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Applied Mechanics

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Chapter 1

Forces and moments

By

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Forces :

A *force* can be defined as any push or pull exerted on a body.

The unit of force is the **Newton**

One **Newton** is the force required to produce in a mass of one Kilogram an acceleration of one meter per second.

When considering a force the following must be known:

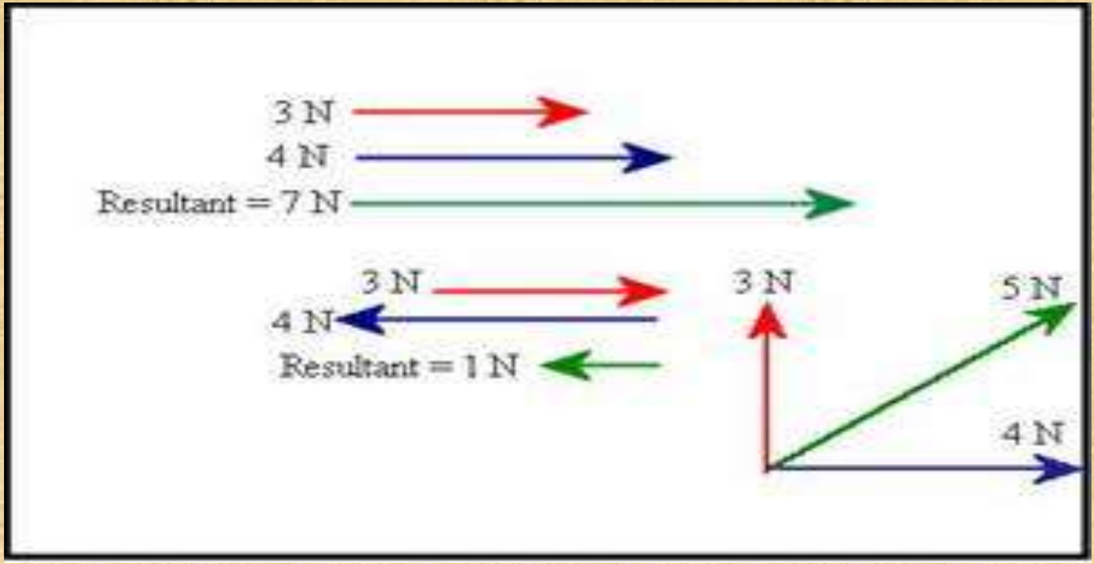
- The magnitude of the force
- The direction in which the force is applied
- The point at which this force is applied

The resultant force

When two or more forces are acting on a body, their combined effect can be represented by **one force** which will have the same effect as the component forces.

Such a force is referred to as the **'resultant force'.**

The process of finding it is called the **'resolution of the component forces'.**

