

Moments 3ii

A Level

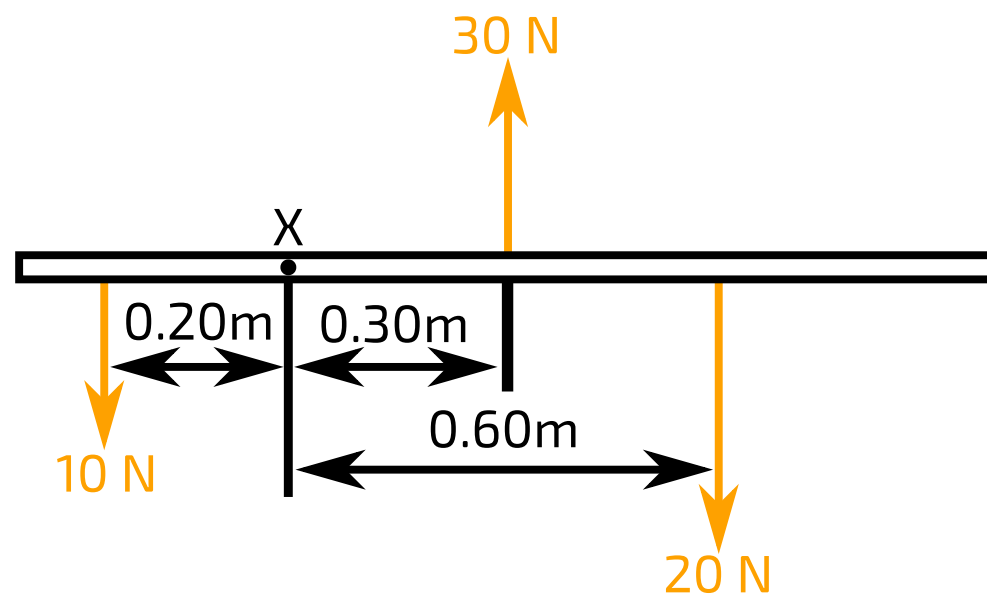


Figure 1: Three forces acting on a rod.

Figure 1 shows three forces acting on a rod.

Part A Moments around X

Find the clockwise moment about point X .

Find the sum of the two anticlockwise moments about point X .

Is the rod in equilibrium? If not, which direction will it rotate?

- ☐ It's impossible to tell whether it is in equilibrium
 - ☐ No, but it is impossible to tell which way it will rotate
 - ☐ Yes
 - ☐ No, and it will rotate clockwise
 - ☐ No, and it will rotate anticlockwise
-

Part B Additional force

An additional force of 4 N can be applied so that the system is then in equilibrium.

Find the distance from X of the line of action for the additional force. The line of action must be applied perpendicular to the length of the rod.



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Moments 4ii

A Level



A concrete paving slab has mass 45 kg and dimensions $0.600\text{ m} \times 0.600\text{ m} \times 0.050\text{ m}$. **Figure 1** shows the paving stone in equilibrium.

