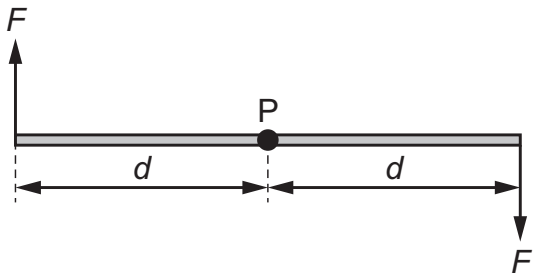
14 Two forces, each of magnitude *F*, act in opposite directions on a rod.



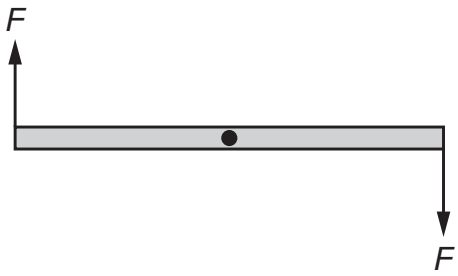
Each force acts on the rod at a distance *d* from the pivot P.

What is the torque of this couple about P?

A 0 **B** $F \times d$ **C** $2F \times d$ **D** $2F \times 2d$

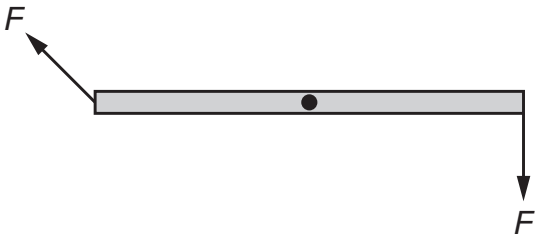
13 Which diagram shows a couple?

A

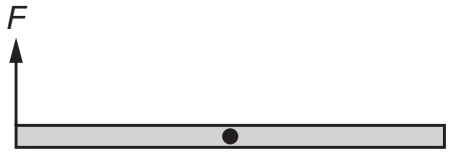


B

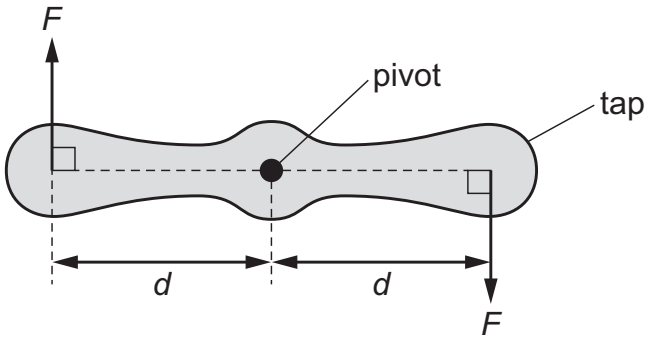
C



D



14 A couple is applied to a tap, as shown.



What is the torque of the couple?

A $\frac{Fd}{2}$ **B** Fd **C** $2Fd$ **D** $4Fd$

2 Fig. 2.1 shows a square metal sheet of non-uniform density, with a thin wooden rod fixed at its centre. One of the corners of the sheet is labelled X.

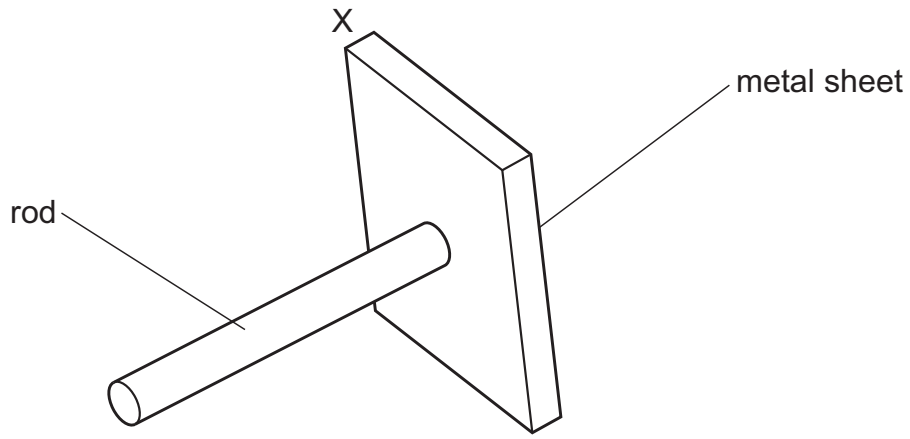


Fig. 2.1

The rod has negligible mass. The mass of the metal sheet is 2.8 kg.
The rod is supported so that the rod is horizontal and the metal sheet is vertical.

