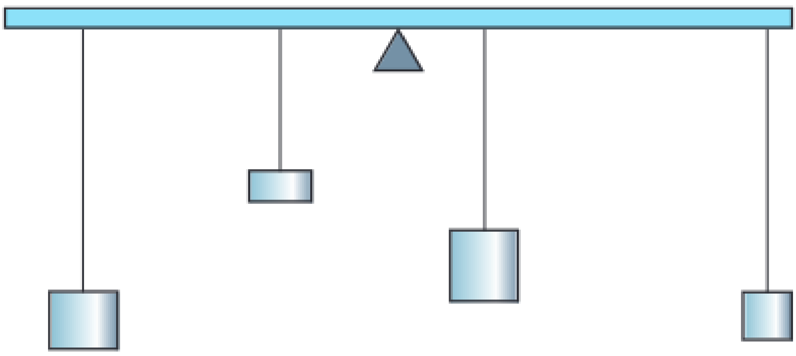
Equilibrium of forces

The principle of moments

> **The principle of moments states that, for an object to be in rotational equilibrium, the sum of the clockwise moments about any point must equal the sum of the anticlockwise moments about that same point.**

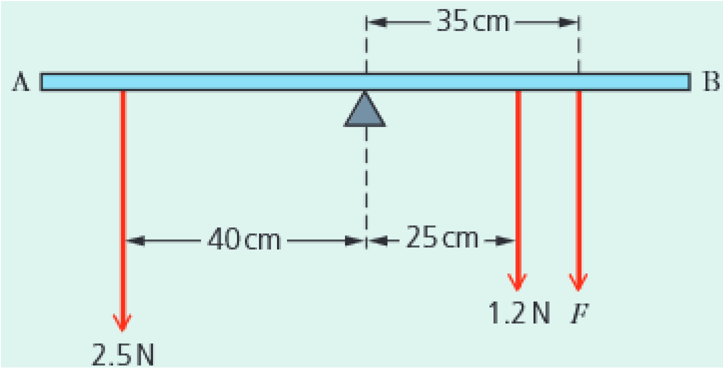


In this image, four weights are hanged on a meter rule with a pivot in the center. The ruler does not rotate and is balanced, so it is in a **rotational equilibrium**.

There is no resultant turning effect.

Let's look at an example.

- Some weights are hanged on a rod AB on a pivot. Calculate the force F required to balance the rod.



On the left of the pivot, the anticlockwise moment is

$2.5\ N \times 0.4\ m = 1\ N\ m$ (remember to change to SI units)

On the right side of the pivot, the total clockwise moment is

$(1.2\ N \times 0.25\ m) + (F \times 0.35\ m) = 0.3\ N\ m + 0.35F\ N\ m$

For the rod to be balanced, it must be in a rotational equilibrium, so both sides' moments must be equal.

$1\ N\ m = 0.3\ N\ m + 0.35F\ N\ m$

Now, we can solve for F.

$0.35F\ N\ m = 0.7\ N\ m$

$F = 2.0\ N\ m$

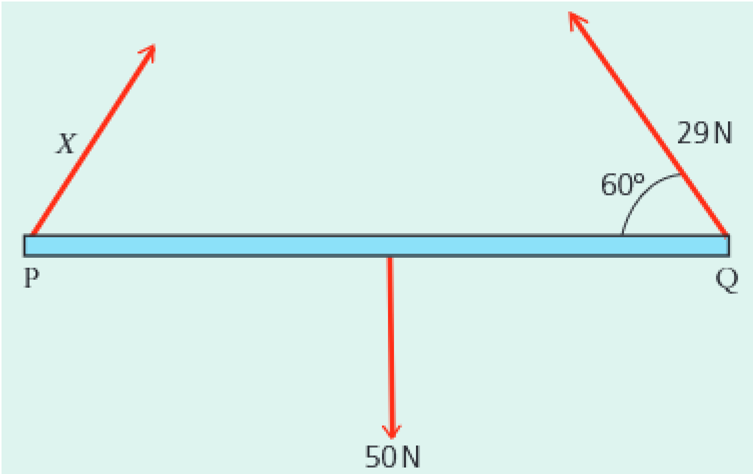
Equilibrium

For an object to be in equilibrium,

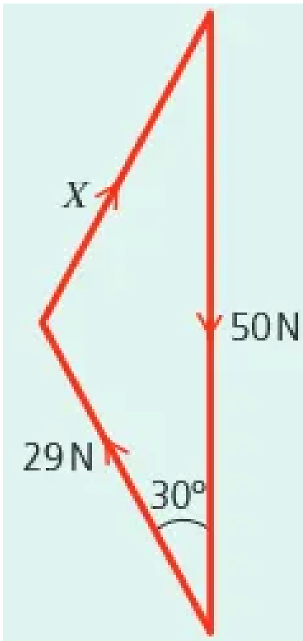
1. **the sum of the forces in any direction must be zero**
2. **the sum of the moments of the forces about any point must be zero**

Here's another example.

- Find the force X which is acting on the rod PQ. The rod PQ is in equilibrium.



Using a vector triangle, we can find X.



The angle is 30° because it is the complementary angle of 60°. Using either a scale diagram or trigonometry, X is found to be $29\ N$ horizontal to the rod PQ.