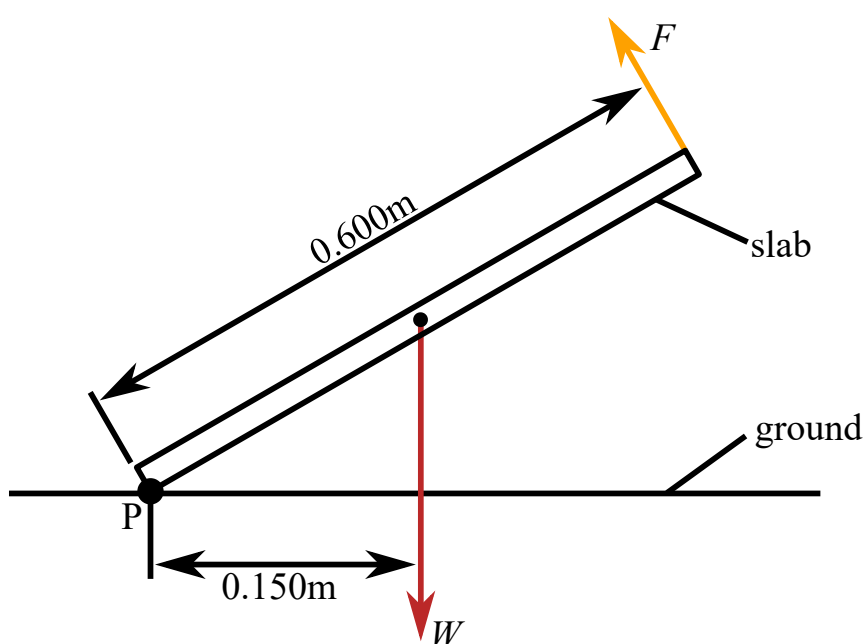


Figure 1: A concrete paving slab in equilibrium.

Part A Magnitude of F

Two forces acting on the slab are shown. The weight of the slab is W , which is shown acting downwards from the centre of the slab. The force F is applied at right angles to the end of the slab.

By taking moments about P , determine the size of the force F .

Part B **Assumptions necessary**

Which of these assumptions are used in part A? Choose all options that apply.

- ☐ We assumed that the ground is smooth, so that there is no friction force between the slab and the ground to consider.
 - ☐ We assumed that the force F is provided by a string that is light, so that there is no mass associated with the force F to consider.
 - ☐ We assumed that the mass is uniformly distributed throughout the slab so the weight is acting through the geometrical centre of the slab (ie, the centre of mass).
-