(a) Define the torque of a couple.

.....

.....

..... [2]

(b) When the rod is supported in such a way that it can rotate freely within its support, the sheet hangs in equilibrium with point X vertically above the rod, as shown in Fig. 2.2.

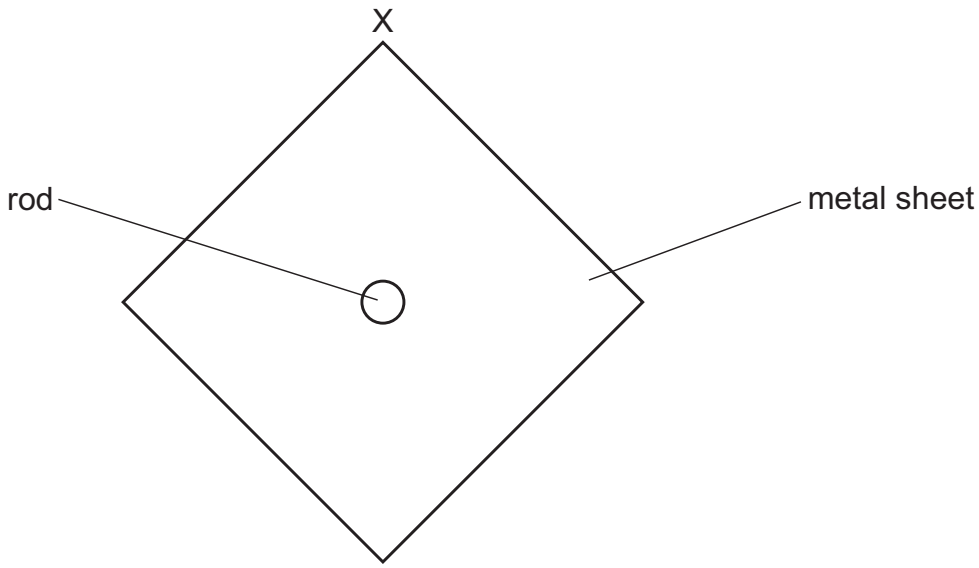


Fig. 2.2

On Fig. 2.2, draw a line to indicate the range of possible positions for the centre of gravity of the metal sheet. [1]

(c) When a torque of 3.3 N m is applied to the rod, the sheet is held in equilibrium with two of its edges horizontal, as shown in Fig. 2.3. Point X is at the top-left corner.

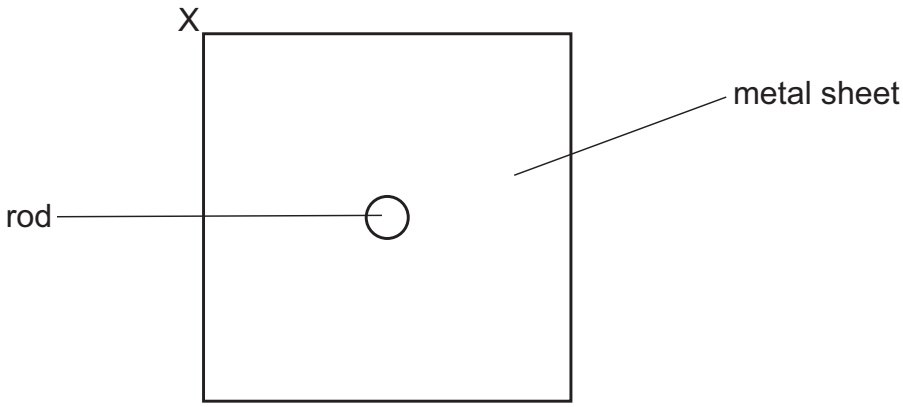


Fig. 2.3

(i) Explain whether the torque applied to the rod to hold the sheet in equilibrium is clockwise or anticlockwise.

