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IGCSE PHYSICS 0625 · TOPICAL PAST PAPERS

Turning Effect of Forces

Paper 2 — Theory / Structured Questions (topical compilation)

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Question # 1: May June 2008/P2/Q2

Fig. 2.1 shows a device for punching holes in a piece of paper. A person applies a force *F* at the end of the arm. Just before the hole is made in the paper, the arm is at rest.

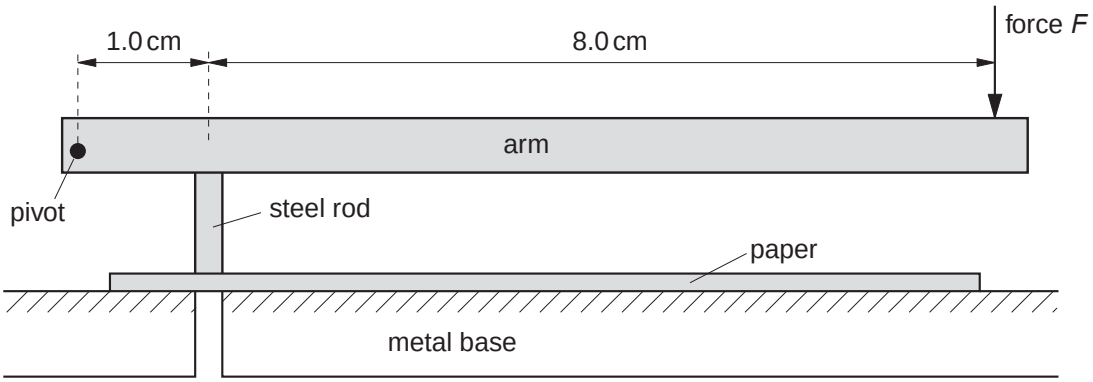

Fig. 2.1

(a) Just before the hole is made, the force upwards on the steel rod is 7.2 N.

Calculate the value of *F*. Use the distances marked on Fig. 2.1.

F = ... [2]

(b) The steel rod pushes the paper into the hole in the metal base with a force of 7.2 N. The end of the steel rod has an area of $2.8 \times 10^{-5}\,m^2$.

Calculate the pressure exerted on the paper.
State the formula that you use in your calculation.

pressure = ... [2]

(c) The force downwards on the paper due to the rod and the force upwards on the rod due to the paper are related by Newton's third law. State Newton's third law.

.....

.....

..... [1]

Question # 2: May June 2013/P21/Q2

Fig. 2.1 shows apparatus used to investigate the turning effect of a force.

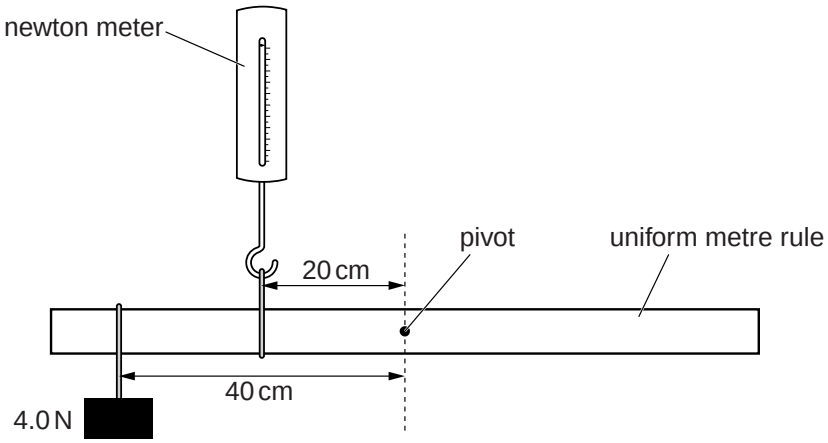

Fig. 2.1

The uniform metre rule is freely pivoted at its centre.

The newton meter is 20 cm from the pivot and a 4.0 N weight is 40 cm from the pivot.

The metre rule is in equilibrium.

(a) State the principle of moments for a body in equilibrium.

.....

.....

..... [1]

(b) Calculate the reading on the newton meter.

reading = ... [2]

(c) The weight of the metre rule is 1.2 N.

Calculate the size of the force exerted on the metre rule by the pivot.

force = ... [2]

Question # 3: May June 2013/P22/Q2

(a) Explain what is meant by the *moment of a force*.

.....

.....

..... [2]

(b) Fig. 2.1 shows a system for raising a heavy piece of metal into a vertical position.

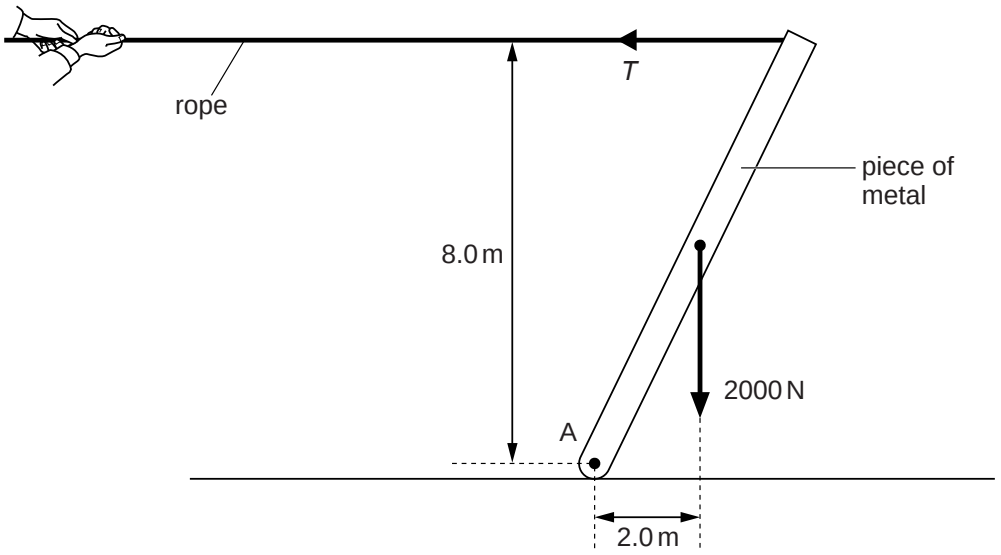

Fig. 2.1 (not to scale)

A man pulls on the rope with a horizontal force *T*. The piece of metal has a weight of 2000 N and is freely pivoted at A. The system is in equilibrium.