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Moments 5i

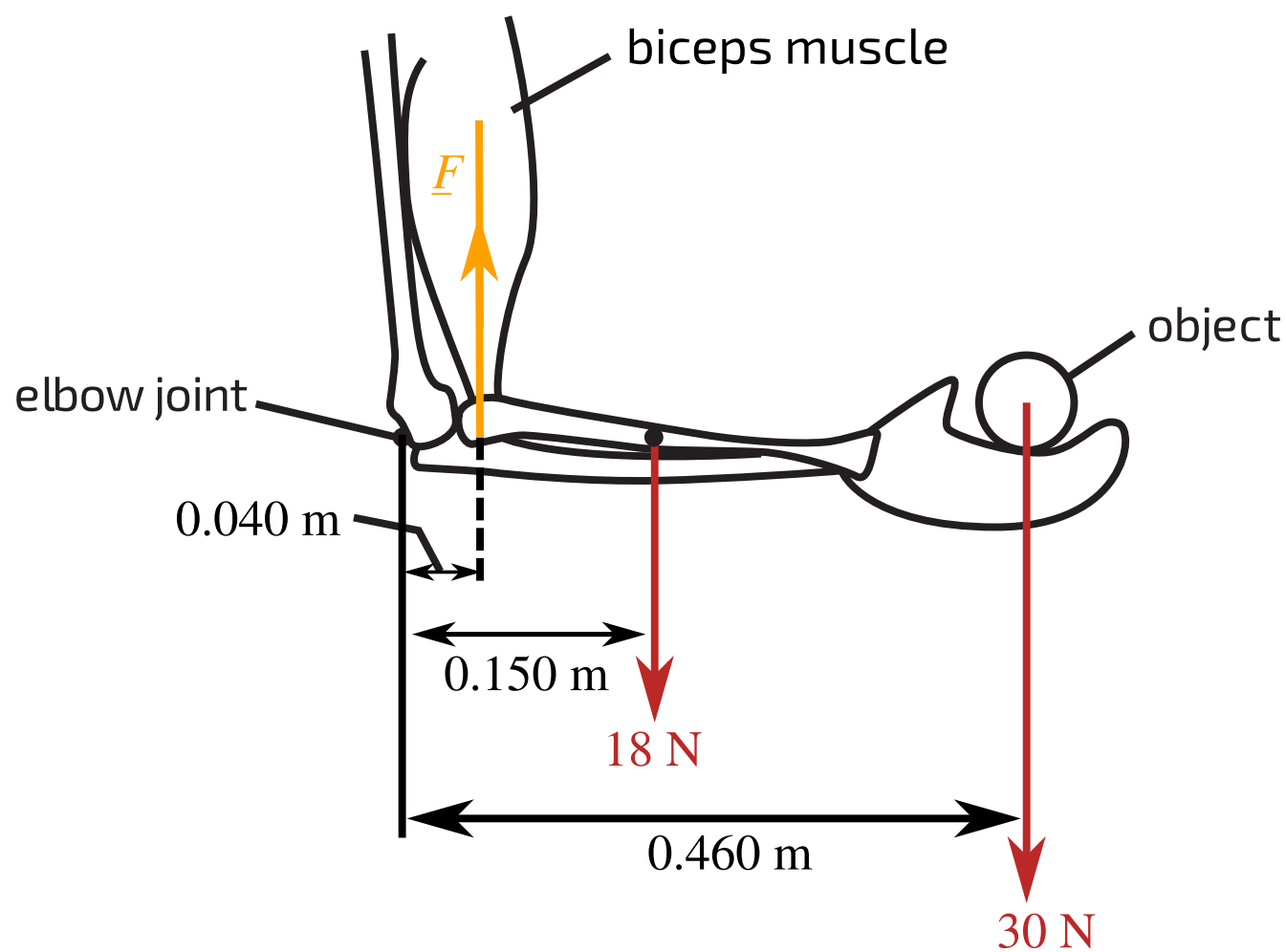


Figure 1: A human arm lifting an object.

Figure 1 shows a human arm lifting an object. The lower arm is horizontal and its centre of gravity is 0.150 m from the elbow joint. The weight of the lower arm is 18 N . The biceps muscle exerts a vertical force F on the arm. The horizontal distance between the elbow joint and the point of attachment of the muscle to the lower arm bone is 0.040 m . The weight of the object held in the hand is 30 N and its centre of gravity is 0.460 m from the elbow joint. The arm is in equilibrium.

Part A Total clockwise moment

Calculate the total clockwise moment about the elbow joint correct to 3 significant figures.