.....

..... [1]

(ii) Show that the centre of gravity of the sheet has a horizontal displacement of 0.12 m from the rod.

[1]

(d) The square metal sheet has an average density of 3000 kg m^{-3} and a uniform thickness of 4.0 mm.

Show that the side length of the sheet is 0.48 m.

[3]

(e) Use the answer in **(b)** and the information in **(c)** and **(d)** to determine the position of the centre of gravity of the sheet. Indicate this position on Fig. 2.3 with a point labelled Y. [2]

[Total: 10]

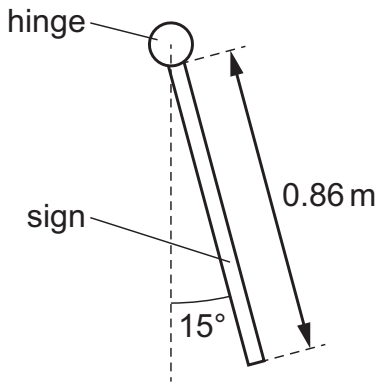
13 Which row describes a pair of forces that forms a couple?

	direction of the forces	magnitude of the forces
A	opposite	different
B	opposite	equal
C	same	different
D	same	equal

15 A square shop sign of uniform density has mass 2.4 kg and sides of length 0.86 m.

The sign is supported by a hinge along its top edge.

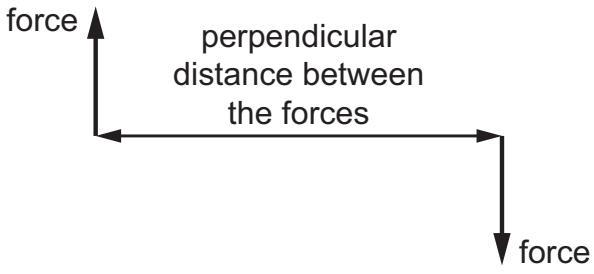
There is friction in the hinge so that the sign hangs from it in equilibrium at an angle of 15° to the vertical, as shown.



What is the moment about the hinge of the weight of the sign?

A 2.6 N m **B** 4.0 N m **C** 5.2 N m **D** 9.8 N m

17 The diagram shows a couple.



How is the torque of the couple calculated?

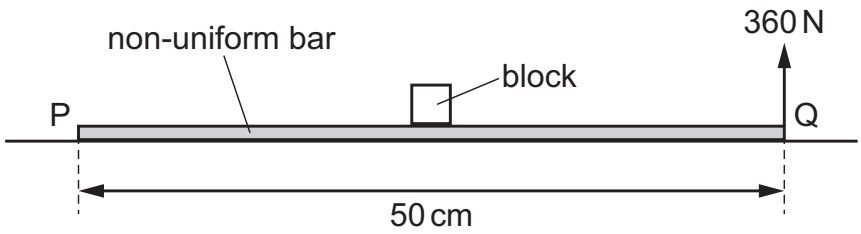
A $\frac{1}{2}$ × perpendicular distance between the forces × magnitude of one of the forces

B perpendicular distance between the forces × magnitude of one of the forces

C perpendicular distance between the forces × magnitude of the sum of the forces

D 2 × perpendicular distance between the forces × magnitude of one of the forces

12 A non-uniform bar PQ has length 50 cm and weight 200 N.



A block of weight 400 N is attached to the top of the bar at its centre. The bar rests on horizontal ground.

A vertical force of 360 N is now exerted upwards on the bar at end Q and is just sufficient to lift end Q from the ground.

What is the distance from the centre of gravity of the bar to end P?

A 0.050 m **B** 0.10 m **C** 0.25 m **D** 0.40 m

10 Which statement about a couple is correct?

A It acts to produce both translational motion and rotation.

B It acts to produce rotation only.

C It acts to produce translational motion only.