(i) By taking moments about A, calculate *T*.

T = ... [2]

(ii) The force *T* and the force that the rope exerts on the man are related by Newton's third law. State the relationship between these forces.

.....

.....

..... [2]

Question # 4: May June 2014/P22/Q2

Fig. 2.1 shows part of a hydraulic jack used to lift the front of a car.

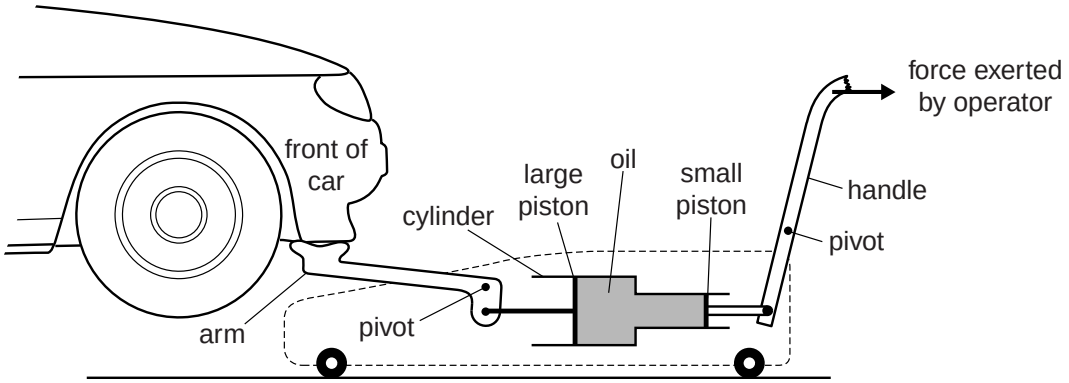

Fig. 2.1 (not to scale)

The operator pulls the handle and causes a force of 50 N to act on the small piston. The force exerted by the oil on the large piston increases by *F*. The large piston moves and rotates the arm about the pivot. This raises the front of the car.

The cross-sectional area of the small piston is 1.5 cm^2.
The cross-sectional area of the large piston is 5.0 cm^2.

(a) Calculate

(i) the pressure in the oil caused by the force on the small piston,

pressure = ... [2]

(ii) the value of *F*.

F = ... [1]

(b) Explain why the large piston moves through a shorter distance than the small piston.

.....

.....

..... [1]

(c) The efficiency of the jack is 75%. Explain what is meant by *efficiency*.

.....

..... [2]

Question # 5: May June 2015/P21/Q2

Fig. 2.1 shows a student doing a press-up. A total force *F* acts upwards on his hands. There is also a force upwards on his toes.

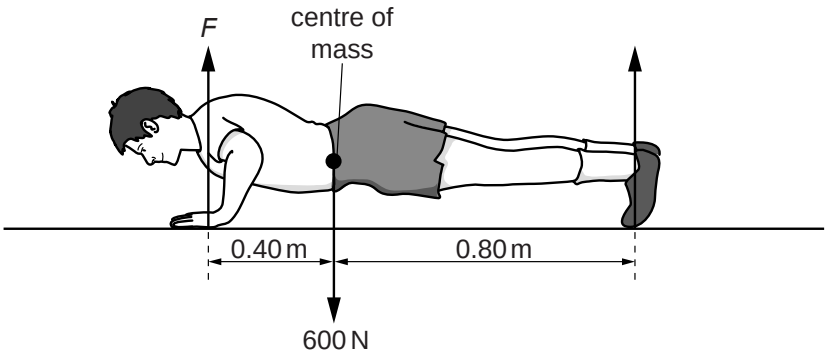

Fig. 2.1 (not to scale)

The weight of the student is 600 N and this force acts downwards from his centre of mass.

(a) **(i)** Explain why the student does work as his body rises from the ground.

.....

.....[1]

(ii) State the form of energy that the student uses to do this work.

.....[1]

(b) At the position shown in Fig. 2.1, the student is stationary.
The weight of the student causes a moment about his toes.

(i) Calculate the moment of the weight of the student about his toes.

moment = ...[1]

(ii) Calculate the value of the force *F*.

F = ...[2]

Question # 6: May June 2017/P21/Q2

Fig. 2.1 shows a student sitting on a chair. Fig. 2.2 shows the same student with his chair tilted backwards slightly.

Fig. 2.1

Fig. 2.2

(a) State and explain how the pressure of the chair on the floor differs in the two positions.

.....

.....

.....

.....[2]

(b) The chair and student fall over if the chair is tilted backwards more than in Fig. 2.2.

Explain why.

.....

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.....

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.....[2]

Question # 7: May June 2017/P22/Q3

Fig. 3.1 shows the brake pedal of a car which is connected to a brake cylinder.

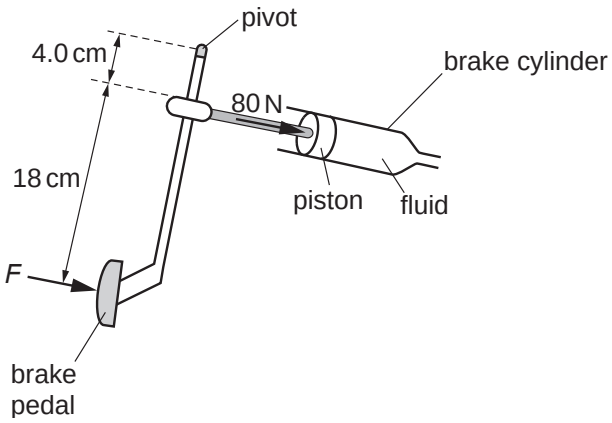


Fig. 3.1 (not to scale)

The brake is pressed with a force *F*. This force produces a moment about the pivot.

Pressing the brake causes a force of 80 N to act on the piston.

(a) Define the term *moment*.

.....

.....[2]

(b) Calculate the force *F* applied to the brake pedal.

F = ...[2]

(c) The cross-sectional area of the piston is 0.0012 m^2.

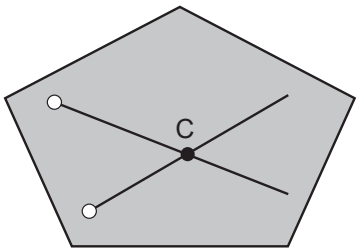
Calculate the pressure exerted by the brake piston on the fluid.

pressure = ...[2]

Question # 8: May June 2020/P21/Q2

A student performs an experiment to mark the centre of mass C on a thin piece of card. There are two holes in the card.

