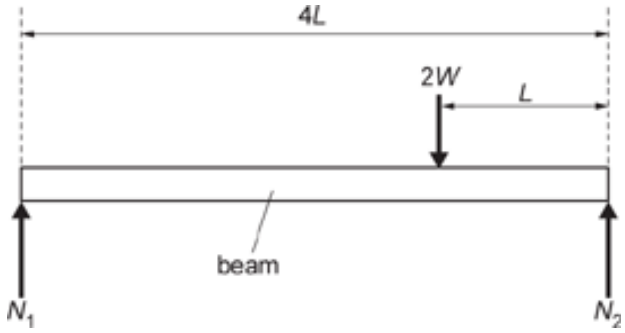
1. A horizontal uniform beam of length $4L$ and weight W is supported at both ends.

An object weighing $2W$ is placed on the beam at a distance L from one end.



What are the magnitudes of the normal reactions N_1 and N_2 on the supports at the ends of the beam?

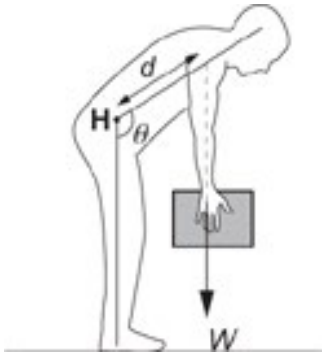
A $N_1 = 0.5W$, $N_2 = 1.5W$
B $N_1 = W$, $N_2 = 2W$
C $N_1 = 1.5W$, $N_2 = 1.5W$
D $N_1 = 2W$, $N_2 = W$

Your answer ☐ **[1]**

2(a). A lab technician is moving boxes.

The technician lifts a box from the floor without bending their knees.

The diagram shows the force W due to the weight of the box.



The box has a mass of 5 kg.
The distance d is 0.6 m and can be assumed to remain constant.

Calculate the moment about the point **H**, due to the weight of the box, when $\theta = 90^\circ$.

State the unit.

moment = ... unit.....**[2]**

(b). The diagrams show how the technician can pick up the box while bending their knees.

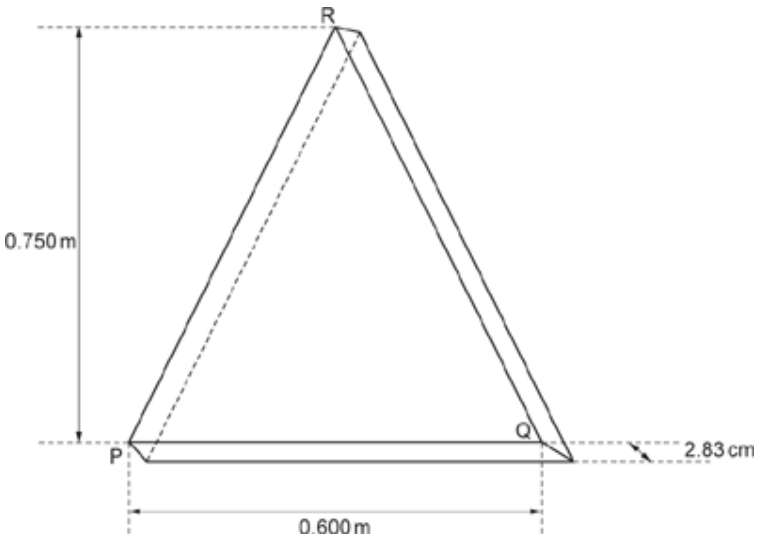
This keeps their spine more vertical.

Explain why bending the knees is less likely to cause damage to the spine.

[3]

3(a). A solid uniform wooden isosceles prism has a mass of 3.98 kg. The corners of one of the triangular faces are P, Q and R.

Fig. 4.1 (not to scale)



A student determines the thickness of the prism to be 2.83 cm.

i. Explain what is meant by centre of gravity.

[1]

ii. **Fig. 4.2** shows a scale drawing of the triangular face.

