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"What one man calls God, another calls the laws of physics."

-Nikola Tesla

# TOPIC 5: MOMENTS

THE ABOUT

# CHAPTER ANALYSIS

MASTERY

- Application heavy chapter
- Different variation of questions for ‘Principle of Moments’

EXAM

- Tested quite often
- Closely linked to chapters like Dynamics

WEIGHTAGE

- Light-medium overall weightage
- Constitute to around **3.5%** of marks for past 5 year papers

KEY CONCEPT

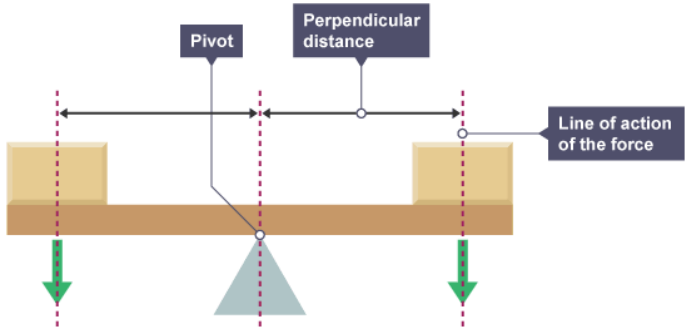
# PRINCIPLE OF MOMENTS
# CENTER OF GRAVITY
# STABILITY

# MOMENTS

**Moment**

Moment of a force is defined as the **product of a force and the perpendicular distance** from the line of action of the force to the pivot.

Units: **Nm**

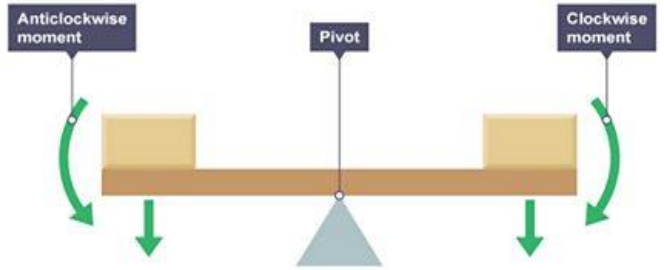



*Formula:*
**Moment = F x d**

*where d is the perpendicular distance*

**Principle of Moments**

When an object is at equilibrium, the sum of clockwise moments about any pivot is equal to the sum of anticlockwise moments about the same pivot.




For an object to be in **equilibrium**,

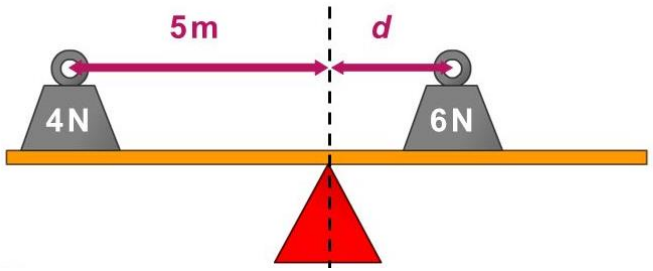
1) **Resultant forces** must be **zero**
2) R**esultant moment** must be **zero**

# MOMENTS (EXAMPLE 1)

The **principle of moments** states that (for a body in equilibrium):

| total clockwise moments | = | total anticlockwise moments |
|---|---|---|

This principle can be used in calculations:




**What is *d*?**

$4 \times 5 = 6d$

$20 = 6d$

$d = 20 / 6$

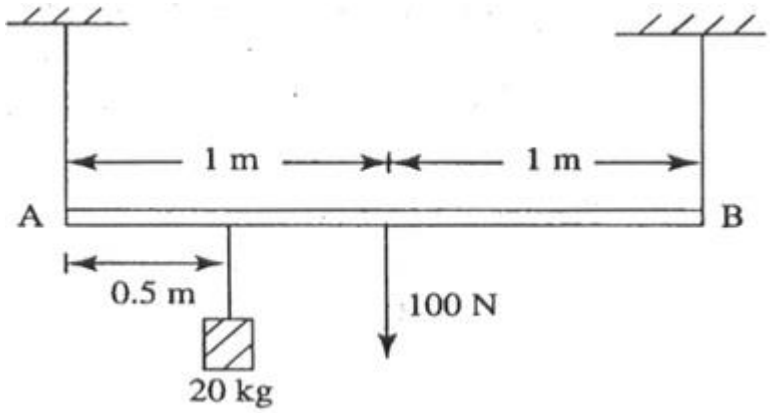
**$d = 3.3$ m**



## Principle of Moments (Example 2)

A uniform rod AB of weight 100 N and length 2 m is supported by two vertical strings at its ends and carries a load of 20 kg as shown in the diagram below.

Determine the tensions in the strings.