D It acts to produce neither rotation nor translational motion.

2 **(a)** Define the moment of a force about a point.

.....

..... [1]

(b) A tree of mass 270 kg grows out of sloping ground and is supported by a post, as shown in Fig. 2.1.

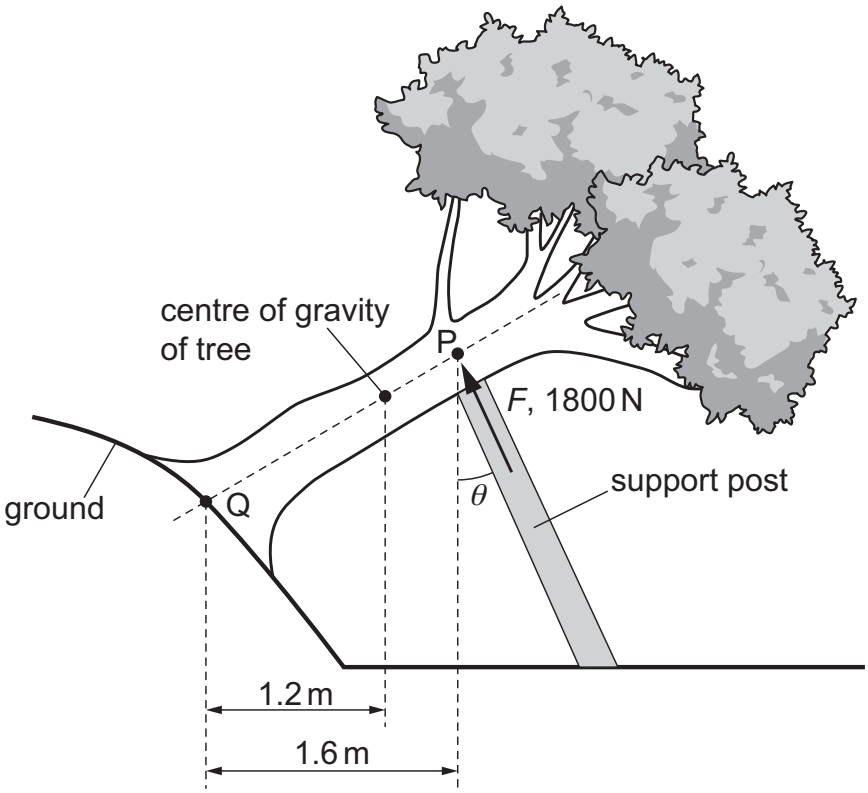


Fig. 2.1 (not to scale)

The ground applies a total force *R* on the tree at point Q.
The centre of gravity of the tree is a horizontal distance of 1.2 m from Q.
The post applies a force *F* of 1800 N perpendicular to the line PQ. The line of action of *F* passes through point P at an angle θ to the vertical. P is a horizontal distance of 1.6 m from Q.
The tree is in equilibrium and all forces act on the tree in the same plane.

(i) By taking moments about point Q, show that θ is 25°.

[3]

(ii) On Fig. 2.2, draw a labelled scale vector triangle to represent the forces acting on the tree. The weight of the tree has been drawn to scale.

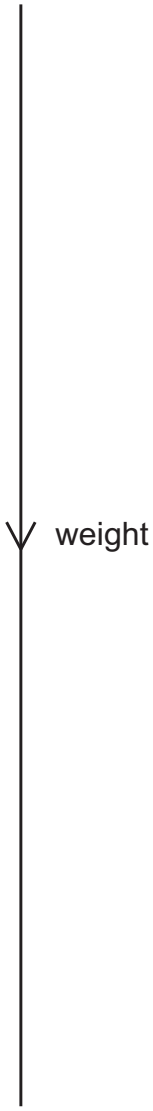


Fig. 2.2

[2]

(iii) The tree exerts a pressure of 150 kPa on the top of the post.

Determine the surface area of the tree in contact with the post.

area = ... m^2 [2]

[Total: 8]

2 **(a)** Define the moment of a force about a pivot.

.....

..... [1]

(b) Three objects A, B and C are placed on a horizontal beam. The beam is in equilibrium, as shown in Fig. 2.1.