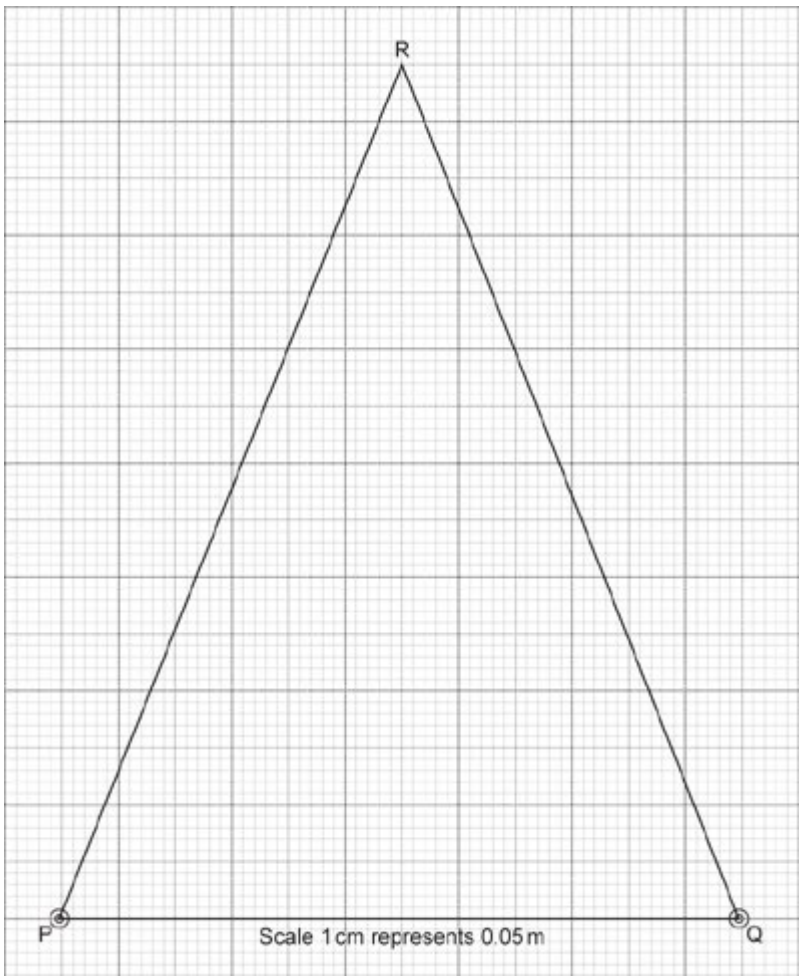


Fig. 4.2

Show that the centre of gravity on the wooden prism is about 0.25 m perpendicularly from the edge of PQ.

In your answer, **draw lines** on **Fig. 4.2**, and label the position of the centre of gravity C on the scale drawing.

[3]

(b). The prism rests on a support along edge PQ. **Fig. 4.3** shows a top view and **Fig. 4.4** shows a side view.

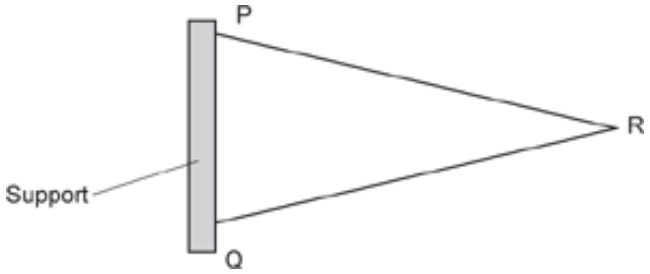


Fig. 4.3 (not to scale) top view

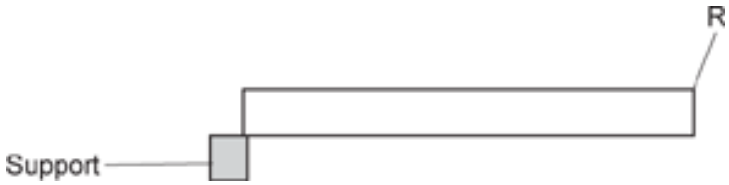


Fig. 4.4 (not to scale) side view

The student applies a force *F* at point R so that the prism is in equilibrium.

i. State the **two** conditions for the equilibrium of the prism.