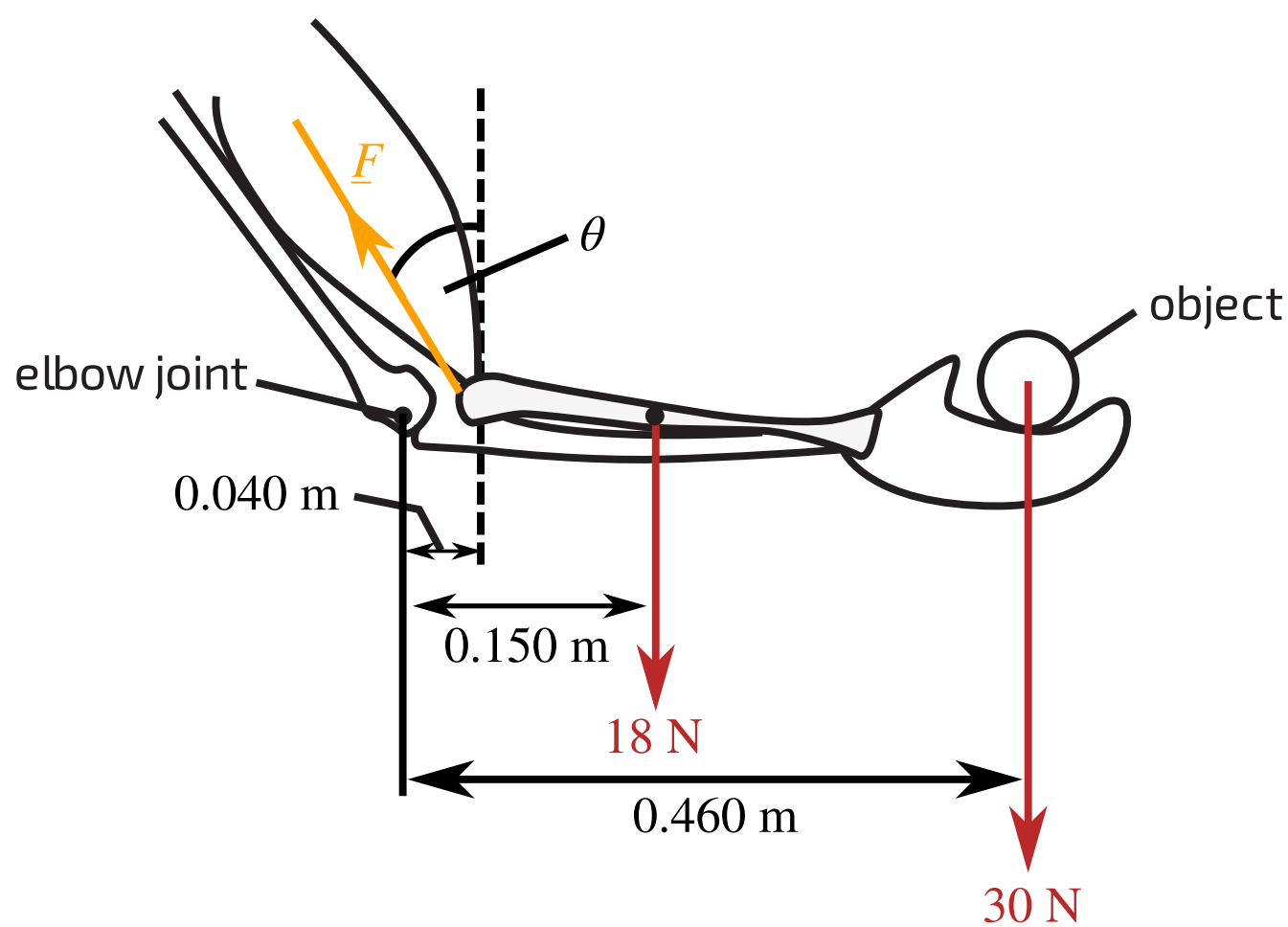


Figure 2: An arm holding a ball with the lower arm moved away from the body.

As the lower arm is moved away from the body, the force F exerted by the biceps muscles acts at an angle θ to the vertical as shown in **Figure 2**.

The lower arm remains horizontal and in equilibrium. Describe and explain what happens to each of the following quantities as the angle θ is increased:

As θ increases, what happens to the anticlockwise moment about the elbow joint?

- ☐ It increases
- ☐ It stays the same
- ☐ It decreases

As θ increases, what happens to the magnitude of the force F ?

- ☐ It stays the same
- ☐ It increases
- ☐ It decreases

Moments 5ii

Figure 1 shows a kitchen cupboard securely mounted to a vertical wall. The cupboard rests on a support at A .

