Moments 3ii

A Level
P P P

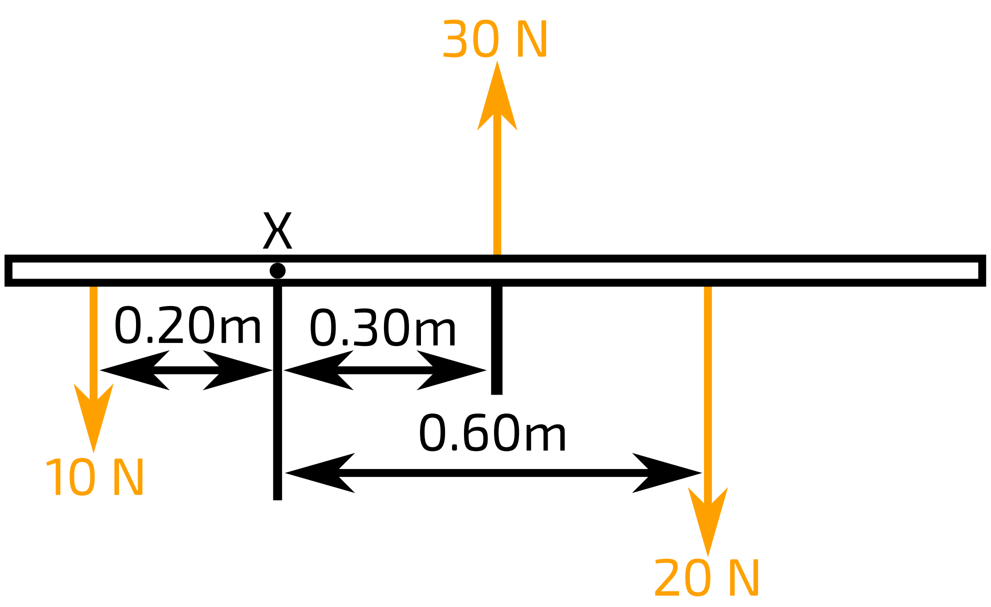

Figure 1: Three forces acting on a rod.

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 $4\,\mathrm{N}$ 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.

Adapted with permission from UCLES, A Level, January 2011, OCR Physics A G481, Question 6

