass 60kg is attached to the beam at B and the beam remains in equilibrium in a horizontal position. The beam is modelled as a uniform rod and the ropes are modelled as light strings.

a. Find i. the tension in the rope attached to the beam at A.
ii. the tension in the rope attached to the beam at C.

b. Particle P is removed and replaced by a particle Q of mass M kg at B. Given that the beam remains in equilibrium in a horizontal position, find the greatest possible value of M,

EXPERT

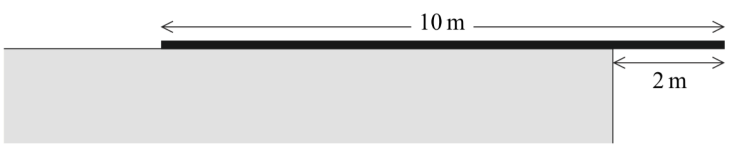
A uniform rod AB has length 3m and weight 120N. The rod rests in equilibrium in a horizontal position, smoothly supported at points C and D, where $AC = 0.5\text{m}$ and $AD = 2\text{m}$, as shown in Fig. 3. A particle of weight W newtons is attached to the rod at a point E where $AE = x$ metres. The rod remains in equilibrium and the magnitude of the reaction at C is now twice the magnitude of the reaction at D.



a. Show that $W = \dfrac{60}{1-x}$.

b. Hence deduce the range of possible values of x.

MASTER



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

a. A woman of mass 50kg 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.

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.

c. State how you have used the fact that the plank is uniform in your solution.

d. State one other modelling assumption which you have made.

A#58 MOMENTS WITH RESOLVING

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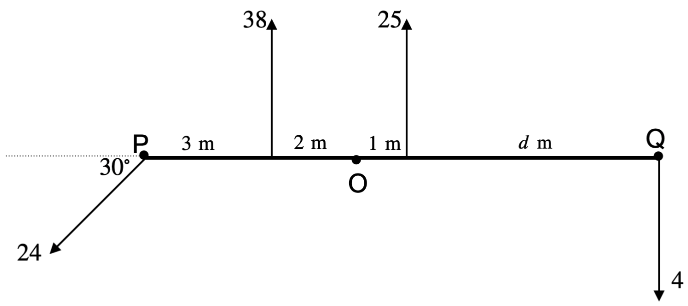
APPRENTICE

The diagram shows a light rod PQ.

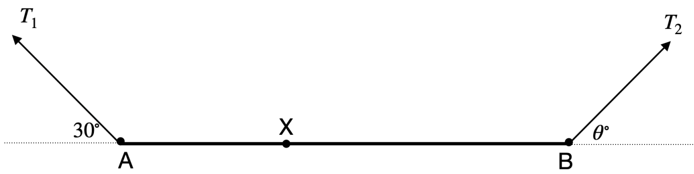
Find the range of possible values for d which will cause PQ to rotate anticlockwise about the point O.



EXPERT

A non-uniform rod AB of mass 5 kg and length $3l$ has its centre of mass at a point X on the rod, where $AX = l$. The rod rests horizontally, supported by two strings as shown.

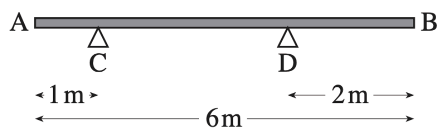
Find the tensions in the strings T_1 and T_2 and the value of θ



MASTER

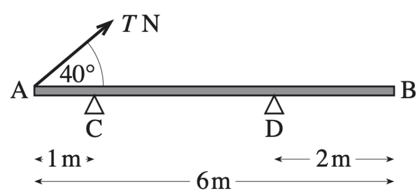
A uniform beam AB, is 6 m long and has a weight of 240 N.

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



a. Calculate the forces acting on the beam from the supports at C and D.

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



b. Calculate the value of T

c. Explain why the support at D cannot be smooth

A#59 HINGE PROBLEMS

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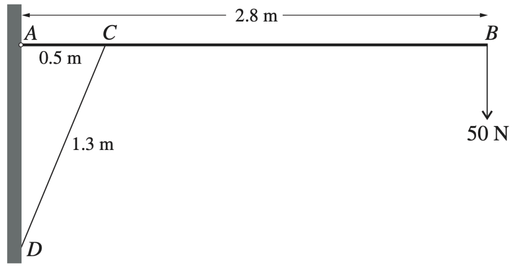
APPRENTICE

A uniform beam AB has weight 70 N and length 2.8 m. The beam is freely hinged to a wall at A and is supported in a horizontal position by a strut CD of length 1.3 m. One end of the strut is attached to the beam at C, 0.5 m from A, and the other end is attached to the wall at D, vertically below A. The strut exerts a force on the beam in the direction DC. The beam carries a load of weight 50 N at its end B.

a. Calculate the magnitude of the force exerted by the strut on the beam

b. Calculate the magnitude of the force acting on the beam at A.