1 _____

_____

2 _____

_____ **[3]**

ii. Calculate the force *F*.

F = ... N **[3]**

4. Describe how to find the centre of mass of a 2-dimensional shape, including any equipment required.

_____

_____

_____

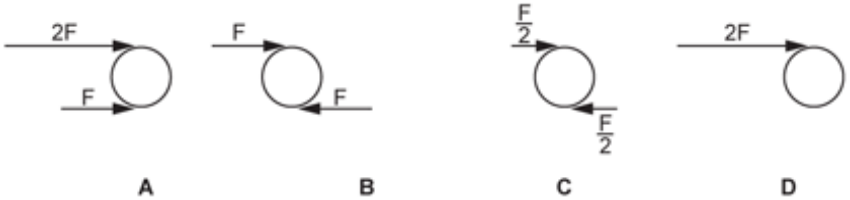
_____

_____

_____ **[3]**

5. Forces are applied to a circular shaft of diameter d.

Which diagram shows a torque of a couple with magnitude Fd?



Your answer ☐ **[1]**

6. An object is in equilibrium.

Only two forces, **X** and **Y**, act on the object.

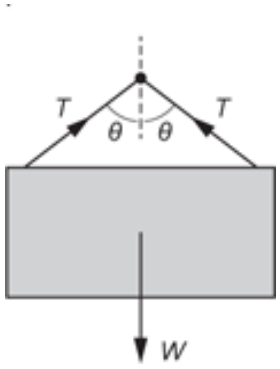
Which of the following statements must be correct?

1 **X** and **Y** are equal and opposite.
2 **X** and **Y** are a Newton's 3rd law force pair.
3 The object is at rest.

A Only 1
B 1 and 2
C 1 and 3
D 1, 2 and 3

Your answer ☐ **[1]**

7. A cable is used to hang a picture from a nail. The diagram shows all the forces acting on the picture. *T* is the tension in the cable and *W* is the weight of the picture.



Which is the correct expression for *W*?

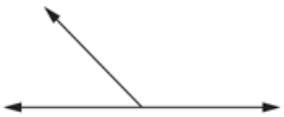
A $W = T \cos \theta$
B $W = 2T \cos \theta$
C $W = T \sin \theta$
D $W = 2T \sin \theta$

Your answer ☐ **[1]**

8. The diagrams show four systems of forces with three forces acting at a single point. The forces are in the same plane. The diagrams are drawn to scale.

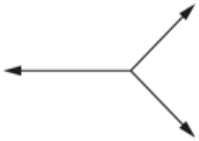
Which system could be in equilibrium?

A

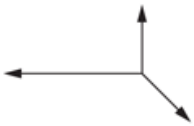


B

C



D



Your answer ☐ **[1]**

9(a). A tent is secured by 3 ropes along each of its long sides, as shown in **Fig. 18. 1**.

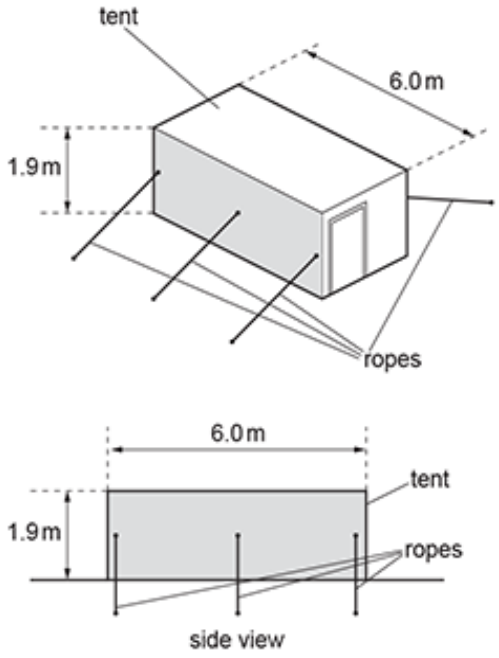


Fig. 18.1

Wind of speed 12 ms^{-1} blows at right angles to the **shaded** side of the tent for 3.0 s. The density of air is 1.2 kg m^{-3}.

i. Show that the mass of air which hits the tent in this time is about 490 kg.

