CHAPTER TWO
TURNING FORCES

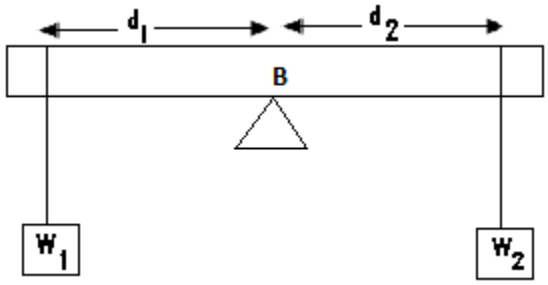
Moment:

- The moment of a force about a point is the product of the force, and the perpendicular distance of its line of action from the point.

- While the clockwise moment causes an object to turn in the clockwise direction, that of the anticlockwise will cause it to turn in the anticlockwise direction.

The principle of moments:

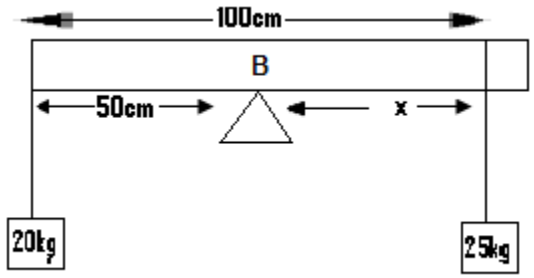
- When a body is in equilibrium, the sum of the clockwise moment about any point, is equal to the sum of the anticlockwise moment about the same point.



- Taking moment about the point B, the clockwise moment = $W_2 \times d_2$ and the anticlockwise moment = $W_1 \times d_1$.- At equilibrium, the clockwise moment = the anticlockwise moment, => $W_2d_2 = W_1d_1$.

(Q1) A metre rule or a 100cm long ruler is pivoted at the 50cm mark, with a mass of 20g suspending from one of its ends. At what distance away from the pivot must a mass of 25g be suspended, in order to keep the rule in equilibrium.

Soln:



Let x = the distance of the 25kg mass from the pivot.

Taking moments about the point B => clockwise moment = 25 × x = 25x.

Anticlockwise moment = 20 × 50 = 1000.

At equilibrium, the clockwise moment = the anticlockwise moment, => 25x = 1000

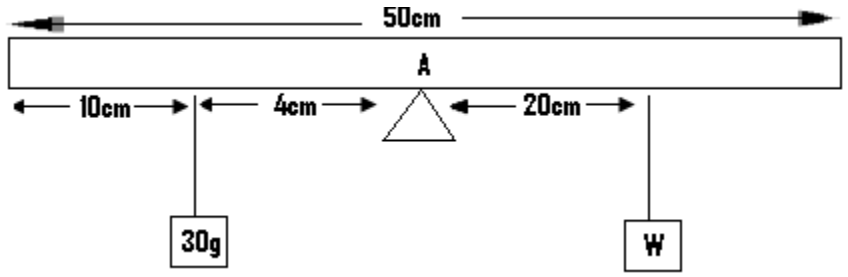
=> x = $\frac{1000}{25}$ => x = 40.

The 25g mass, must be suspended at a distance of 40cm away from the pivot.

(Q2) A half-metre rule (i.e. a 50cm long rule), has a 30g weight suspended 10cm away from one end, with the fulcum or the pivot being located 4cm away from the 30g

weight. Determine the weight which must be suspended 20cm away from the pivot in the opposite direction in order to keep the rule in equilibrium.

Soln:



Let W = the weight needed to keep the half metre rule in equilibrium.

Taking moment about the point A, clockwise moment = 20 × W = 20W.

The anticlockwise moment = 30 × 4 = 120.

At equilibrium , the sum of the clockwise moment = that of the anticlockwise moment.

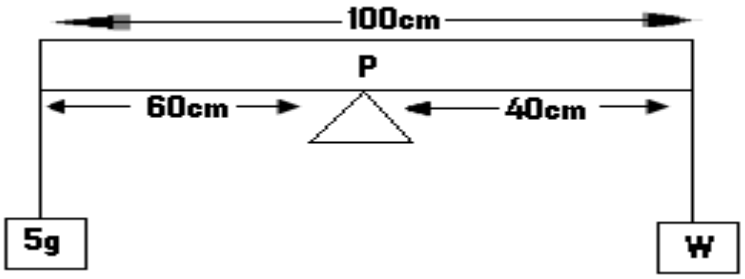
=> 20W = 120 => W = $\frac{120}{20} = 6$.

=> The required weight = 6g.

(Q3) A metre rule is pivoted at the 60cm mark. A 5g weight is hanged at the 0cm mark (the zero centimeter mark). Find the weight which must be hanged at the 100cm mark in order to balance the rule.

N/B: Since the rule is 100cm long, the 0cm mark and the 100cm mark refer to the two ends of the rule.

Soln:



Let W = the required weight.

Taking moment about the point P, => clockwise moment = 40 $\times$ $W = 40W$.

The anticlockwise moment = 5 $\times$ 60 = 300.

At equilibrium, sum of clockwise moment = the sum of the anticlockwise moment.

