Moments

This is a product of the **force** multiplied by the perpendicular distance between its line of action and the axis of rotation.

The moment is also known at turning force or torque

Moment (Nm) = Force (N) x perpendicular distance (m)

A couple
Two forces that are equal in magnitude but opposite in direction (and acting along parallel lines), thus creating the turning effect of a torque or moment.

Principle of moments
For an object to be in equilibrium (with no movements about a turning point), the sum of anticlockwise moments is equal to the sum of clockwise moments.

Examples 1
A rod mass 8kg and 2m long is balance horizontally by two inextensible string tied to the end A and B of the rod when a mass of 20kg hangs 0.5m from A. Find the tensions in the strings at A and B. [take g = 10ms^{-2}]
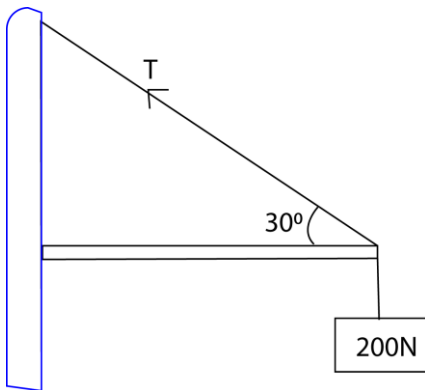
Solution
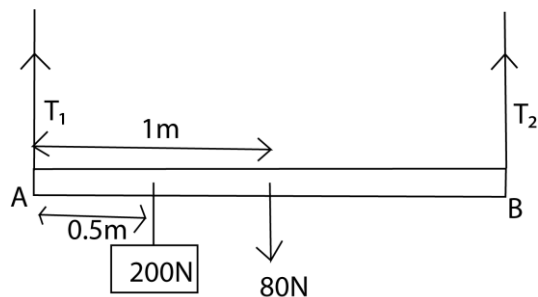
The sum of moments of initial at A = 0
$0 = 0.5 \times 200 + 1 \times 80 - T_2 \times 2$
$T_2 = 90$

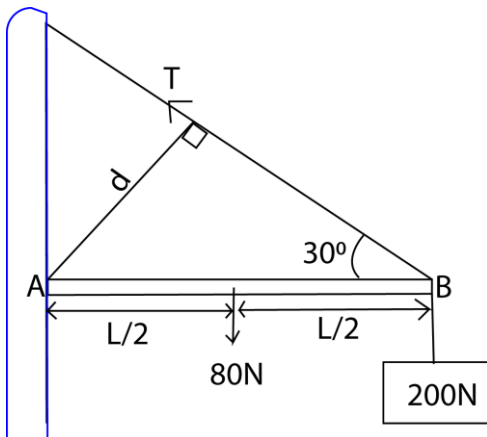But $T_1 + T_2 = 200 + 80$
   $T_1 + 90 = 280$
      $T_1 = 190N$

Example 2

A force of 200N hangs on a uniform rod of weight 80N and held at equilibrium by a string as shown in the figure below.

Calculate the tension in the string

Solution

Taking moments at A

$T \times d = 80 \times \frac{L}{2} + 200L$
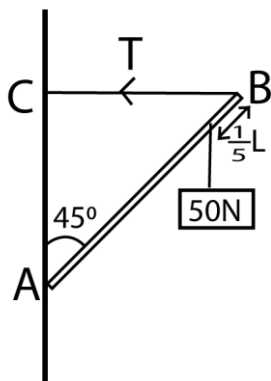
But $d = L \sin 30$

$T L \sin 30 = 240L$
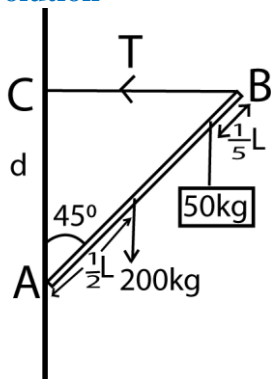 $T = 480N$

Example 3

A rod of length L weighing 200kg is held by a horizontal string BC in equilibrium with a mass of 50kg as shown in the diagram below. Find the tension T.