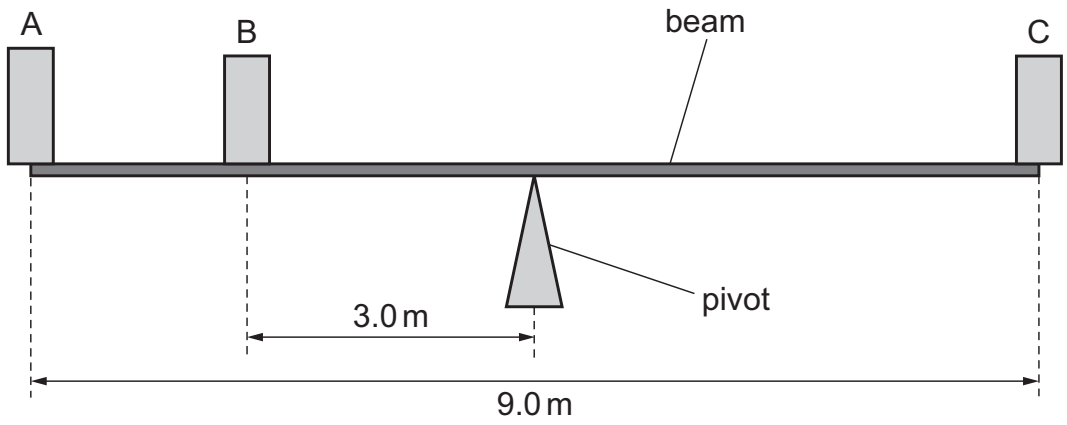


Fig. 2.1 (not to scale)

The beam is uniform and has length 9.0 m.
A pivot is at the midpoint of the beam.
Object A has mass 90 kg and is at one end of the beam.
Object B has mass *m* and is a distance of 3.0 m from the pivot.
Object C has mass 150 kg and is at the other end of the beam.

(i) Calculate *m*.

m = ... kg [3]

(ii) Object A is removed and replaced by a wire fixed to the end of the beam and to the ground, as shown in Fig. 2.2.

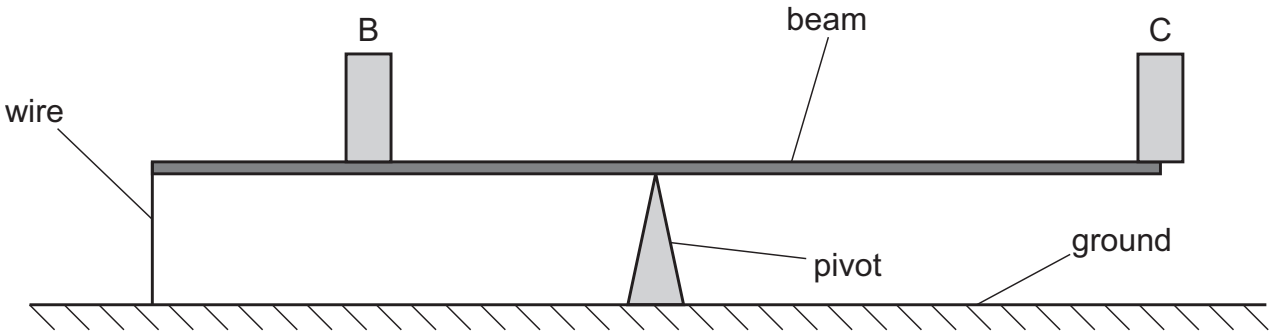


Fig. 2.2

After the change, the beam is again horizontal and in equilibrium. The positions of B and C are unchanged.

The wire has a diameter of 1.8×10^{-3} m and has a strain of 1.2×10^{-3}.
The wire is not extended beyond its limit of proportionality.

Calculate the Young modulus of the wire.

Young modulus = ... Pa [3]

(iii) Object B is now moved to a new position closer to the pivot without passing it. The beam is again horizontal and in equilibrium.

State and explain the effect, if any, that this has on the strain in the wire.

.....

.....

..... [2]

[Total: 9]