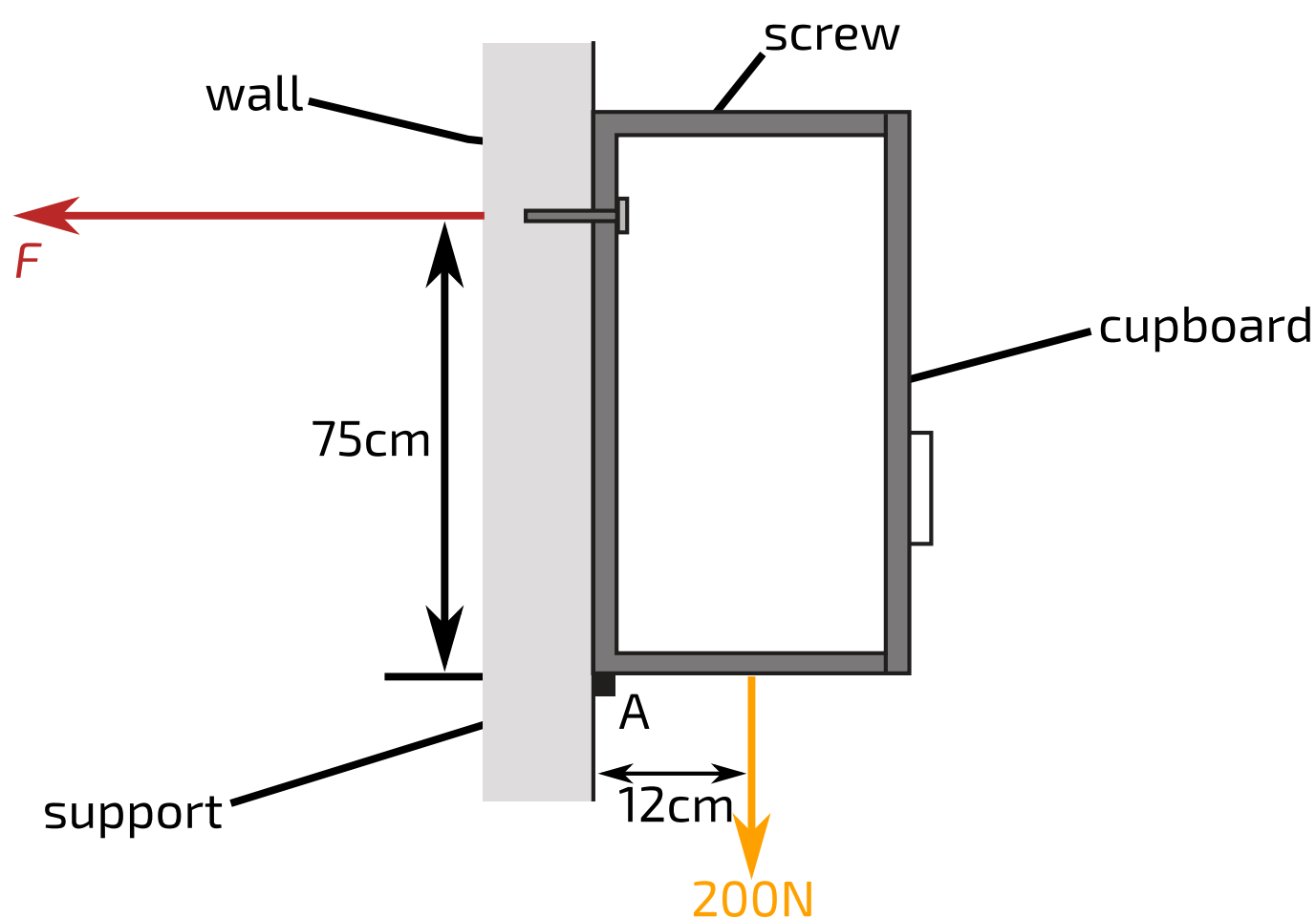


Figure 1: The forces acting on a cupboard.

The total weight of the cupboard and its contents is 200 N. The line of action of its weight is at a distance of 12 cm from A . The screw securing the cupboard to the wall is at a vertical distance of 75 cm from A .

Part A Determine F

The direction of the force F provided by the screw on the cupboard is horizontal as shown in **Figure 1**. By taking moments about A , determine the value of F .

Part B Screw secured closer

State and explain how your answer to the previous question would change, if at all, if the same screw was secured much closer to A .

Let us represent the distance from the line of action of F to the screw by d . The clockwise moment is , so the anticlockwise moment is also as the system must stay in equilibrium. Hence, we have the equation .

Therefore, $F \propto$, meaning that as the distance d (ie, if the screw is secured closer to A), the force .