Fig. 2.1 shows the card and two lines that the student draws on the card.



key
○ = hole
C = centre of mass

Fig. 2.1

(a) Describe a method used to draw these two lines in their correct positions on the card.

Make clear what extra apparatus is needed. You may draw a diagram, if you wish.

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..... [3]

(b) The student holds the card loosely between her fingers. The card is vertical, resting with its lower edge on a bench as shown in Fig. 2.2.

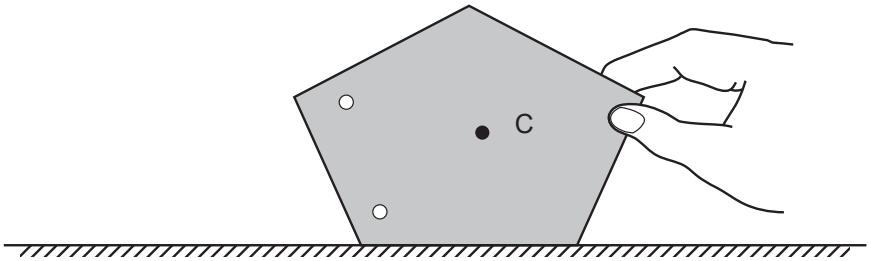

Fig. 2.2

The card is tilted slightly, as shown in Fig. 2.3, and then released.

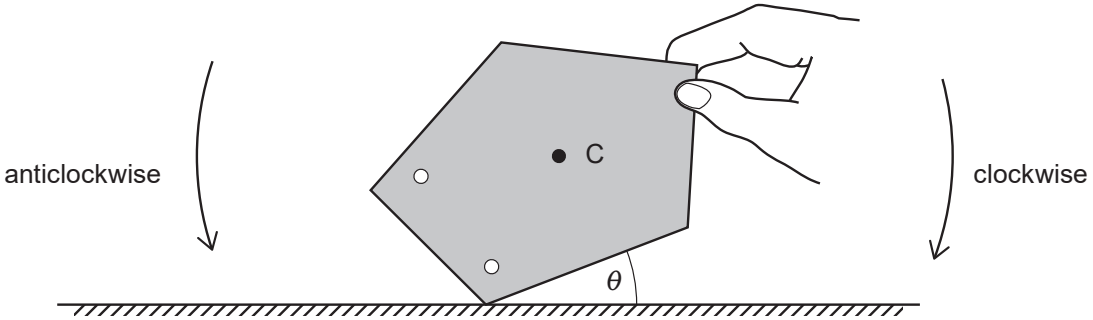

Fig. 2.3

When angle θ is small, the card falls clockwise, back to the position shown in Fig. 2.2.

(i) Explain why the card falls anticlockwise when θ is large.

.....

.....

.....

..... [2]

(ii) State one change to the card that makes it more stable.

.....

..... [1]

[Total: 6]

Question # 9: Oct Nov 2003/P2/Q2

(a) Fig. 2.1 shows the same vertical force of 200 N exerted by a cyclist on the pedal of a bicycle in three different positions **A**, **B** and **C**.

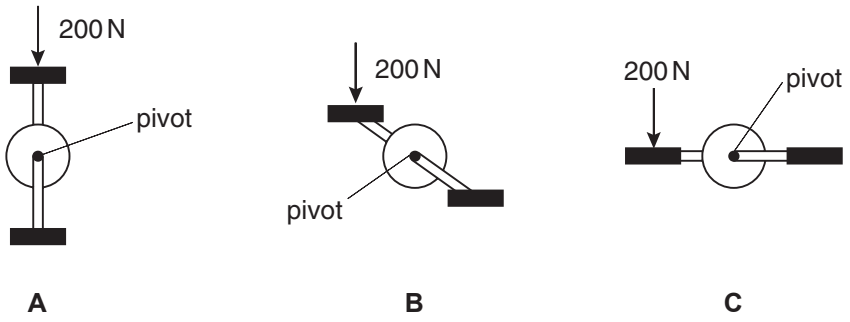

Fig. 2.1

State the position, **A**, **B** or **C**, in which the force exerts the largest moment about the pivot.

Give a reason for your answer.

.....

.....

..... [2]

(b) Fig. 2.2 shows a support for a leg in plaster and Fig. 2.3 shows a simplified diagram of the forces acting on the leg.

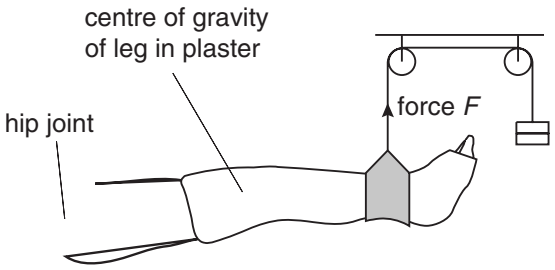

Fig. 2.2

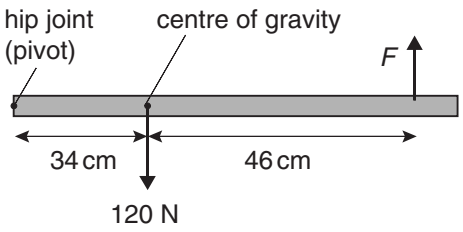

Fig. 2.3

Calculate the force *F* needed to keep the leg in a horizontal position.

F = ... [3]

Question # 10: Oct Nov 2008/P2/Q2

Fig. 2.1 shows a wooden walking-stick that has a metal head and a rubber foot. It balances on a pencil placed 0.50 m from its rubber foot.

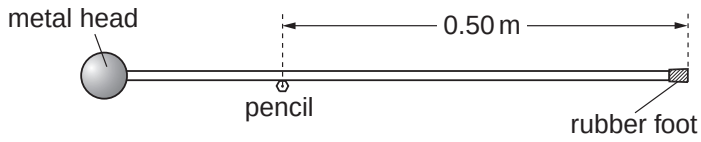

Fig. 2.1

(a) State the distance between the centre of mass of the walking-stick and the end of the rubber foot.

distance = ... [1]

(b) The pencil is moved along the walking-stick towards its rubber foot. State and explain the motion of the walking-stick.