Moments 2ii

A Level

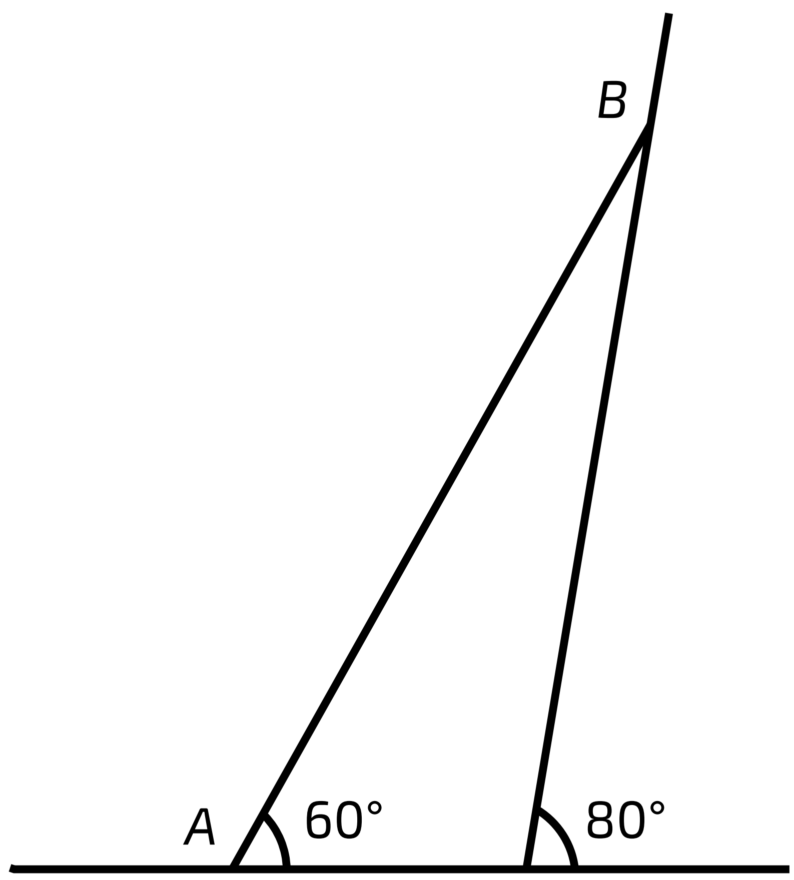

Figure 1: A uniform rod AB resting in equilibrium in a vertical plane against a smooth wall.

A uniform rod AB, of weight $25\,\mathrm{N}$ and length $1.6\,\mathrm{m}$, 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.

Used with permission from UCLES, A Level, January 2007, OCR M1, Question 3

Gameboard:
STEM SMART Single Maths 39 - Moments

Moments 4ii

A Level

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

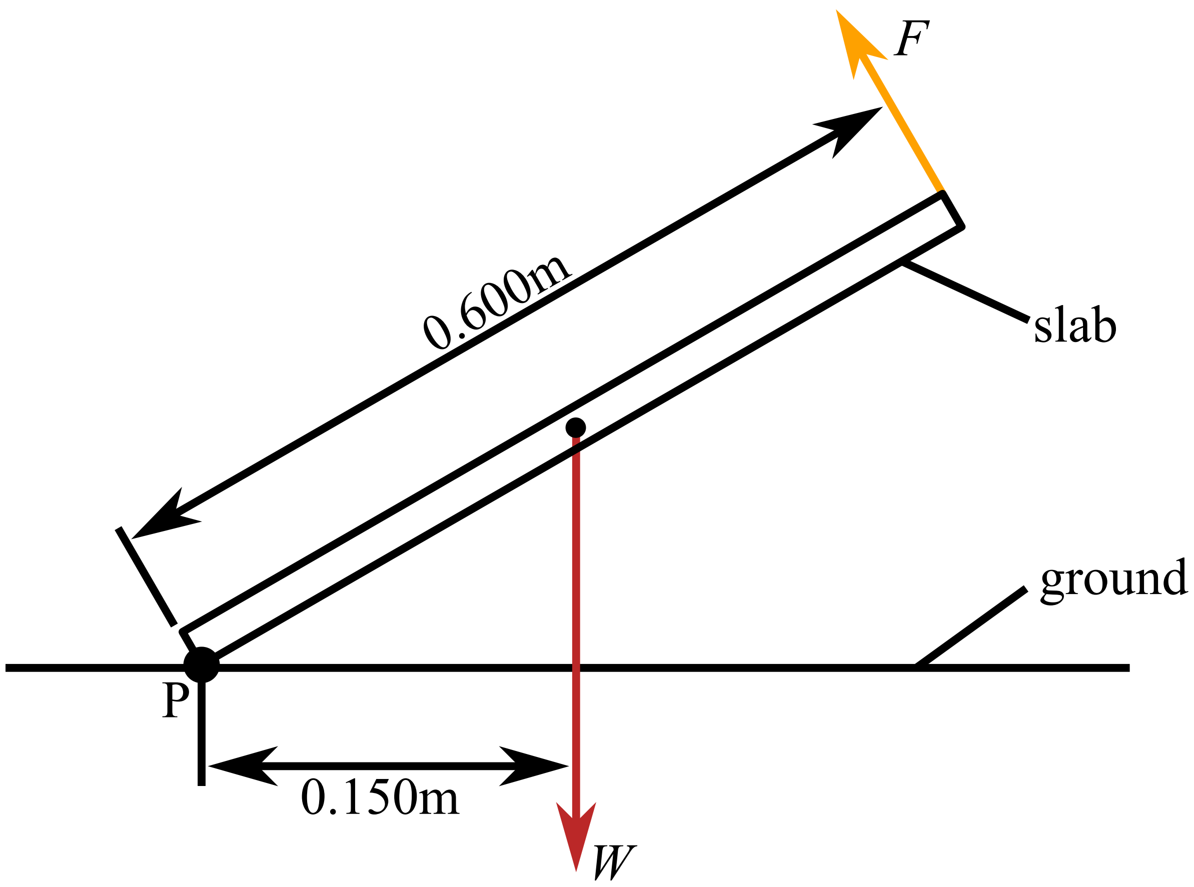

Figure 1: A concrete paving slab in equilibrium.