Items:

12 N m

24 N m

2.4 N m

$Fd = 24$

$\frac{F}{d} = 24$

$F = 24d$

d^2

d

$\frac{1}{d}$

increases

stays the same

decreases

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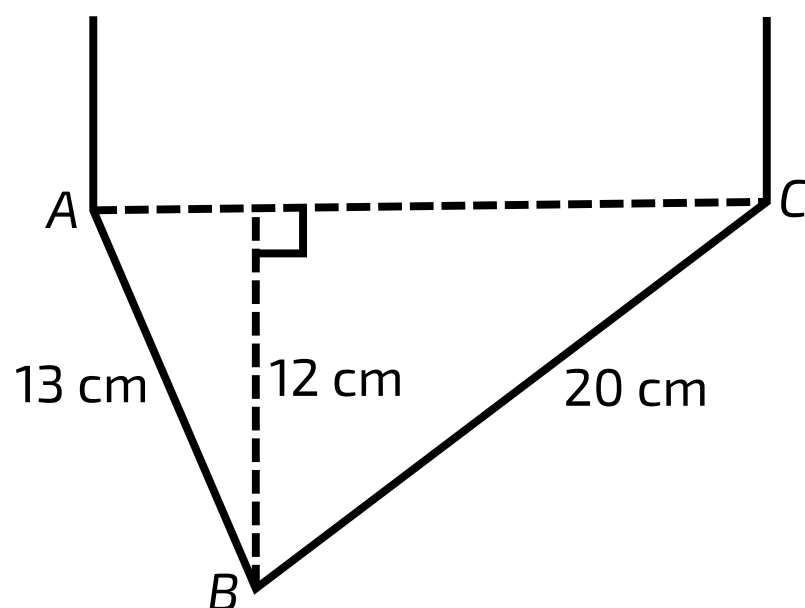


Figure 1: A rigid body consisting of two rods.

A rigid body ABC consists of two uniform rods AB and BC , rigidly joined at B . The lengths of AB and BC are 13 cm and 20 cm respectively, and their weights are 13 N and 20 N respectively. The distance of B from AC is 12 cm. The body hangs in equilibrium, with AC horizontal, from two vertical strings attached at A and C .

Part A Tension in string at A

Find the tension in the string attached at A correct to 3 significant figures.

Part B Tension in string at C

Find the tension in the string attached at C correct to 3 significant figures.