.....

.....

.....

..... [3]

Question # 11: Oct Nov 2009/P2/Q7

Fig. 7.1 shows a rectangular concrete slab of weight 18 000 N. It rests on a brick wall and is the roof of a bus shelter. The concrete slab is 3.0 m wide.

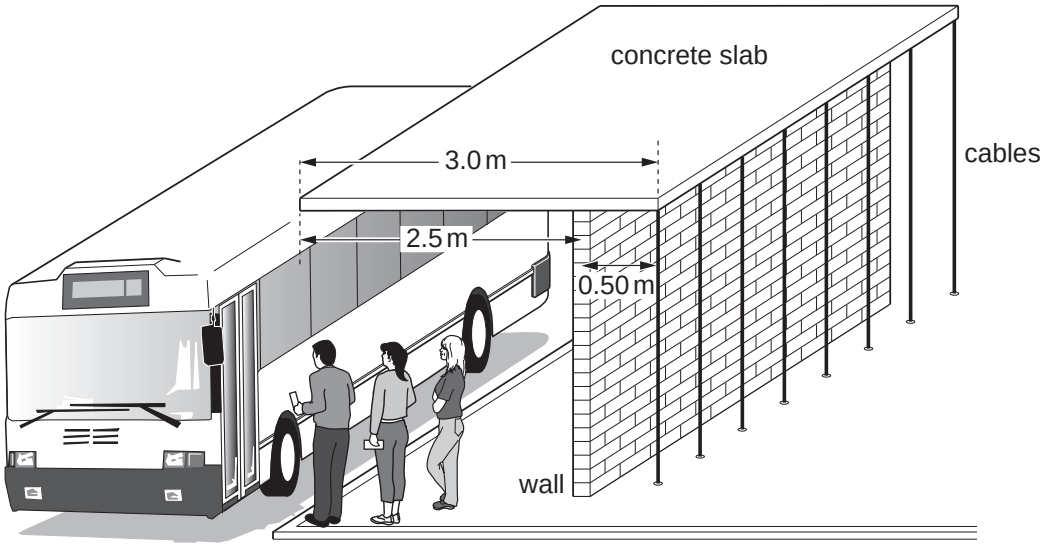

Fig. 7.1

The wall is 2.5 m from the front of the concrete slab and 0.50 m from the back. The cables behind the shelter pull downwards and stop the slab toppling forwards.

(a) The concrete slab is of uniform thickness and density. Determine the perpendicular distance between the wall and the centre of mass of the slab.

distance = ... [1]

(b) **(i)** State the principle of moments.

.....

.....

..... [2]

(ii) Calculate the total downward force exerted by the cables on the slab.

force = ... [2]

Question # 12: Oct Nov 2010/P22/Q3

Fig. 3.1 shows a firefighter of total weight 840 N in equilibrium at the top of a ladder that is pivoted at point P.

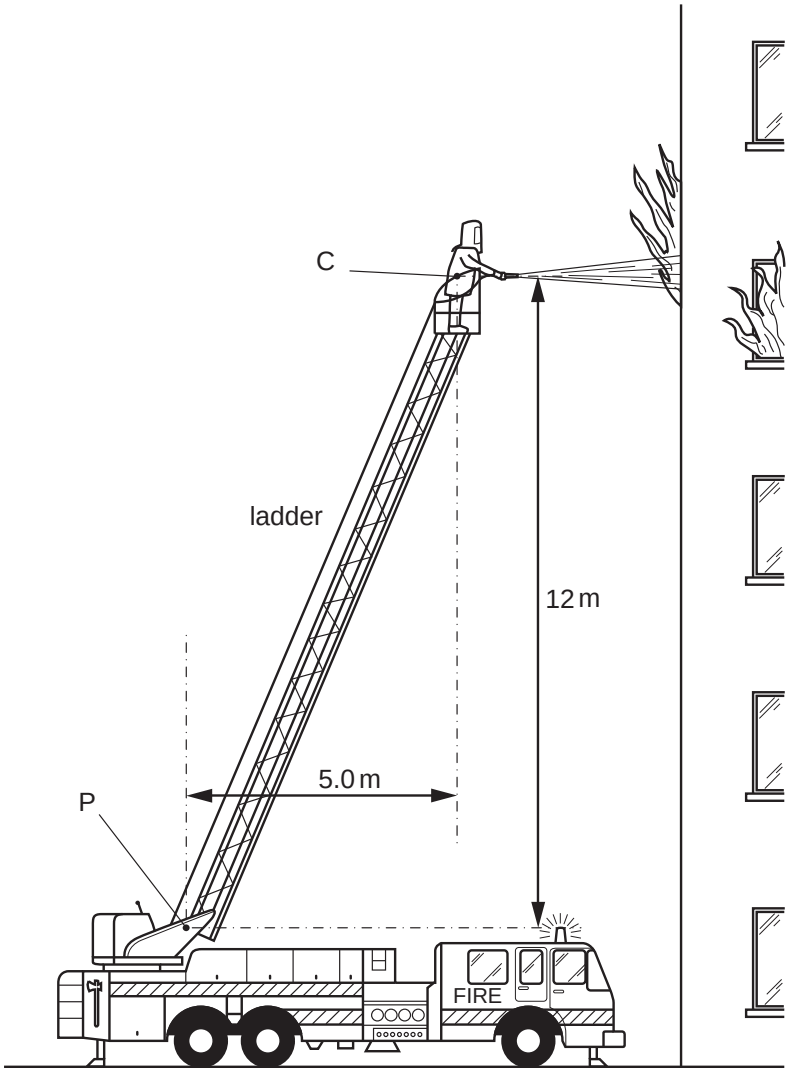

Fig. 3.1

The ladder leans towards a burning building at an angle such that the centre of gravity C of the firefighter is 12 m above and 5.0 m to the right of P. The firefighter holds a hose that directs a high-speed jet of water horizontally into a burning building.

(a) (i) Calculate the moment *M* of the firefighter's weight about P.

moment = ...[2]

(ii) The jet of water causes a horizontal force *R* on the firefighter that acts towards the left, through C. This opposes the turning effect of his weight. Calculate the size of *R* that, on its own, ensures that *M* is exactly cancelled.

force = ... [1]

(iii) Suggest a third force that has a turning effect about P on the ladder.

.....

..... [1]

(b) Fig. 3.2 shows the firefighter.