[3]

ii. All of the air incident on the shaded side of the tent is deflected at 90° to the original direction as shown in **Fig. 18. 2**.

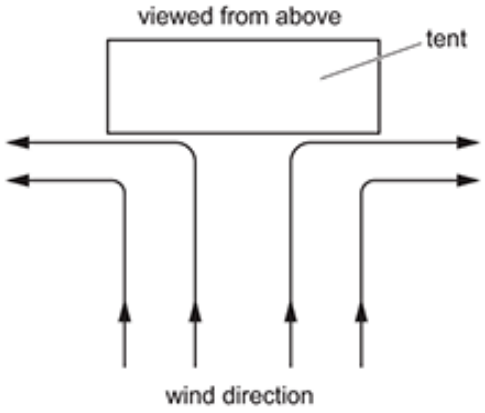


Fig. 18.2

Use the information given in **(a)(i)** to calculate the magnitude of the force *F* exerted by the wind on the shaded side of the tent.

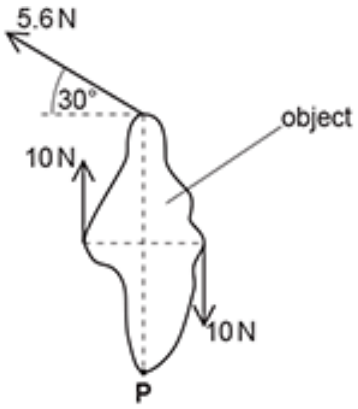
F = ... N **[2]**

(b). *When the wind speed exceeds 20 ms^{-1} the ropes securing the tent break.

Describe, and explain in terms of forces, how the ropes and the shape of the tent could be modified to withstand wind speed exceeding 40 ms^{-1}.

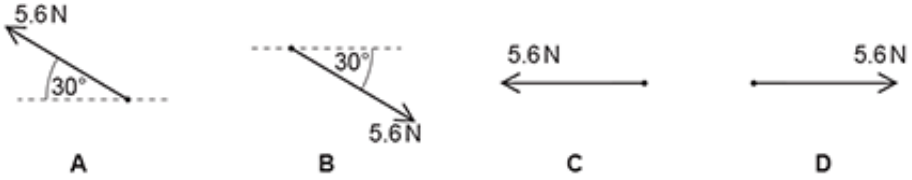
[6]

10. The object below is in equilibrium.



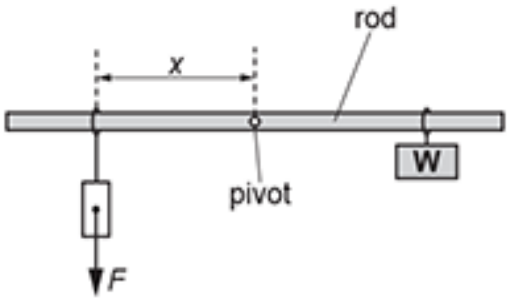
A force, not shown on the diagram, also acts on the object at point **P**.

Which of the following shows the correct direction and magnitude of the force acting at point **P**?



Your answer ☐ **[1]**

11. A student balances a uniform metal rod horizontally.



The rod is pivoted at its middle. The position of weight **W** is kept constant.
The distance of the weight *F* from the pivot is *x*. The student changes *F* and then adjusts *x* so that the rod remains balanced.
Which statement is correct?

A A graph of *F* against *x* will be a straight line through the origin.
B The upward force at the pivot is equal to *F*.
C The weight of **W** is equal to *Fx*.
D *x* is inversely proportional to *F*.

Your answer ☐ **[1]**

12(a).

A ball of mass 0.16 kg is dropped from rest from a height of 2.5 m above the ground.

Assume air resistance is negligible.