Moments 2ii

A Level

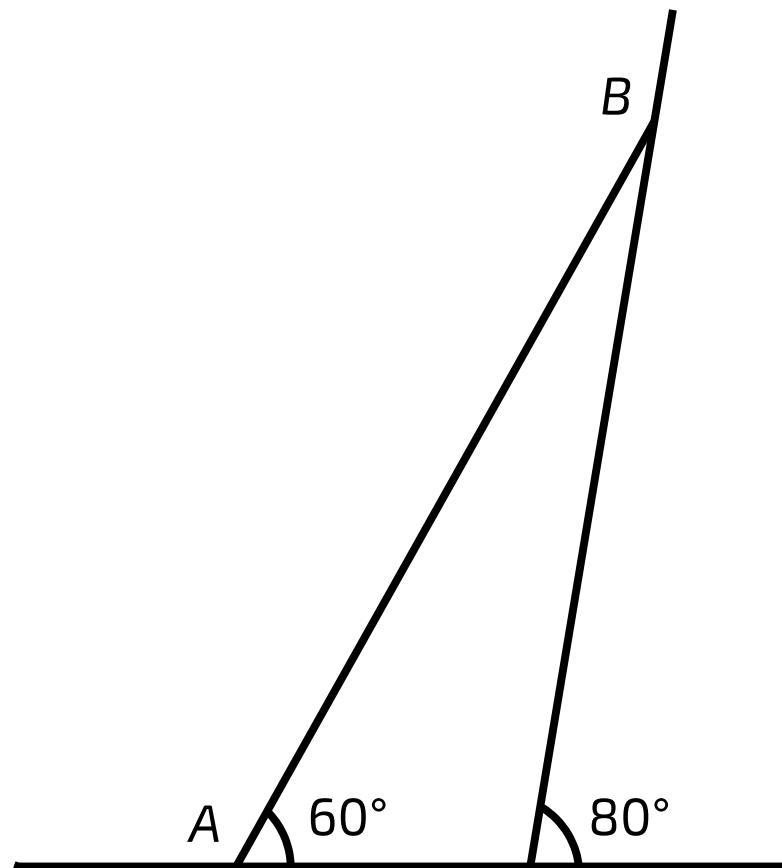


Figure 1: A uniform rod AB resting in equilibrium in a vertical plane against a smooth wall.

A uniform rod AB , of weight 25 N and length 1.6 m , rests in equilibrium in a vertical plane with the end A in contact with rough horizontal ground and the end B resting against a smooth wall which is inclined at 80° to the horizontal. The rod is inclined at 60° to the horizontal.

Calculate the magnitude of the force acting on the rod at B . Give your answer to 3 significant figures.

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Moments 4i

A Level



A uniform square board of mass 10.0 kg and side 2.00 m is modelled as a lamina $ABCD$. The board is in equilibrium in a vertical plane with the point A on rough horizontal ground. The edge AD rests on a fixed wedge whose point of contact, E , is smooth. The distance AE is 1.50 m and the edge AD makes an angle of 15.0° with the horizontal (see [Figure 1](#)).

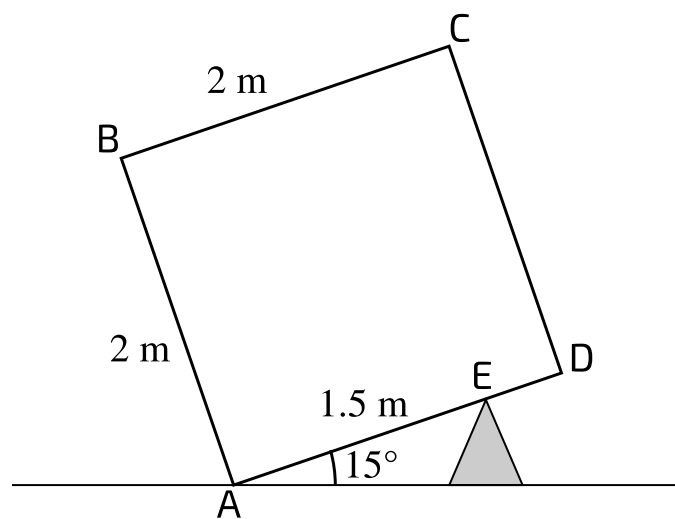


Figure 1: Board $ABCD$ resting in equilibrium on a smooth wedge.

Part A Force at E

Calculate the magnitude of the force which the board exerts on the wedge at E .

Part B Frictional force at A

Calculate the magnitude of the frictional force acting at A .

Part C Value of m

A small object m is now fixed to the board at B . Assuming that the board does not slip, calculate the value of m for which the board remains on the wedge.