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

In order to solve this problem, is it necessary to make any assumptions about the distribution of mass within the paving slab? Explain your answer.

More practice questions?

Adapted with permission from UCLES, A Level, June 2010, OCR Physics A G481, Question 6

Gameboard:

STEM SMART Single Maths 39 - Moments

Moments 5i

A Level

P P P

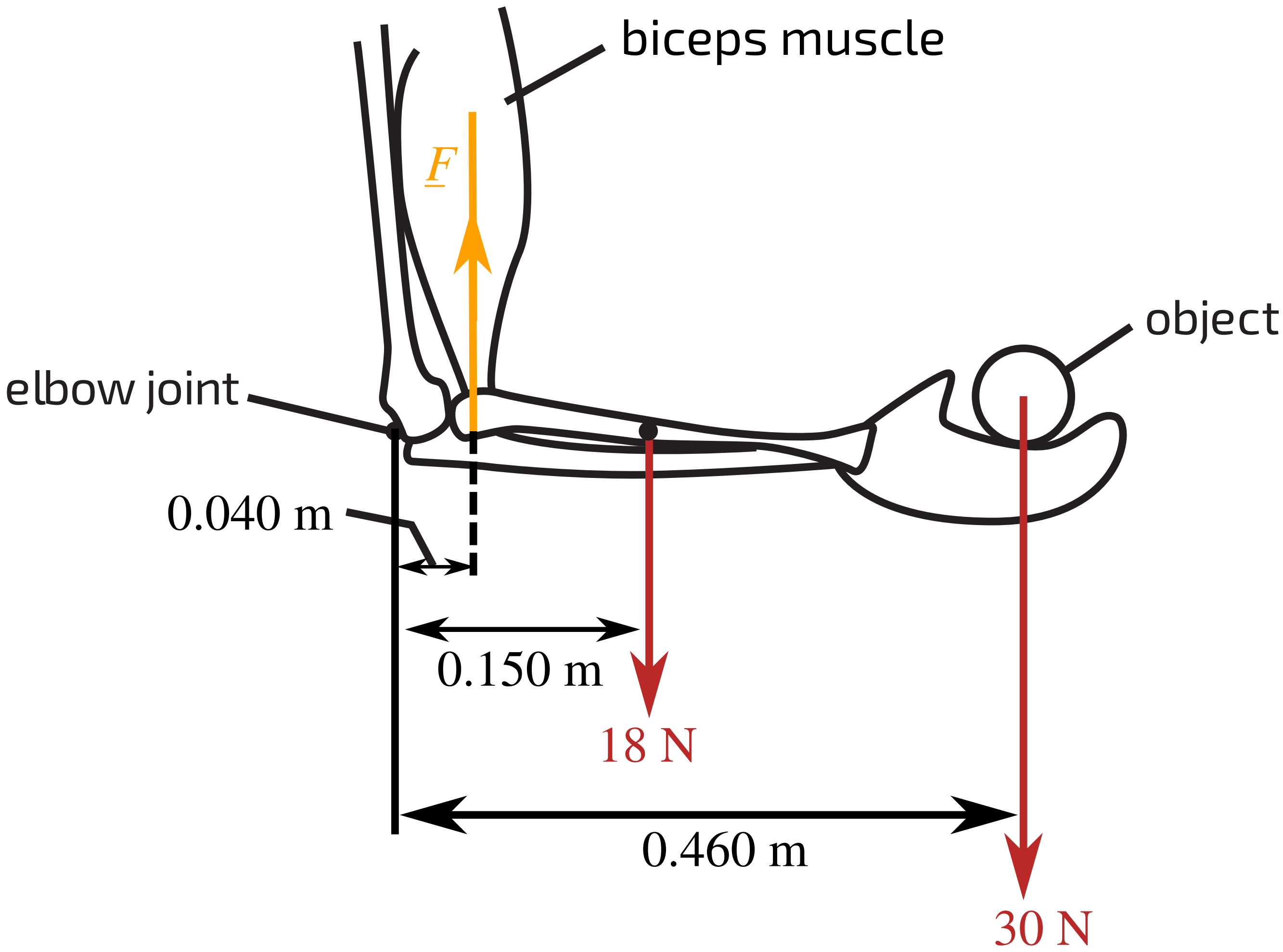

Figure 1: A human arm lifting an object.

Figure 1 shows a human arm lifting an object. The lower arm is horizontal and its centre of gravity is $0.150\,\mathrm{m}$ from the elbow joint. The weight of the lower arm is $18\,\mathrm{N}$. 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 $0.040\,\mathrm{m}$. The weight of the object held in the hand is $30\,\mathrm{N}$ and its centre of gravity is $0.460\,\mathrm{m}$ 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.