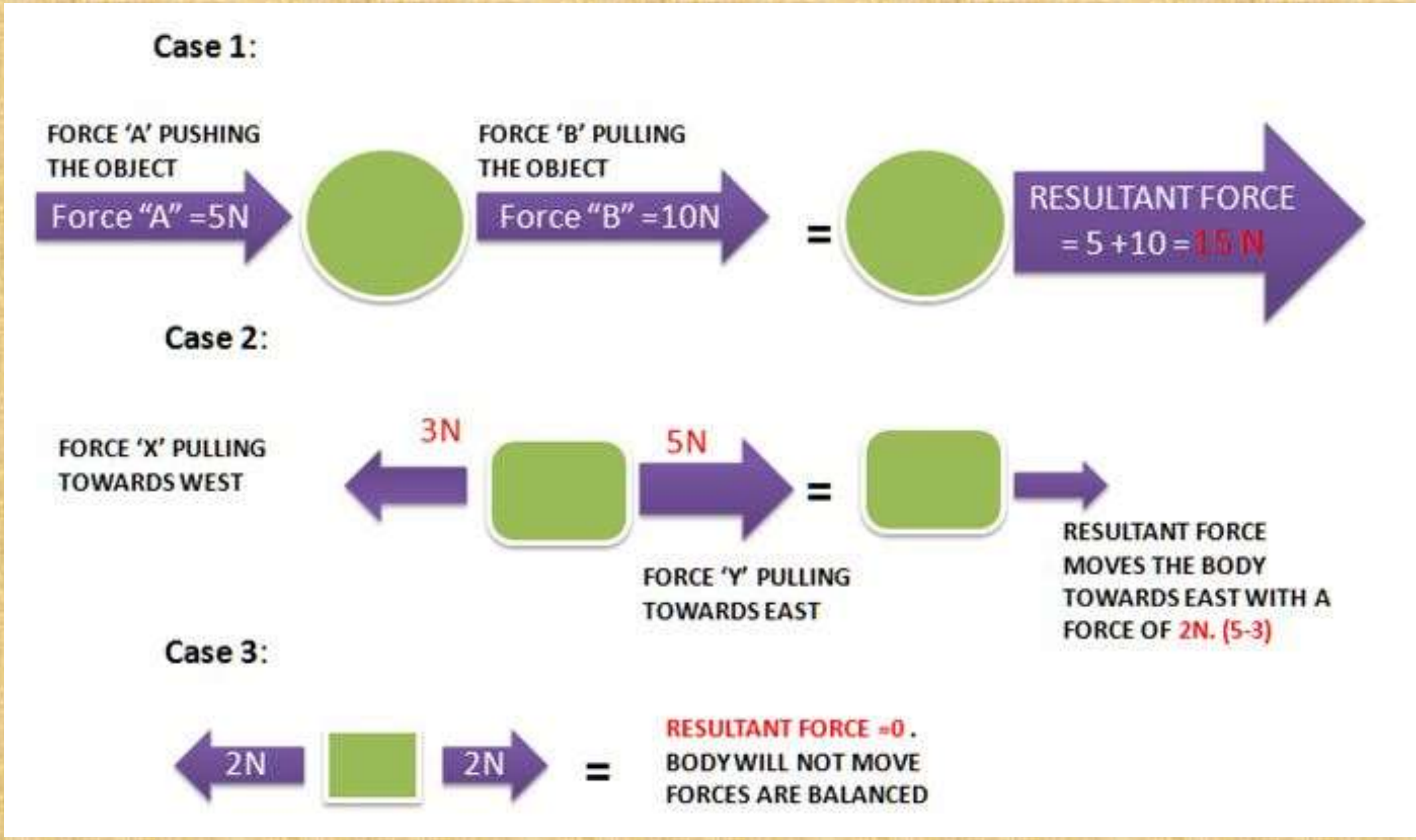


(a) ***Resolving two forces which act in the same straight line***

If both forces act in the **same straight** line and in the same direction the resultant is their sum,

but if the forces act in **opposite directions** the resultant is the difference of the two forces and acts in the direction of the **larger** of the two forces.