Solution

Moments about A

$$T \times d = (200 \times 9.8) \times \frac{1}{2}Lcos\ 45 + (50 \times 9.8) \times \frac{4}{5}Lcos\ 45$$
But $d = Lcos\ 45$
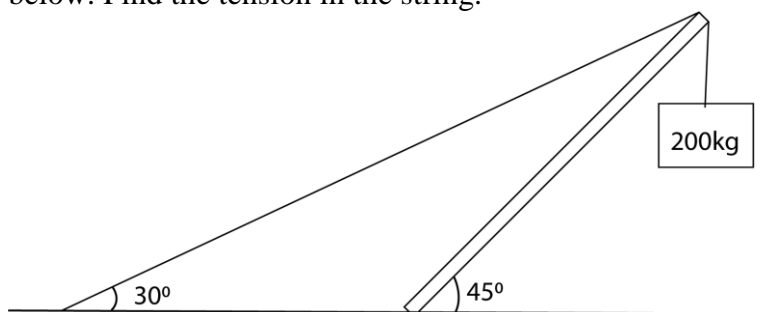
Therefore,
$$T \times Lcos\ 45 = (200 \times 9.8) \times \frac{1}{2}Lcos\ 45 + (50 \times 9.8) \times \frac{4}{5}Lcos\ 45$$
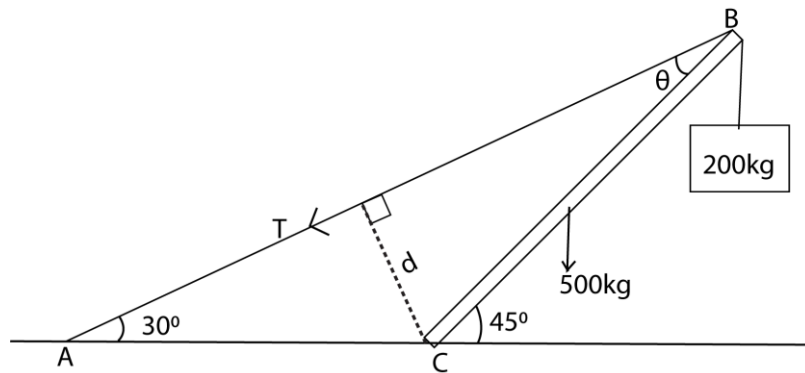
$$T = 1372N$$

Example 4
A rod of 500 N is balanced by a string AB and a mass of 200kg as shown in the diagram below. Find the tension in the string.

Solution

Taking moments at C
Let the length of the rod b L

$$T \times d = (500 \times 9.8) \times \frac{L}{2}\cos 45 + (200 \times 9.8) \times L\cos 45$$

But $d = L\sin\theta$
$45^0 = 30^0 + \theta$
$\theta = 15^0$

It implies that
$$T \times L\sin 15 = (500 \times 9.8) \times \frac{L}{2}\cos 45 + (200 \times 9.8) \times L\cos 45$$
$$T = 12047N$$

Exercise
1. A mass of 5kg is suspended from end A of a uniform bean of mass 1kg and length 1m. the end B of the beam is hinged to a wall. The beam is kept horizontal by a wire attached to point A and C on the wall at a height 0.75m above B.
   (i) Draw a sketch diagram to show the forces acting on the beam
   (ii) Calculate the tension in the wire. [T = 90N]
   (iii) What is the force exerted by hinge on the beam [F = 72.1N]
2. A uniform ladder AB of length 12m is placed at an angle of 60^0 to the horizontal with one end B leaning against the wall and the other end A on the ground. Calculate the reaction force R of the wall at B and force F of the ground at A if the weight of the ladder AB is 200N. [R = 200N, F = 57.7N]

Center of gravity
This is a point where the resultant force of attraction of a body acts

**Center of gravity of regular object**
For regular shape bodies, the center of gravity is at the geometric center of the body e.g. the center of gravity of a Uniform meter ruler is at 50cm mark, for circle, it is at the center. For a rectangular and square body it is at the point of intersection of the diagonals.

Irregular body
The best way of finding the center of gravity of an irregular object is by use a plumb line. A plumb line is made from a thread of cotton with a loop at one end and a weight tied at other end.

For a irregular card board for instance, three small holes are made at well-shaped intervals

around the edge of the card
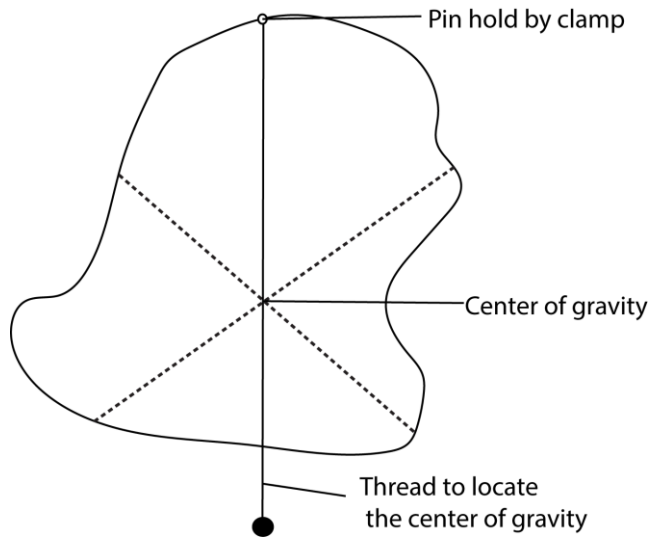
A pin is then put through one of the holes and firmly by a clamp and stand so that the card board swings on it.

The card board will come to rest with its center of gravity below the point of support along the vertical line of plumb line.

The cardboard is hung through another hole, the point of interception of the two vertical lines is the center of gravity.

Factors that affect stability
1. The position of center of gravity, should be low.
2. Width of the base: the wider the width of the base, the more stable the body is.

Way of increasing stability
1. Increasing the base area
2. Lowering the center of gravity

Application of center of gravity
1. cars have very heavy framed to lower center of gravity
2. Racing cars have wide wheel base to lower center of gravity.