Part B Further from body

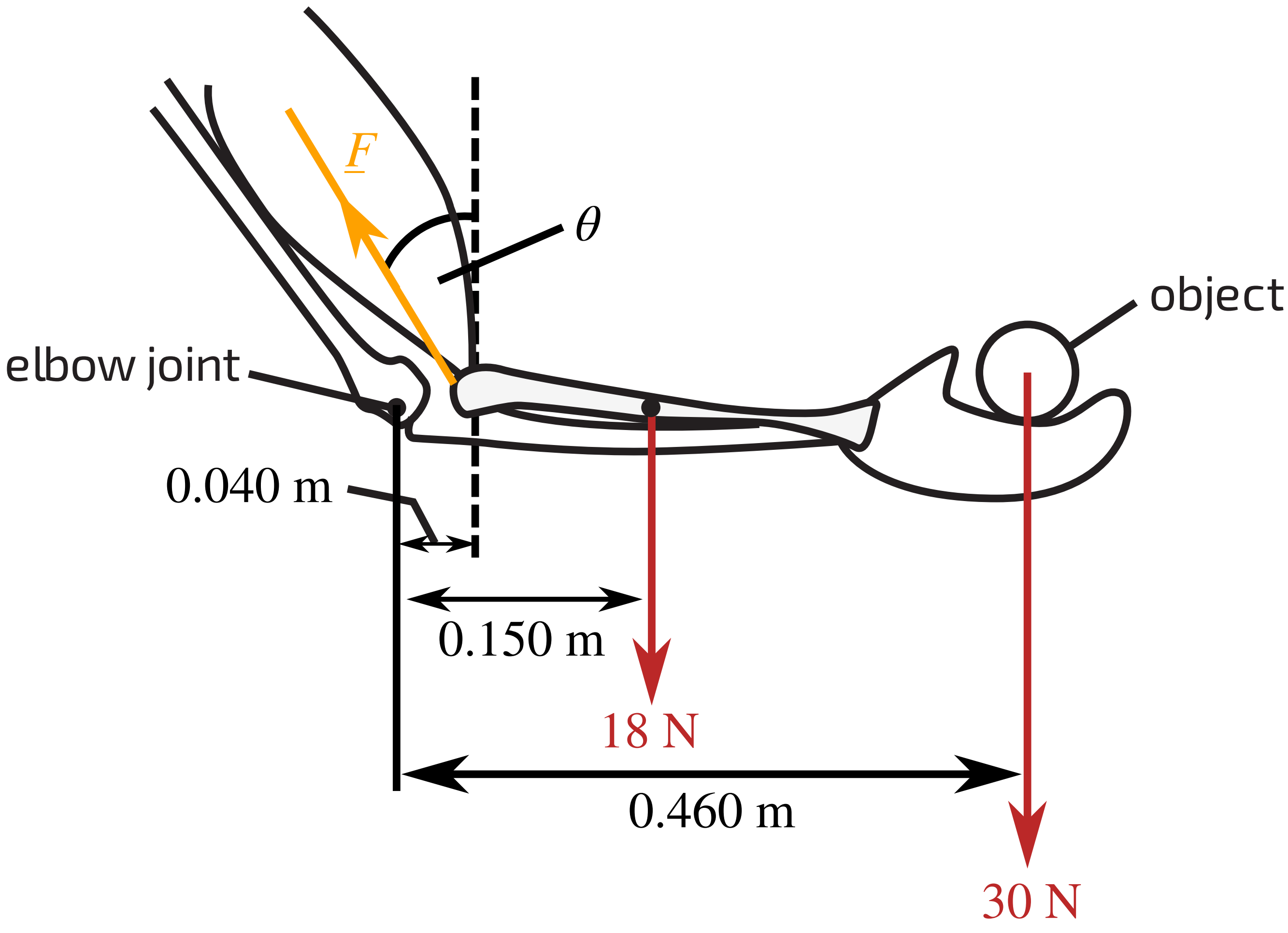

Figure 2: An arm holding a ball with the lower arm moved away from the body.