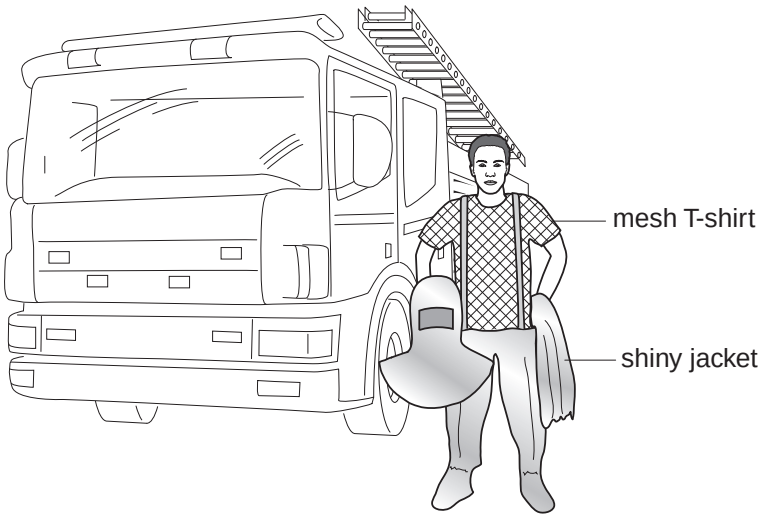

Fig. 3.2

The jacket of his protection suit has a shiny, silver-coloured outer surface. Underneath it he wears a loosely-woven mesh T-shirt (string vest).

Explain how wearing the shiny jacket and the mesh T-shirt helps to keep the firefighter cool when he is close to a source of intense heat.

.....

.....

.....

.....

.....

..... [4]

Question # 13: Oct Nov 2011/P22/Q1

A builder needs to determine the density of a solid cube of wood.

He places the 50 cm mark of a uniform metre rule on a pivot, so that the rule balances.

He then places the cube on the rule with its centre of gravity directly above the 75 cm mark. A mass of 0.050 kg is moved along the rule until balance is restored. This is shown in Fig. 1.1.

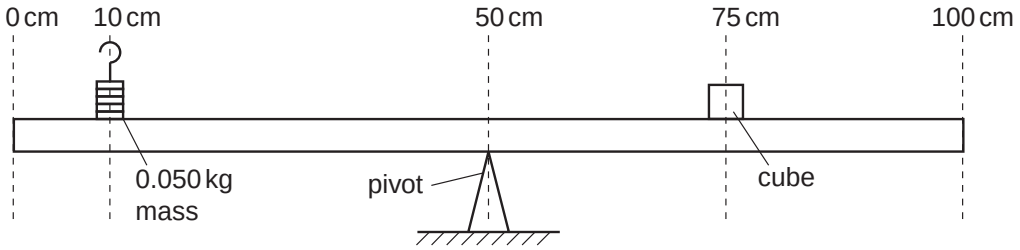

Fig. 1.1 (not to scale)

The rule is balanced when the 0.050 kg mass is at the 10 cm mark.

(a) Calculate the mass of the cube.

mass = ...[3]

(b) The cube has a volume of $1.6 \times 10^{-4}\,m^3$. Determine the density of the wood.

density = ... [2]

Question # 14: Oct Nov 2012/P22/Q1

(a) Describe an experiment to verify *the principle of moments*. You may include a diagram in your answer.

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..... [4]

(b) Fig. 1.1 shows a spanner tightening a nut.

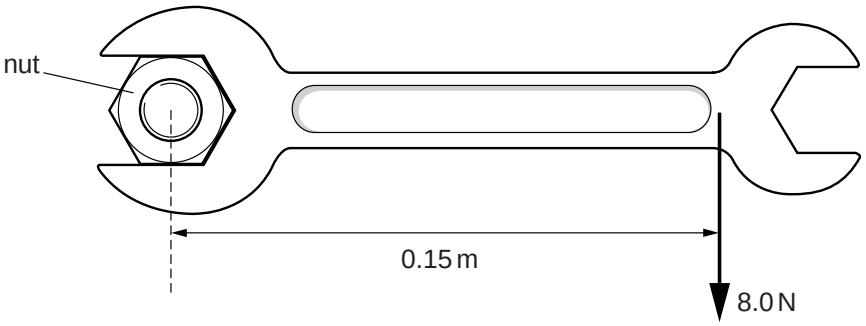

Fig. 1.1

A force of 8.0 N is applied to the spanner at a perpendicular distance of 0.15 m from the centre of the nut.

Calculate the moment of the force acting on the nut.

moment = ... [2]

Question # 15: Oct Nov 2013/P21/Q3

A girl of weight 550 N is playing on a see-saw with her brother. Fig. 2.1 shows her brother of weight *W* sitting 1.1 m to the right of the balance point.

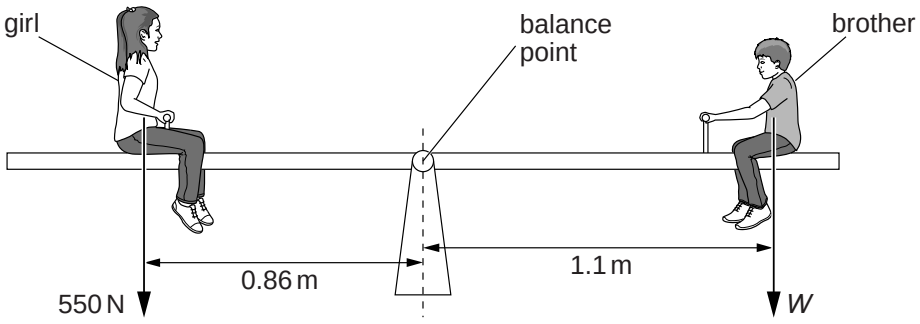

Fig. 2.1 (not to scale)

The see-saw is balanced when the girl sits 0.86 m to the left of the balance point.

(a) Calculate *W*.

W = ...[2]

(b) The girl and her brother slide equal distances along the see-saw away from each other.

Describe and explain what happens.

.....

.....

.....

.....[3]

Question # 16: Oct Nov 2014/P21/Q2

A student places a metre rule on the edge of a triangular prism. The prism is used as a pivot and the rule balances about the 50 cm mark.

The student then places a block of wood at the 10 cm mark on the rule and an empty measuring cylinder at the 80 cm mark. The rule is still balanced. Fig. 2.1 shows the arrangement.