(a) ***Resolving two forces which act in the same straight line***



(a) ***Resolving two forces which act in the same straight line***

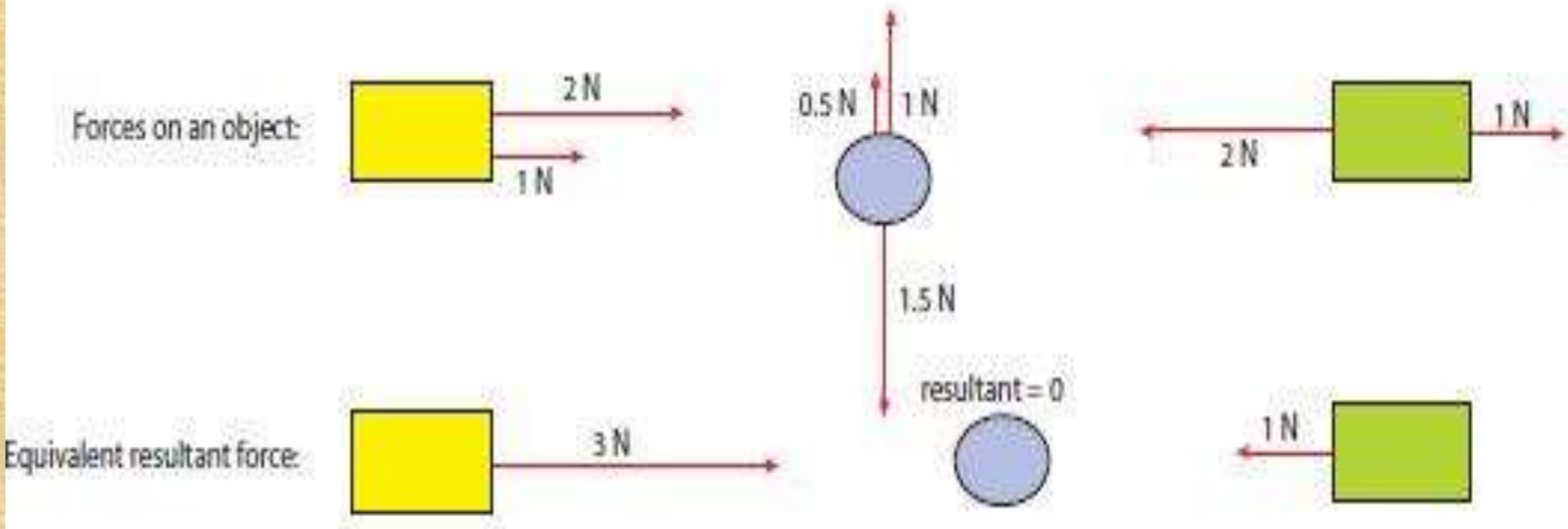
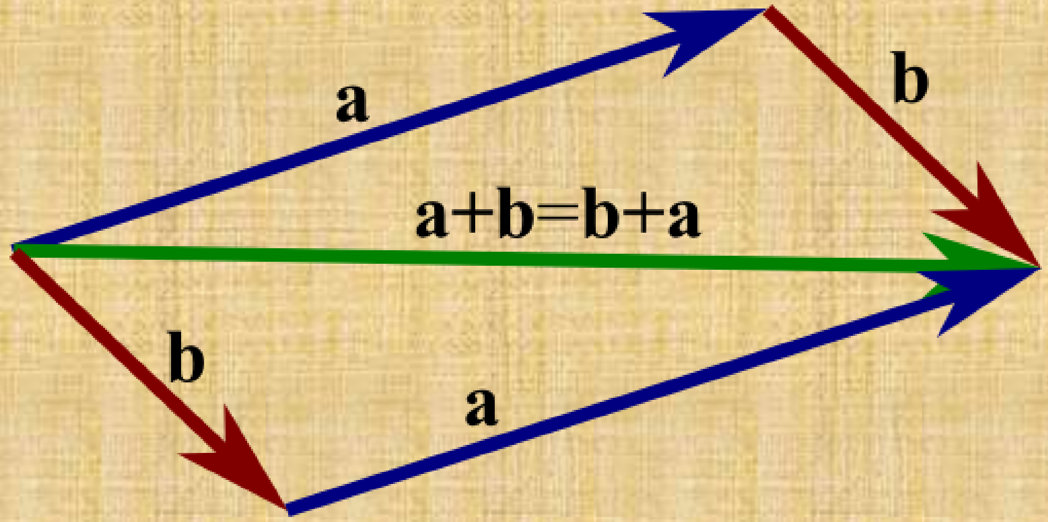


Fig. 9.5 resultant forces.

(b) *Resolving two forces which do not act in the same straight line*

When the two forces do not act in the same straight line, their resultant can be found by completing a parallelogram of forces.