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

A Level

P P P

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

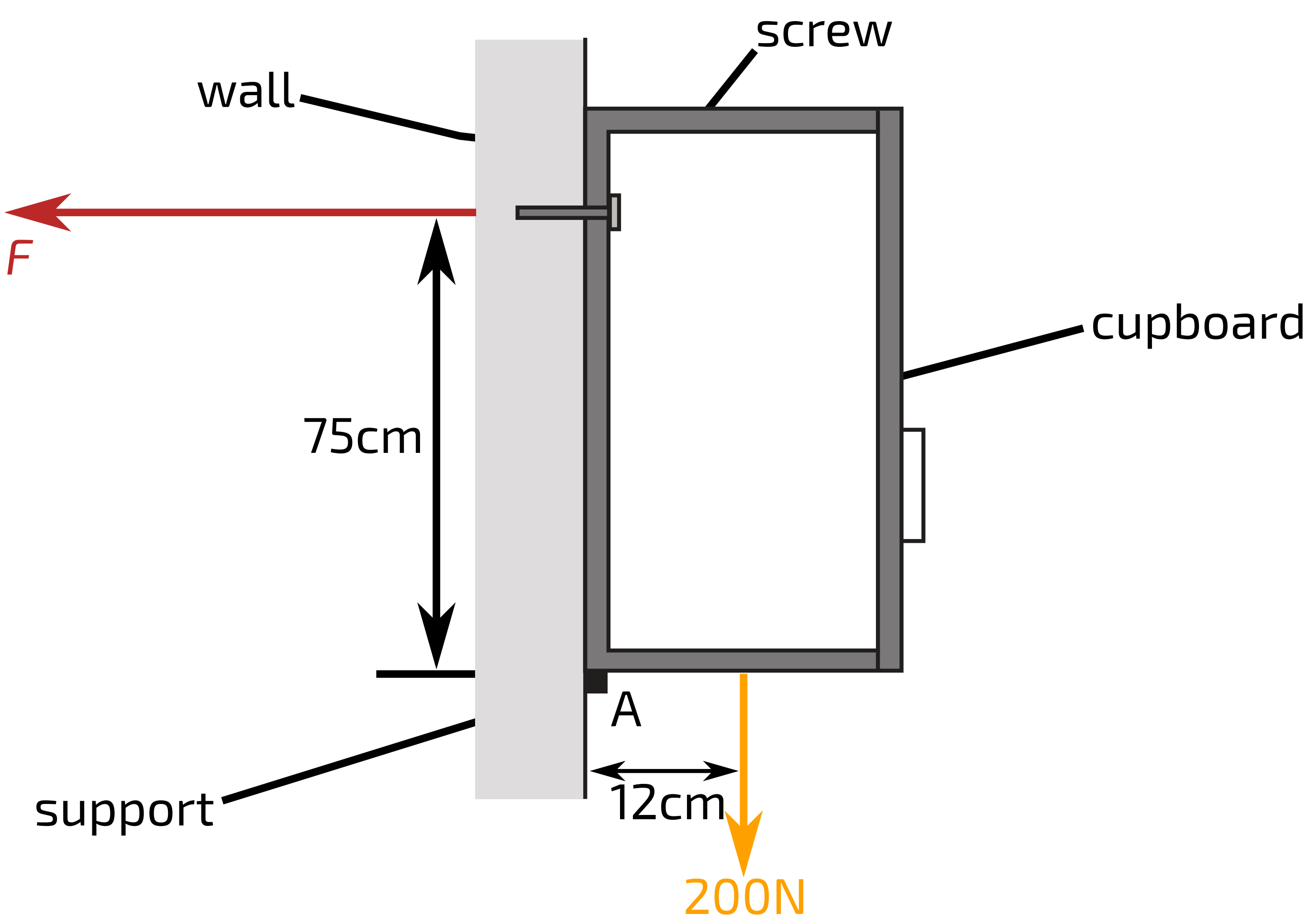

Figure 1: The forces acting on a cupboard.

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

$12\,\mathrm{N\,m}$ $24\,\mathrm{N\,m}$ $2.4\,\mathrm{N\,m}$ $Fd = 24$ $\frac{F}{d} = 24$ $F = 24d$ d^2 d $\frac{1}{d}$ **increases** **stays the same** **decreases**

Adapted with permission from UCLES, A Level, May 2009, OCR Physics A G481, Question 5