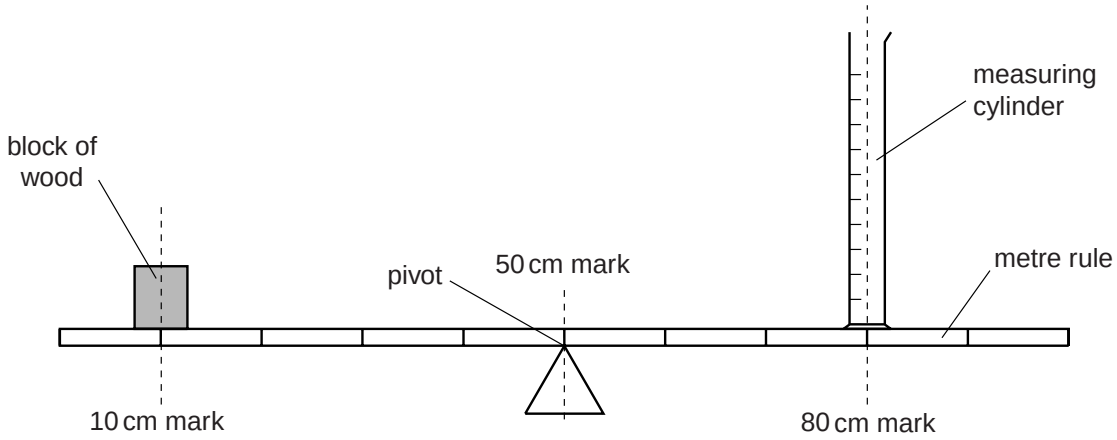

Fig. 2.1 (not to scale)

The student now places a weight of 0.39 N on top of the block of wood. She then starts to pour oil into the measuring cylinder. The rule balances again when there is 60 cm^3 of oil in the measuring cylinder.

The gravitational field strength *g* is 10 N / kg.

(a) Calculate

(i) the weight of the oil in the cylinder,

weight = ...[2]

(ii) the mass of the oil in the cylinder.

mass = ...[1]

(b) Calculate the density of the oil.

density = ...[2]

Question # 17: Oct Nov 2014/P22/Q2

In hospitals, doctors and nurses operate taps with their elbows in order to avoid contamination.

Fig. 2.1 shows a hospital tap with a long handle.

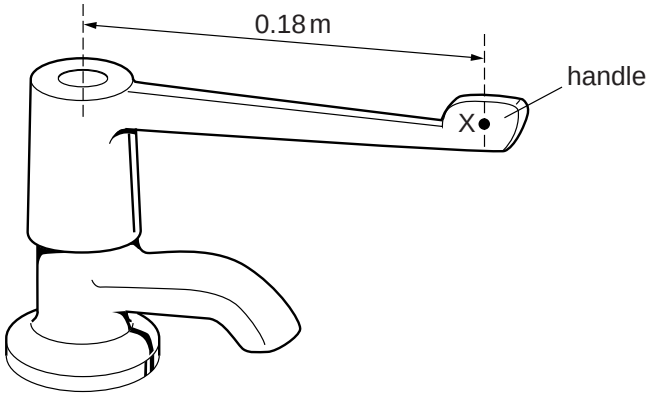

Fig. 2.1

(a) A nurse applies a force of 2.5 N at a point X on the handle, 0.18 m from the axis of the tap.

(i) Calculate the maximum moment about the axis that this force can produce.

moment = ...[2]

(ii) The moment produced by the nurse is less than this maximum value.

Suggest one reason why this is so.

.....

.....[1]

(b) State how the force needed to operate the tap is affected by the length of the handle.

.....

.....[1]

Question # 18: Oct Nov 2015/P21/Q4

Fig. 4.1 shows a screwdriver of mass 64 g resting in equilibrium on a pivot.

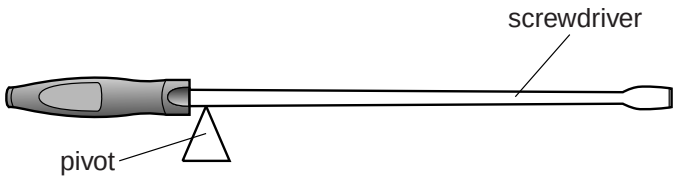

Fig. 4.1

(a) On Fig. 4.1, mark and label with a C, the centre of mass of the screwdriver. [1]

(b) The gravitational field strength is 10 N / kg.

(i) Calculate the weight of the screwdriver.

weight = ... [1]

(ii) On Fig. 4.1, draw an arrow labelled *W* to represent the weight of the screwdriver. [1]

(c) State two conditions that apply when an object is in equilibrium.

1. .....

.....

.....

2. .....

.....

.....

[2]

Question # 19: Oct Nov 2016/P21/Q2

Fig. 2.1 shows a bed that folds away against a wall during the day.

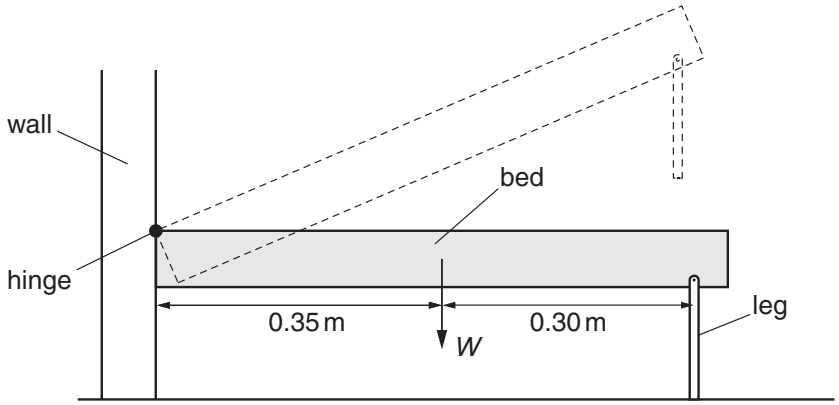

Fig. 2.1 (not to scale)

When it is horizontal, the bed is supported on one side by a hinge and on the other side by two legs. The weight *W* of the bed acts through its centre of mass, which is at a horizontal distance of 0.35 m from the hinge.

(a) The mass of the bed is 26 kg. The gravitational field strength *g* is 10 N / kg.