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Moments 2i

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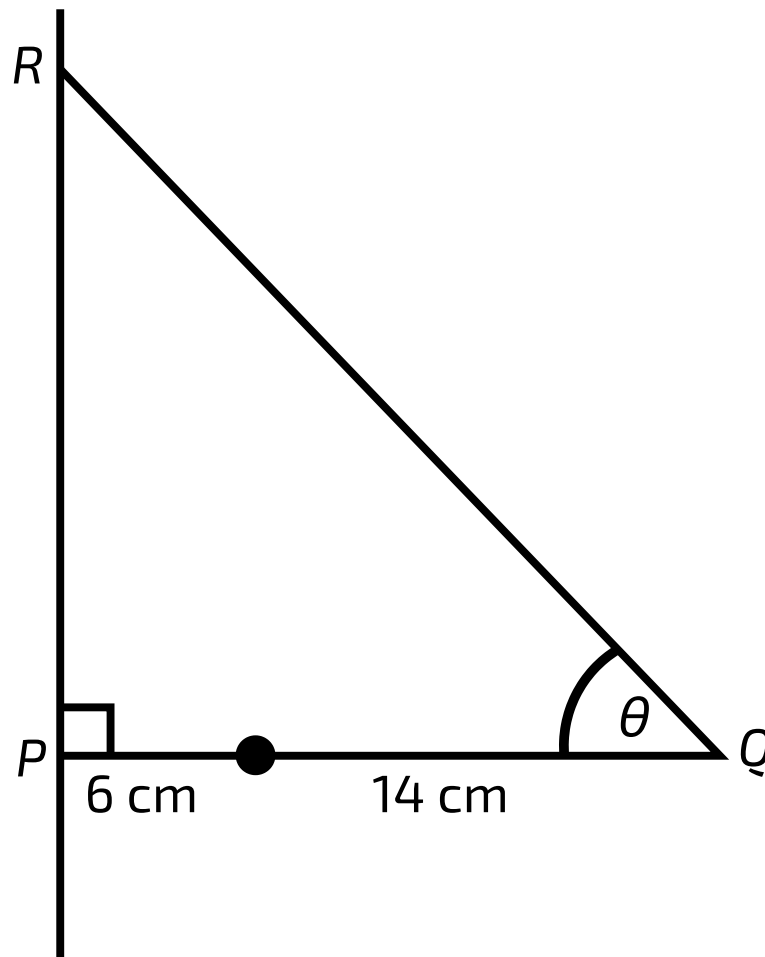


Figure 1: A uniform rod PQ resting against a rough vertical wall at P and held in a horizontal position, perpendicular to the wall, by a light inextensible string at Q .

A uniform rod PQ has weight 18 N and length 20 cm . The end P rests against a rough vertical wall. A particle of weight 3 N is attached to the rod at a point 6 cm from P . The rod is held in a horizontal position, perpendicular to the wall, by a light inextensible string attached to the rod at Q and to a point R on the wall vertically above P , as shown in the diagram. The string is inclined at an angle θ to the horizontal, where $\sin \theta = \frac{3}{5}$. The system is in limiting equilibrium.

Part A Tension in the string

Find the tension in the string to 3 significant figures.

Part B Magnitude of the force

Find the magnitude of the force exerted by the wall on the rod to 3 significant figures.

Part C Coefficient of friction

Find the coefficient of friction between the wall and the rod. Give your answer to 3 significant figures.

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Moments 1ii

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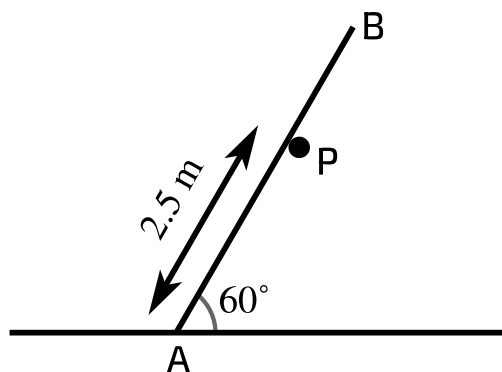


Figure 1: A uniform rod AB , in limiting equilibrium, is supported by a peg at P and A is on rough horizontal ground.

A uniform rod AB , of mass 3 kg and length 4 m , is in limiting equilibrium with A on rough horizontal ground. The rod is at an angle of 60° to the horizontal and is supported by a small smooth peg P , such that the distance AP is 2.5 m (see **Figure 1**).

Part A Force on the rod

Find the force acting on the rod at P . Give your answer to 2 significant figures.

Part B Coefficient of friction

Find the coefficient of friction between the ground and the rod. Give your answer to 2 significant figures.

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