Gameboard:

STEM SMART Single Maths 39 - Moments

Moments 3i

A Level

P P P

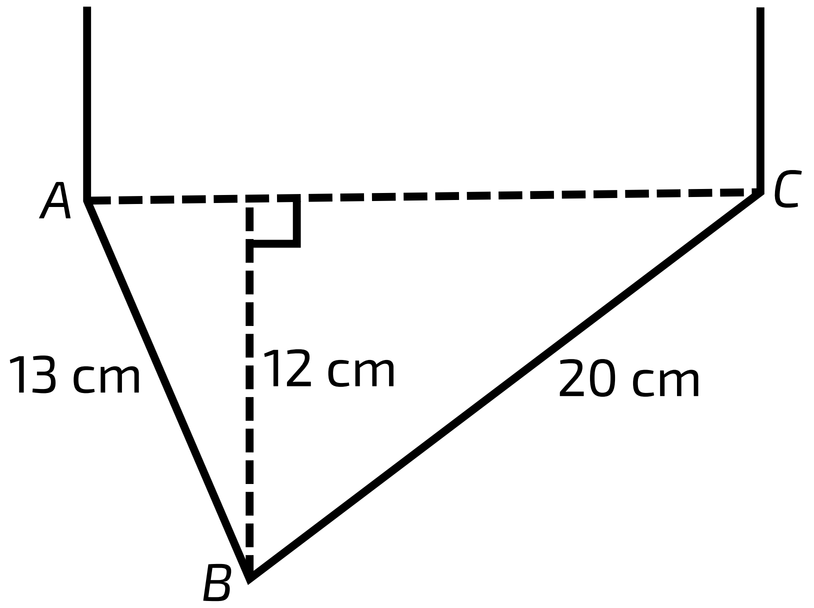

Figure 1: A rigid body consisting of two rods.

A rigid body ABC consists of two uniform rods AB and BC, rigidly joined at B. The lengths of AB and BC are $13\,\mathrm{cm}$ and $20\,\mathrm{cm}$ respectively, and their weights are $13\,\mathrm{N}$ and $20\,\mathrm{N}$ respectively. The distance of B from AC is $12\,\mathrm{cm}$. 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.