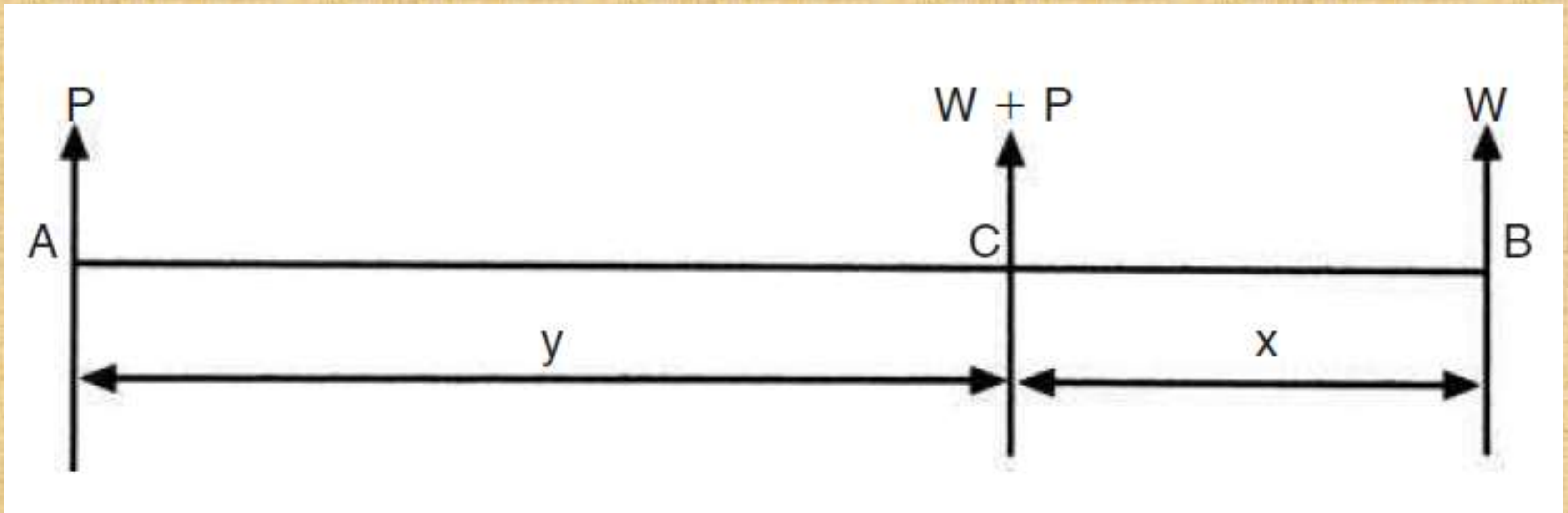


(c) *Resolving two forces which act in parallel directions*

When two forces act in **parallel directions**, their combined effect can be represented by **one force** whose magnitude is **equal to the algebraic sum** of the two component forces, and which will **act through a point about which their moments are equal**.

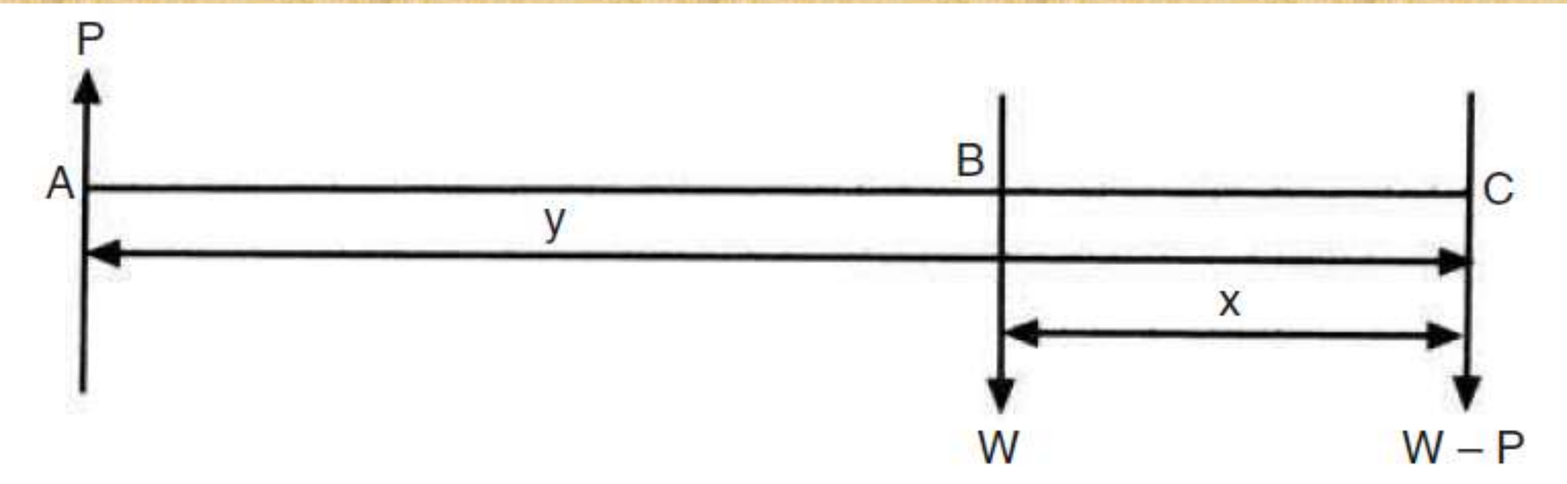
Example 1

The parallel forces W and P are acting upwards through A and B respectively. Let W be greater than P. Their resultant (W + P) acts upwards through the point C such that P x y =W x X. Since W is greater than P, the point C will be nearer to B than to A.



Example 1

The parallel forces W and P are acting in opposite directions through A and B respectively. Let W be greater than P. Their resultant (W - P) acts through the point C on AB produced such that P x y =W x X.