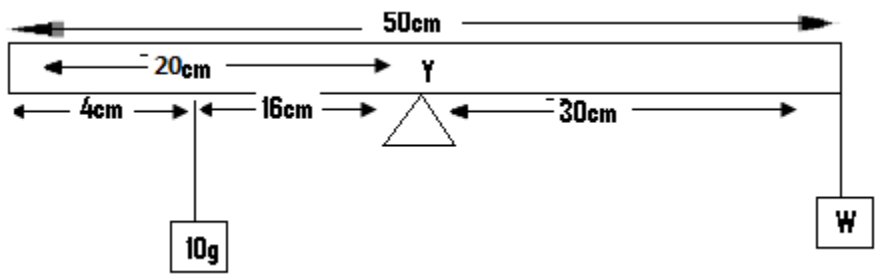
=> 40W = 300 => W = $\frac{300}{40}$

=> W = 7.5.

=> The required weight = 7.5g.

(Q4) A uniform-half meter rule is pivoted at the 20cm mark, and a weight of 10kg is hanged at the 4cm mark. Determine the weight which must be hanged at the other end of the rule in order to balance it.

Soln:



Let the required weight = W.

Taking moment about the point Y => the clockwise moment = 30 $\times W = 30$W.

The anticlockwise moment = 10$\times$ 16 = 160.

At equilibrium , sum of the clockwise moment = the sum of the anticlockwise moment

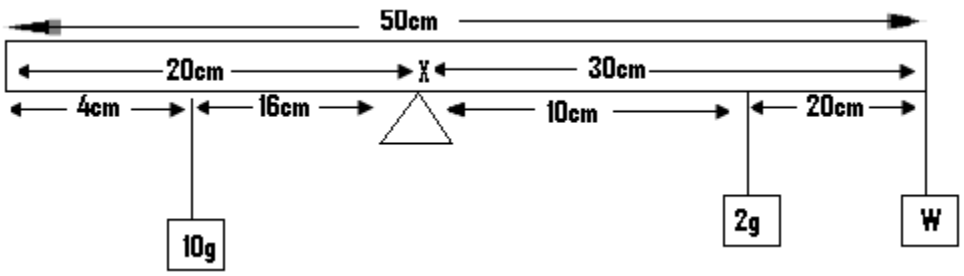
=> 30W = 160 => W = $\frac{160}{30}$

=> W = 5.3.

=> the required weight = 5.3g.

(Q5) A half – metre rule is pivoted at the 20cm mark, and a 10gf weight is hanged at the 4cm mark. If a weight of 2g is to be hung at the 30cm mark, find the weight which must be hanged at its end which is closer to the 2g weight, in order to keep the half metre rule in equilibrium.

Soln:



Let W = the required weight.

Taking moment about X, => clockwise moment $(2 \times 10) + (30 \times W) = 20 + 30W$.

The anticlockwise moment = 10 × 16 = 160.

At equilibrium, the sum of the clockwise moment = the sum of the anticlockwise moment.

=> 20 + 30W = 160

=> 30W = 160 – 20 = 140,

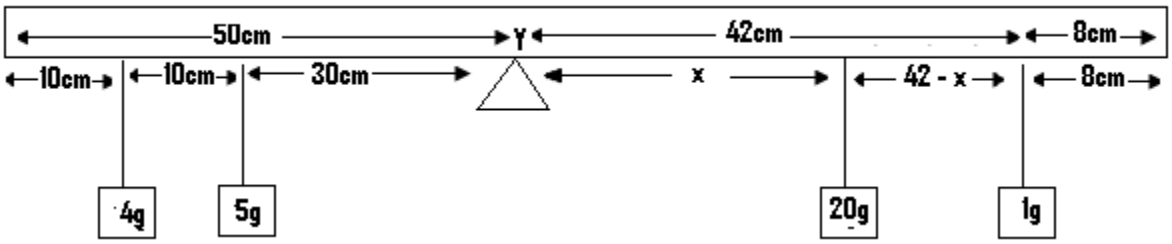
=> W = $\frac{140}{30} = 4.6$

=> The required weight = 4.6g.

(Q6) A 100cm rule is pivoted at its mid point or the 50cm mark, and as such divided into two portions. With reference to the first portion, a 5gf weight is hanged 30cm away from the pivot. Another weight of mass 4gf also hangs at a point which is 40cm away

from the pivot. With respect to the other portion, a 1gf weight hangs 8cm away from the end.At what distance away from the pivot must we hang a 20gf weight in order to keep the rule in equilibrium.

Soln:



Let x = the distance of the 20g weight from the pivot.

Taking moment about the point Y => the sum of the clockwise moments = $(20 \times x) + (1 \times 42) = 20x + 42$.

The sum of the anticlockwise moment = $\{4 \times (10 + 30)\} + \{(5 \times 30) = (4 \times 40) + (150) = 160 + 150 = 310$.

But at equilibrium, the sum of the clockwise moment = the sum of the anticlockwise moment => 20x + 42 = 310 = > x = 13.4 => the 20g weight must be positioned 13.4cm away from the pivot.