Used with permission from UCLES, A Level, Specimen Paper 2004, OCR M2, Question 4

Gameboard:

STEM SMART Single Maths 39 - Moments

Moments 4i

A Level

P P P

A uniform square board of mass $10.0\,\mathrm{kg}$ and side $2.00\,\mathrm{m}$ 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 $1.50\,\mathrm{m}$ and the edge AD makes an angle of $15.0\,^{\circ}$ with the horizontal (see **Figure 1**).

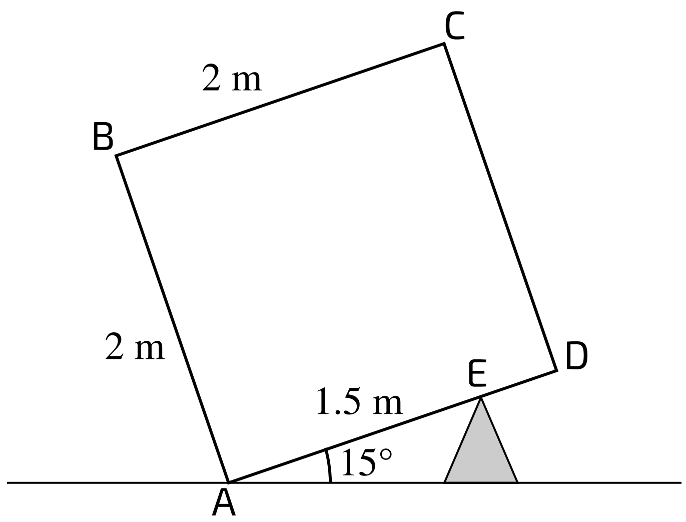

Figure 1: Board $ABCD$ resting in equilibrium on a smooth wedge.

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.

Used with permission from UCLES, A Level Maths, June 2004, OCR M2, Question 4

Gameboard:

STEM SMART Single Maths 39 - Moments

Moments 2i

A Level

P P P

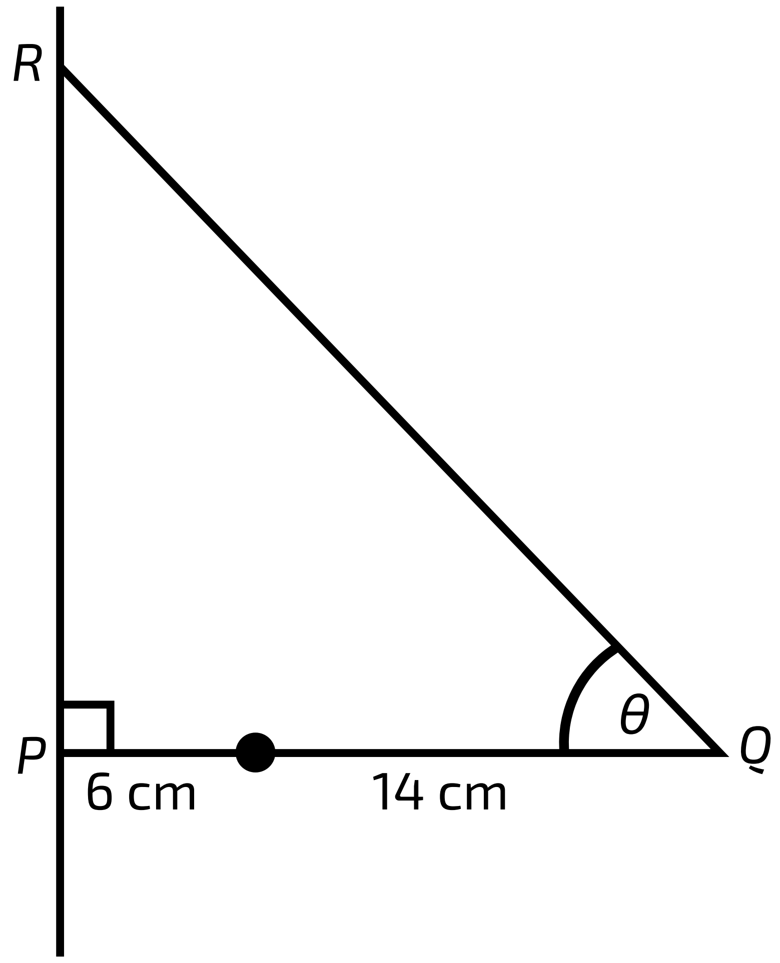

Figure 1: A uniform rod PQ resting against a rough vertical wall at P and held in a horizontal position, perpendicular to the wall, by a light inextensible string at Q.