EXPERT

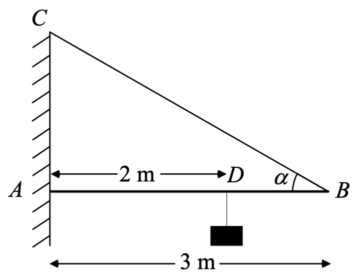
A uniform steel girder AB, of mass 40 kg and length 3 m, is freely hinged at A to a vertical wall. The girder is supported in a horizontal position by a steel cable attached to the girder at B. The other end of the cable is attached to the point C vertically above A on the wall, with $\angle ABC = \alpha$, where $\tan \alpha = \dfrac{3}{4}$.

A load of mass 60 kg is suspended by another cable from the girder at the point D, where $AD = 2$ m. The girder remains horizontal and in equilibrium. The girder is modelled as a rod, and the cables as light inextensible strings.

a. Show that the tension in the cable BC is 980 N.

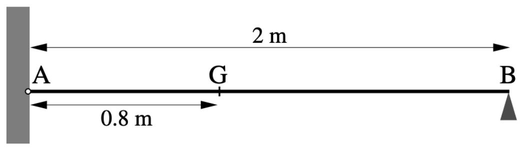
b. Find the magnitude of the reaction on the girder at A.

c. Explain how you have used the modelling assumption that the cable at D is light.



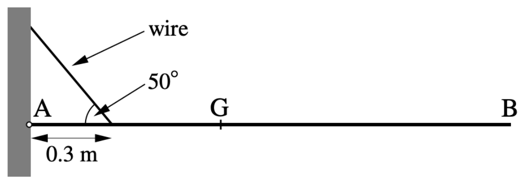
MASTER

A thin straight beam AB is 2 m long. It has a weight of 600 N and its centre of mass G is 0.8 m from A. The beam is freely pivoted about a horizontal axis through A.



The beam is held horizontally in equilibrium.
Initially this is done by means of a support at B, as shown.
a. Calculate the force on the beam due to the support at B

The support at B is now removed and replaced by a wire attached to the beam 0.3 m from A and inclined at $50°$ to the beam. The beam is still horizontal and in equilibrium.
b. Calculate the tension in the wire.



The forces acting on the beam at A due to the hinges are a horizontal force X N in the direction AB, and a downward vertical force Y N, which have a resultant of magnitude R at α to the horizontal.
c. Calculate X, Y, R and α

A#60 LADDER PROBLEMS (not for AQA students)

TAILORED TUTORS
A LEVEL MATHS

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APPRENTICE

A uniform ladder, of weight W, rests with its top against a rough vertical wall and its base on rough horizontal ground.

The coefficient of friction between the wall and the ladder is μ and the coefficient of friction between the ground and the ladder is 2μ. When the ladder is on the point of slipping, the ladder is inclined at an angle of $\frac{\pi}{4}$ to the horizontal.

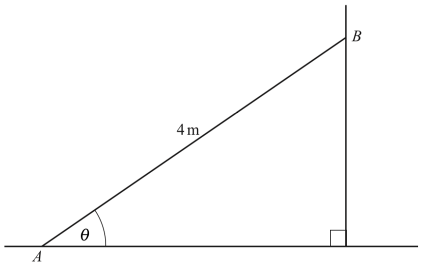
a. Draw a diagram to show the forces acting on the ladder.

b. Find the value of μ.

EXPERT

A uniform ladder AB of weight W N and length 4m rests with its end A on rough horizontal ground and its end B against a smooth vertical wall. The ladder is inclined at an angle θ to the horizontal where $\tan\theta = \frac{1}{2}$ (see diagram). A small object S of weight $2W$ N is placed on the ladder at a point C, which is 1m from A. The coefficient of friction between the ladder and the ground is μ and the system is in limiting equilibrium.

a. Show that $\mu = \frac{2}{3}$.

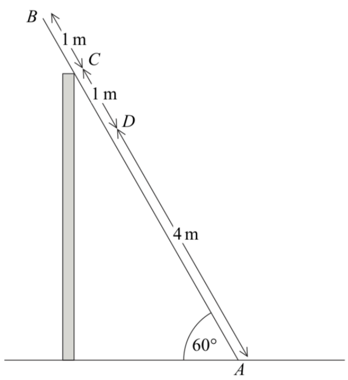


A small object of weight aW N is placed on the ladder at its mid-point and the object S of weight $2W$ N is placed on the ladder at its lowest point A.

b. Given that the system is in equilibrium, find the set of possible values of a.

MASTER

A uniform ladder AB, of length 6 metres and mass 22kg, rests with its foot, A, on rough horizontal ground. The ladder rests against the top of a smooth vertical wall at the point C, where the length AC is 5 metres. The vertical plane containing the ladder is perpendicular to the wall, and the angle between the ladder and the ground is 60°. A man, of mass 88kg, is standing on the ladder.



The man may be modelled as a particle at the point D.
The length of AD is 4 metres.
The ladder is on the point of slipping

a. Draw a diagram to show the forces acting on the ladder.

b. Find the coefficient of friction between the ladder and the horizontal ground.