**Answer:**

Let the tension of the string at A be T1
the tension of the string at B be T2

Taking moments at A,

100 x 1 + 200 x 0.5 =T2 x 2

T2 = 100 N

Sum of upward forces = sum of downward forces

T1 + T2 = 200 + 100

T1 = 300 – 100 = 200 N

**OR**

Taking moments at B

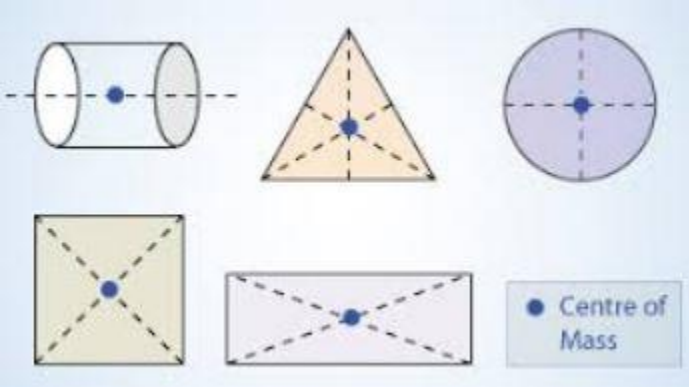
100 x 1 + 200 x 1.5 =T1 x 2

T1 = 200 N

# CENTER OF GRAVITY

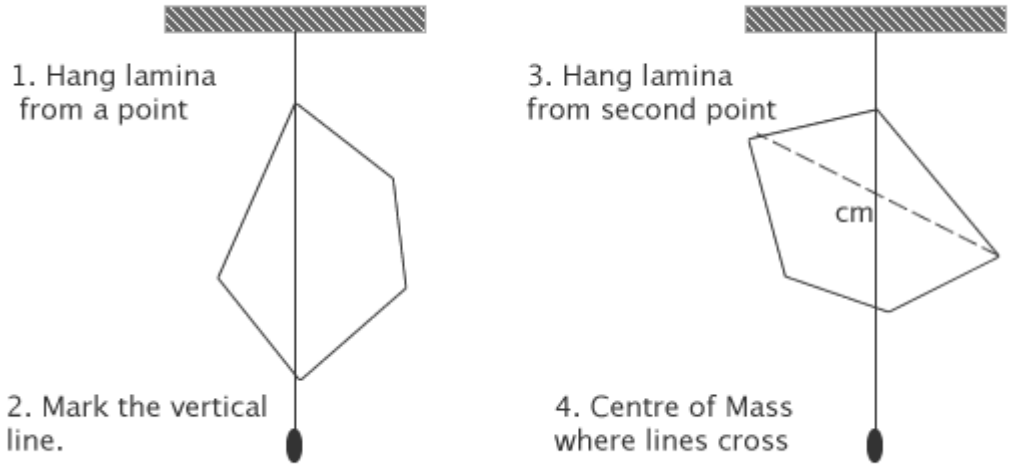
**Center of gravity** is defined as the point through which the entire weight of the object appears to act.

A regular body with uniform weight distribution will have its center of gravity in the centroid.




## CENTER OF GRAVITY

For **irregular bodies**, we can use a plumb line to determine the center of gravity.

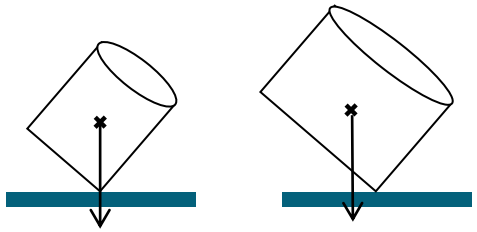
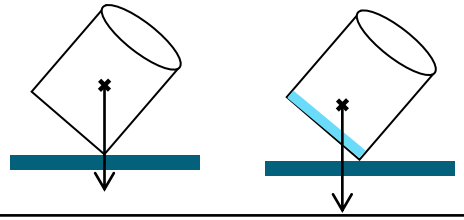


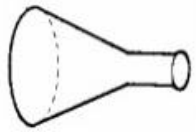
# STABILITY

## STABILITY

Stability is the measure of a body's ability to return to its original position after being tilted slightly.

**To increase stability,**

| | |
|---|---|
| **Increase base area** |  |
| **Lower center of gravity** |  |

| Equilibrium | Diagram |
|---|---|
| **Stable equilibrium**<br>- when object is displaced, the cg of the object is raised<br>- the line of action of the cg still falls within its base area<br>- the weight generates a moment about the pivot causing the object to return to its original position |  <br>Stable Equilibrium |
| **Unstable equilibrium**<br>- when object is displaced, the cg of the object is raised<br>- the line of action of the cg falls outside its base<br>- its weight generates a moment about the pivot causing the object to topple over |  <br>unstable equilibrium |
| **Neutral equilibrium**<br>- when object is displaced, the cg of the object remains at the same horizontal level<br>- the line of action through the cg will always pass through the pivot point<br>- its weight has zero moment about the pivot |  <br>neutral equilibrium |

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