Calculate the weight *W* of the bed.

W = ...[1]

(b) **(i)** State the principle of moments.

.....

.....

.....

.....[2]

(ii) Determine the size of the total upward force exerted on the bed by the two legs when the bed is horizontal.

total force = ...[3]

Question # 20: Oct Nov 2016/P22/Q3

When the lid of a freezer is opened, it pivots about the hinge at the back of the freezer. The handle is at the front.

Fig. 3.1 is a side view of the freezer.

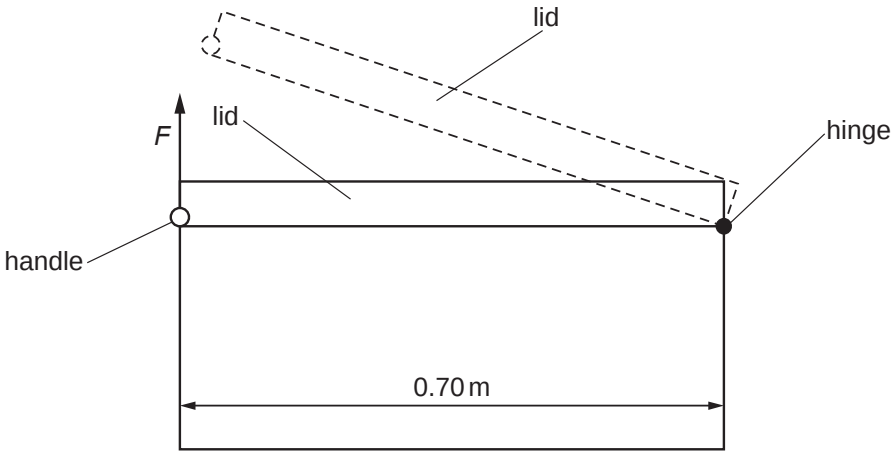

Fig. 3.1

The handle is 0.70 m from the hinge. The lid has a mass of 2.0 kg.

(a) The gravitational field strength *g* is 10 N / kg.

(i) Calculate the weight of the lid.

weight = ...[1]

(ii) The lid is uniform and its centre of mass is at its centre. The weight of the lid produces a moment about the hinge.

1. Calculate the moment about the hinge when the lid is closed.

moment = ...[2]

2. The moment required to open the lid is greater than the value calculated in **(a)(ii)1.**

Suggest one reason for this.

.....

.....[1]

(b) The lid is closed. To open the lid, a force *F* is applied to the handle as shown in Fig. 3.1.

The direction of *F* is vertically upwards and *F* is the smallest possible force that opens the lid.

A force on the handle in any other direction must be larger than *F* in order to open the lid. Explain why.

.....

.....

.....[1]

Question # 21: Oct Nov 2017/P21/Q1

Fig. 1.1 shows a painter standing on a wooden plank, directly above the right-hand support.

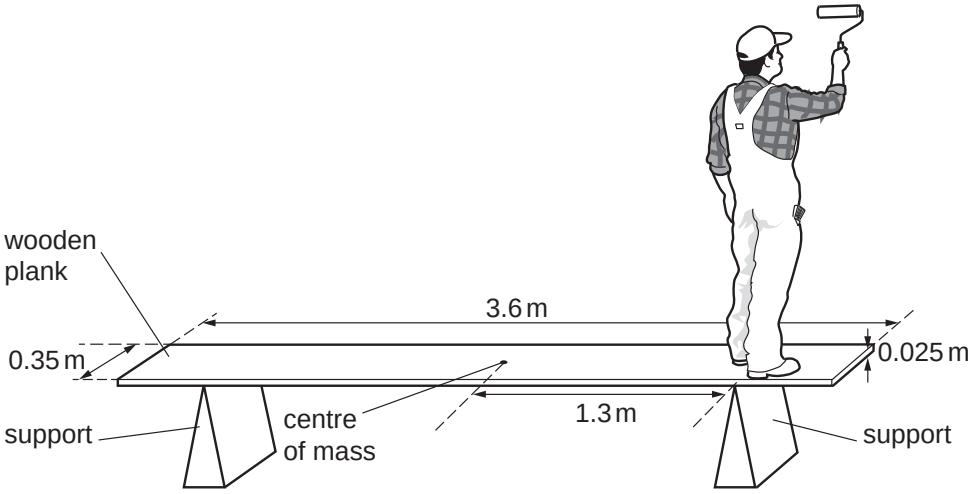

Fig. 1.1

The plank has length 3.6 m, width 0.35 m and thickness 0.025 m.

The gravitational field strength g is 10 N / kg and the mass of the plank is 23 kg.

(a) Calculate the density of the wood from which the plank is made.

density = ... [2]

(b) The centre of mass of the plank is in the middle of the plank at a distance of 1.3 m from each of the supports.

Calculate

(i) the weight of the plank,

weight = ... [1]

(ii) the moment of the plank about the right-hand support.

moment = ... [2]

(c) The painter moves further to the right along the plank and the plank rotates about the right-hand support.

Explain why the plank rotates.

.....

.....

.....

..... [1]

Question # 22: Oct Nov 2017/P22/Q3

A solid, rectangular concrete block is lying horizontally on flat ground with one of its largest sides in contact with the ground. Fig. 3.1 shows the dimensions of the block.

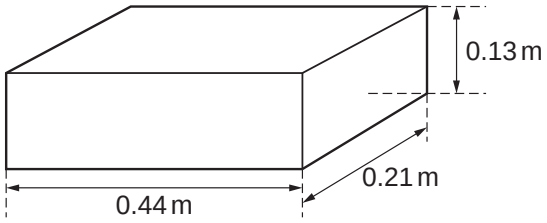

Fig. 3.1

The weight of the block is 240 N.

(a) Calculate the pressure on the ground caused by the block.

pressure = ...[2]

(b) State why the total pressure on the ground underneath the block is larger than the value obtained in **(a)**.

.....

.....[1]

(c) The block is of uniform density.

(i) State the height of the centre of mass of the block above the ground.

height = ...[1]

(ii) The block is rotated about its lower, left-hand edge so that it comes to rest on one of its smallest sides.

This is shown in Fig. 3.2.