A uniform rod PQ has weight $18\,\mathrm{N}$ and length $20\,\mathrm{cm}$. The end P rests against a rough vertical wall. A particle of weight $3\,\mathrm{N}$ is attached to the rod at a point $6\,\mathrm{cm}$ 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.

Used with permission from UCLES, A Level, June 2014, OCR M2, Question 4

Gameboard:

STEM SMART Single Maths 39 - Moments

Moments 1ii

A Level

P P P

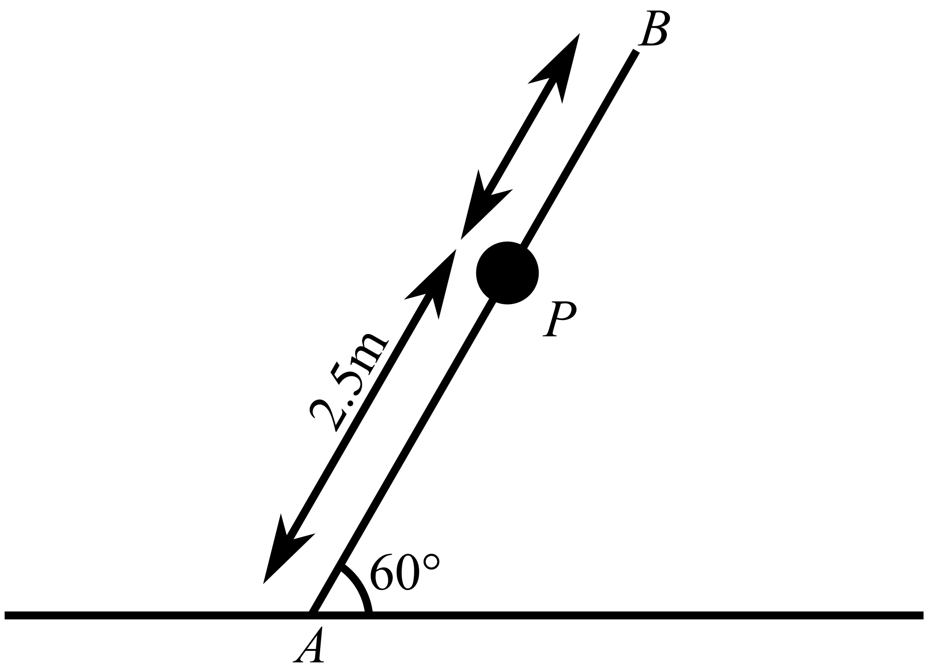

Figure 1: A uniform rod AB, in limiting equilibrium, is supported by a peg at P and A is on rough horizontal ground.

A uniform rod AB, of mass $3\,\mathrm{kg}$ and length $4\,\mathrm{m}$, 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 $2.5\,\mathrm{m}$ (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.

Used with permission from UCLES, A Level Maths, January 2013, OCR M2, Question 5

Hanging a Non-uniform Bar

A Level

This problem involves centre of mass calculation, which is not covered in some Physics A Levels. For more information please check with your teacher.

A non-uniform bar of mass m is hung horizontally between two walls, using two light ropes attached to the ends. One of the ropes makes an angle $\theta = 36.9\,^{\circ}$ to the vertical, and the other makes an angle $\phi = 53.1\,^{\circ}$ to the vertical.

If the bar is $l = 1.00\,\mathrm{m}$ long, how far away from the closest edge is the centre of mass?