Calculate

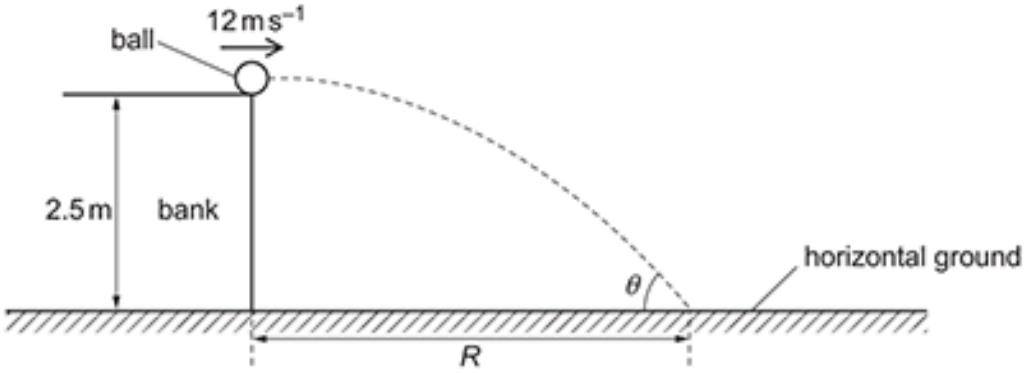
i. the change in gravitational energy E_p

E_p = ... J **[1]**

ii. the velocity *v* of the ball as it reaches the ground.

v = ... ms^{-1} **[2]**

(b). The ball from **(a)** is now fired horizontally with a speed of 12 ms^{-1} from a bank.
The height of the bank is 2.5 m.
The time for the ball to travel from the edge of the bank to the horizontal ground is 0.71 s.
The path of the ball is shown in the diagram.
The ball hits the horizontal ground a distance *R* from the bottom of the bank.
Assume air resistance is negligible.



Calculate

i. *R*

R = ... m **[1]**

ii. the kinetic energy E_k of the ball as it reaches the ground

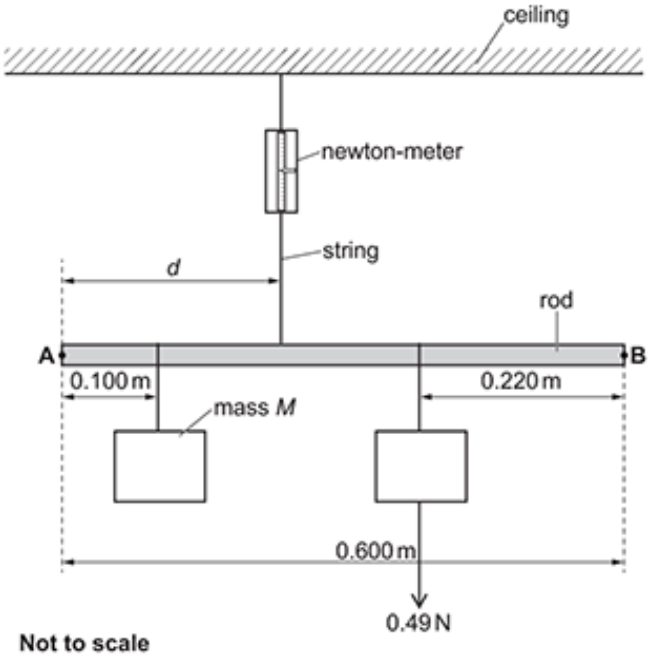
E_k = ... J **[2]**

iii. the angle *θ* between the ground and the direction of the ball as it reaches the ground.

θ = ... ° **[1]**

13(a).

The diagram shows a uniform rod which is in equilibrium. The rod has a circular cross-section and has length 0.600 m and weight 2.1 N.



Mass *M* is suspended at a distance of 0.100 m from point **A**.
A weight of 0.49 N is suspended at a distance of 0.220 m from point **B**.
A string is attached to the rod at a distance *d* from point **A**.
The tension in the string, measured by the newton-meter (force meter), is 3.9 N.

i. Show that *M* is about 0.13 kg.

[2]

ii. By taking moments about point **A**, determine *d*.

d = ... m **[3]**

(b). State the **two** conditions for an object to be in equilibrium.

1 _____

_____

2 _____

_____

[3]

END OF QUESTION PAPER