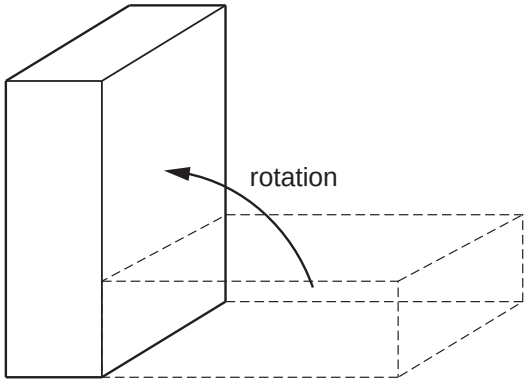

Fig. 3.2

Explain why work is done as the block is rotated.

.....

.....

.....

.....[2]

Question # 23: Oct Nov 2018/P22/Q2

A sports car is designed to be very stable when turning a corner at high speed.

Fig. 2.1 shows the position of the centre of mass of the car.

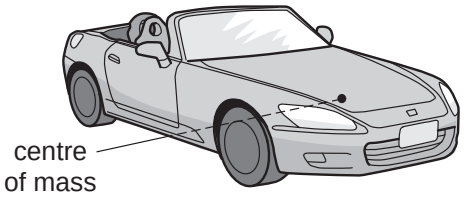

Fig. 2.1

(a) State what is meant by *centre of mass*.

.....

..... [1]

(b) State two features of the design that make the car in Fig. 2.1 stable.

1. .....

2. .....
[2]

(c) Fig. 2.2 shows an irregularly shaped piece of card.

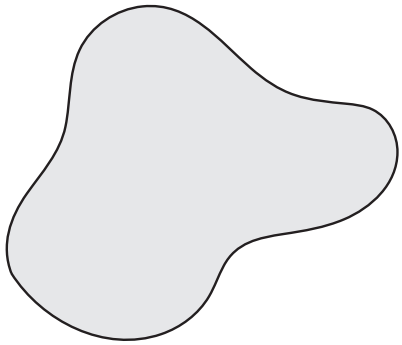

Fig. 2.2

Describe how to determine the position of the centre of mass of the piece of card.

You may draw on Fig. 2.2 or in the blank space.

.....

.....

.....

.....

.....

.....

.....

..... [3]

Question # 24: Oct Nov 2020/P21/Q3

3 Fig. 3.1 shows a door and an automatic door-closer viewed from above.

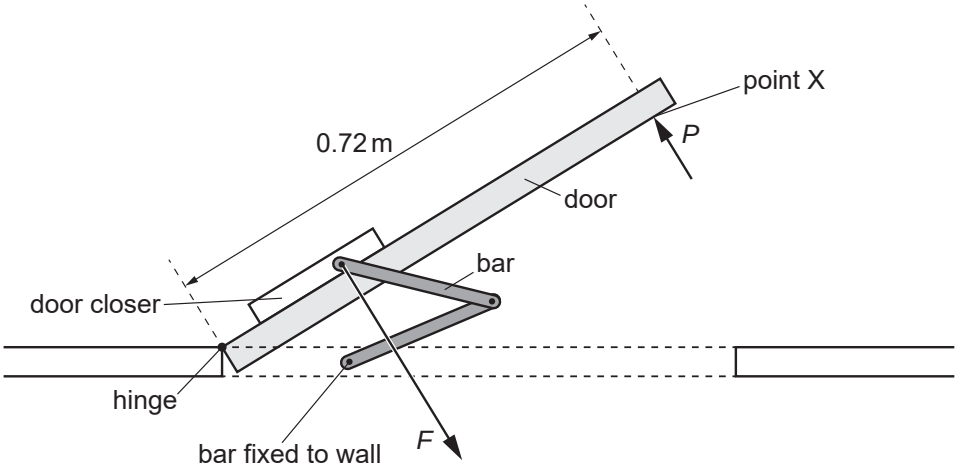

Fig. 3.1

When the door opens and closes, the hinge acts as a pivot.

A girl opens the door by exerting a force *P* at point X.

Force *P* is perpendicular to the surface of the door.

(a) Fig. 3.1 shows that point X is a distance of 0.72 m along the front of the door from the hinge. The force *P* is 25 N.

(i) Calculate the moment of force *P* about the hinge.

moment of force = ... [2]

(ii) The door rotates about the hinge by 90°. The circumference of a circle of radius 0.72 m is 4.5 m.

Calculate the work done on the door by force *P*.

work done = ... [2]

(b) As the door opens, there is a force *F* on the door in the direction shown in Fig. 3.1.

Although force *F* is larger than force *P*, the door rotates about the hinge.

Explain why.

.....

.....

.....

..... [2]

[Total: 6]

Question # 25: Oct Nov 2020/P22/Q1

1 A glass beaker has a mass of 50 g. A liquid of density 1.8 g / cm^3 is poured into the beaker until it reaches the 200 cm^3 mark.

(a) Calculate the total mass of the beaker and its contents.

mass = ... [3]

(b) The centre of mass of a metre rule is at the 50 cm mark.

(i) State what is meant by *centre of mass*.

.....

..... [1]

(ii) The metre rule is placed on a pivot. The tip of the pivot is under the 80 cm mark on the rule.

The beaker with its contents is then placed at different positions along the rule until the rule is balanced.

Fig. 1.1 shows the arrangement with the rule balanced.

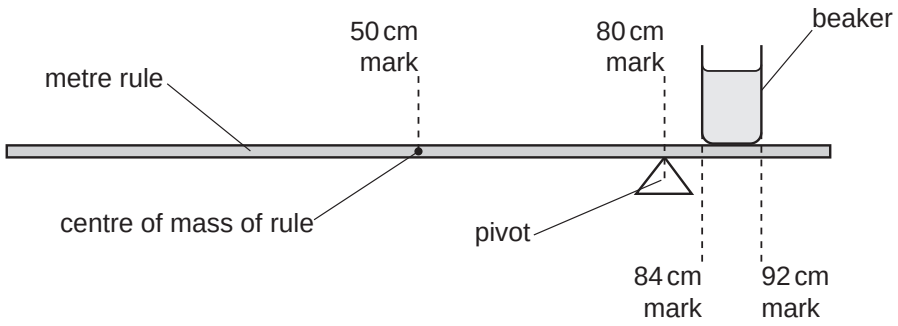

Fig. 1.1

One side of the beaker is at the 84 cm mark and the other side is at the 92 cm mark.

Calculate the mass of the rule.

mass = ... [3]

[Total: 7]