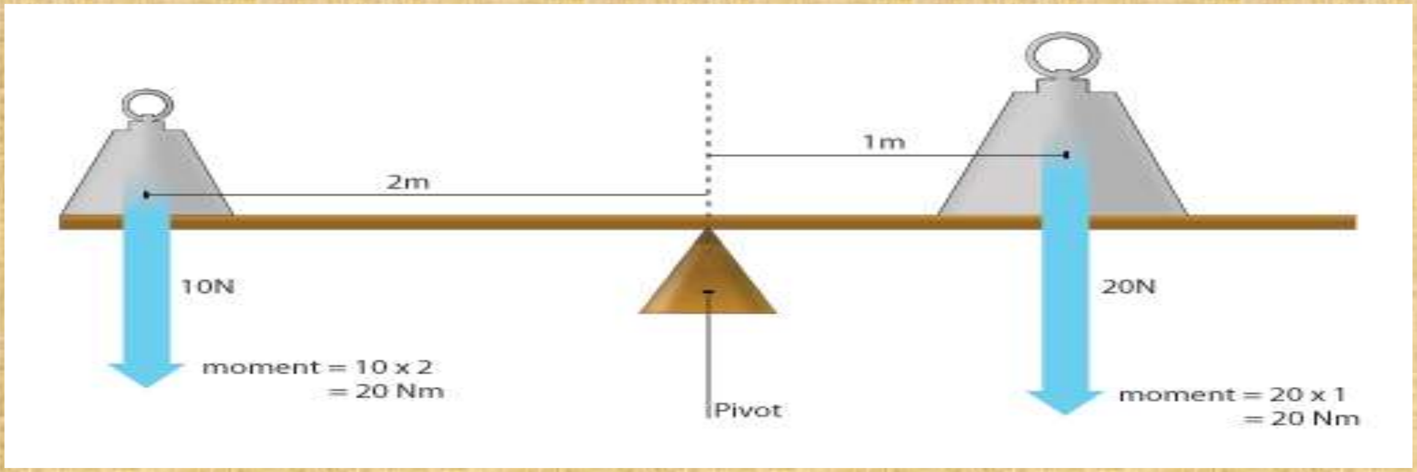
Moments of forces

The moment of a force is a measure of the turning effect of the force about a point

The moment depends on the following:

- The **magnitude** of the force
- The **length of the lever** upon which the force acts

(the lever being the perpendicular distance between the line of action of the force and the point about which the moment is being taken)



The magnitude of the moment:

is the product of the force and the length of the lever. Thus, if the force is measured in Newtons and the length of the lever in metres, the moment found will be expressed **in Newton-metres (Nm).**

Resultant moment:

When two or more forces are acting about a point their combined effect can be represented by one imaginary moment called the **'Resultant Moment'.**

The process of finding the resultant moment is referred to as the **'Resolution of the Component Moments'.**

Resolution of moments:

To calculate the resultant moment about a point find:

- The sum of the moments to produce rotation in a clockwise direction about the point.

- The sum of the moments to produce rotation in an anticlockwise direction.

- Take the lesser of these two moments from the greater and the difference will be the magnitude of the resultant.

- The direction in which it acts will be that of the greater of the two component moments.

Weight & Mass

Mass is the fundamental measure of the quantity of matter in a body and is expressed in **KG and TON**

Weight is the force exerted on a body by the Earth’s gravitational force and is measured in **Newton (N) and kilo – Newton (KN)**

Weight = Mass x Acceleration

MOMENTS OF MASS

Since:

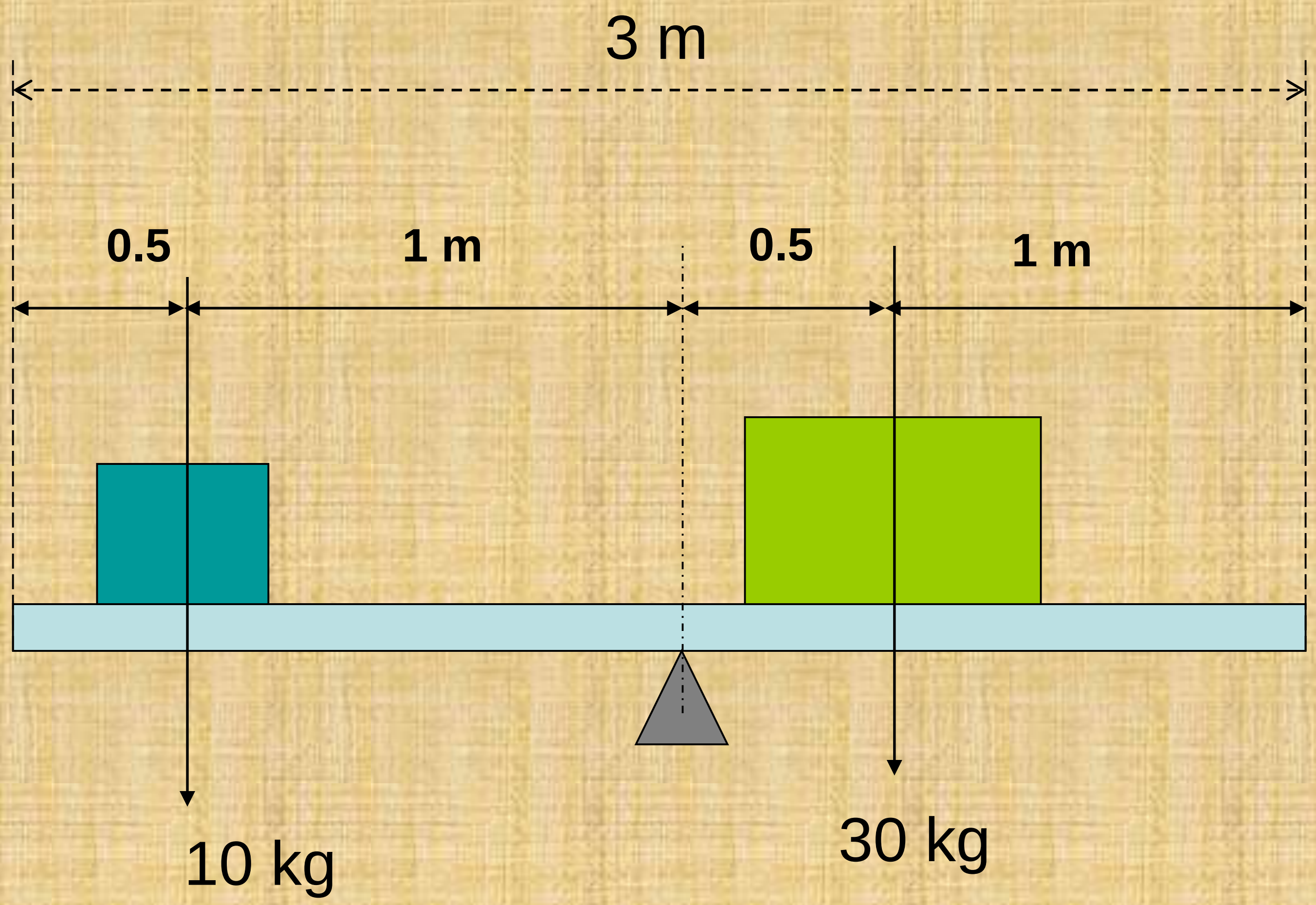
- **The Force Of Earth's Gravity is <u>*Constant*</u> = 9.81 m/s^2**

Therefore:

- **The Weight Of Bodies Is Proportional To Their Mass**
- **The Resultant Moment Of two Or More Weights About A Point Could Be Expressed In Terms Of Their Mass Moments**

Moments are taken about O, the middle of the plank.

Clockwise moment = 30 X 0.5 = 15 kg m
Anti-clockwise moment = 10 X 1.0 = 10 kg m
Resultant moment 5 kg m clockwise



Exercise 1

1 A capstan bar is 3 metres long. Two men are pushing on the bar, each with a force of 400 Newtons. If one man is placed half-way along the bar and the other at the extreme end of the bar, find the resultant moment about the centre of the capstan.

2 A uniform plank is 6 metres long and is supported at a point under its mid-length. A 10 kg mass is placed on the plank at a distance of 0.5 metres from one end and a 20 kg mass is placed on the plank 2 metres from the other end. Find the resultant moment about the centre of the plank.

3 A uniform plank is 5 metres long and is supported at a point under its mid-length. A 15 kg mass is placed 1 metre from one end and a 10 kg mass is placed 1.2 metres from the other end. Find where a 13 kg mass must be placed on the plank so that the plank will not tilt.

4 A weightless bar 2 metres long is suspended from the ceiling at a point which is 0.5 metres in from one end. Suspended from the same end is a mass of 110 kg. Find the mass which must be suspended from a point 0.3 metres in from the other end of the bar so that the bar will remain horizontal.

5 Three weights are placed on a plank. One of 15 kg mass is placed 0.6 metres in from one end, the next of 12 kg mass is placed 1.5 metres in from the same end and the last of 18 kg mass is placed 3 metres from this end. If the mass of the plank be ignored, find the resultant moment about the end of the plank.