

Topic : Force — Turning Effect, Moment of Force1. Force — Definition

- Force is a push or pull acting on an object which can change its state of rest or motion.
- It is a vector quantity — has both magnitude and direction.
- SI Unit of Force = Newton (N)

2. Turning Effect of Force

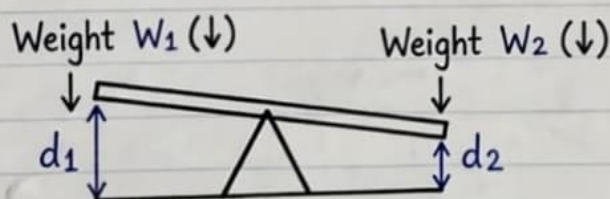
- When a force is applied to an object pivoted at a point, it can cause the object to rotate/turn about that point.
- This turning effect is called the Moment of Force (or Torque).

3. Moment of Force (Torque)

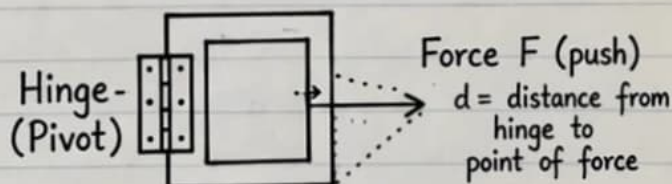
- The moment of a force is the turning effect produced by the force about a pivot/point.
- It depends on two factors:
 - (i) Magnitude of the force applied
 - (ii) Perpendicular distance from the pivot to the line of action of the force
- Formula: Moment = Force $\times$ Perpendicular distance from pivot
- SI Unit of Moment = Newton-metre (N m)

4. Principle of Moments

- It states that for a body in rotational equilibrium, the sum of the clockwise moments about the pivot = the sum of the anticlockwise moments about the pivot.
- This principle is used in levers, seesaws, balances, etc.

Diagram 1: Seesaw

Clockwise moment = $W_2 \times d_2$
Anticlockwise moment = $W_1 \times d_1$

Diagram 2: Opening a Door

Moment = $F \times d$
Greater distance $\rightarrow$ easier to open the door

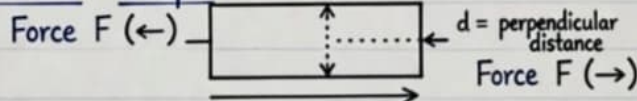
* Note: The perpendicular distance is measured from the pivot to the line of action of the force.*

Topic: Force — Moment of Force (Cont.), Couple & Equilibrium5. Couple

- A couple is formed by two equal and opposite parallel forces acting on a body but NOT acting along the same line.
- The two forces do not produce translational motion, only rotational motion.
- Example: Turning a car's steering wheel, twisting a bottle cap, turning a screwdriver.
- Characteristics of a Couple:
 - (i) The two forces are equal in magnitude, opposite in direction, and parallel.
 - (ii) The net force = 0, so there is no translation — only rotation.
 - (iii) The effect is measured by the moment of the couple.

5. Moment of the Couple

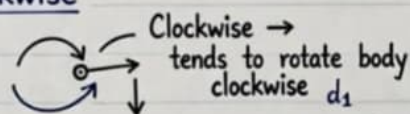
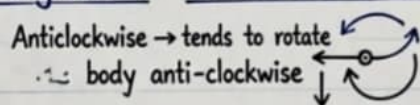
- Moment of couple = Force $\times$ Perpendicular distance between the two forces
Formula: Moment of couple = $F \times d$
- Direction: Clockwise or Anticlockwise
SI Unit = Newton-metre (N m)

Diagram 3: Couple

Both forces = F , opposite direction, parallel. They form a COUPLE $\rightarrow$ produce rotation.

6. Clockwise & Anticlockwise Moments

- Clockwise Moment: The moment which tends to rotate the body in the clockwise direction.
- Anticlockwise Moment: The moment which tends to rotate the body in the anticlockwise direction.

Diagram 4: Clockwise vs Anticlockwise

If clockwise moment $\rightarrow$ anticlockwise moment $\rightarrow$ body rotates clockwise

If anticlockwise moment $\rightarrow$ clockwise moment $\rightarrow$ body rotates anticlockwise

7. Equilibrium

- A body is said to be in equilibrium when it is at rest or moving with uniform velocity and
- Conditions for Equilibrium:
 1. Translational Equilibrium: The vector sum of all forces acting on the body = 0.
 $\rightarrow$ Sum of forces in each direction = 0 ($\Sigma F = 0$)
 2. Rotational Equilibrium: The sum of all clockwise moments = the sum of all anticlockwise moments.
 $\rightarrow$ This is the Principle of Moments.

Key Points to Remember

- A body in equilibrium is balanced — no rotation, no net force.
- Couple produces rotation without translation.
- Moment of couple is independent of the pivot point.

* Note: For a body to be in complete equilibrium, BOTH conditions must be satisfied.*

Topic : Force — Centre of Gravity & Stability

- The Centre of Gravity of a body is the point where the entire weight of the body appears to act vertically downward.
- It is the point at which the mass of the body is considered to be concentrated for studying its motion.
- For a uniform regular body, the Centre of Gravity lies at its geometric centre.

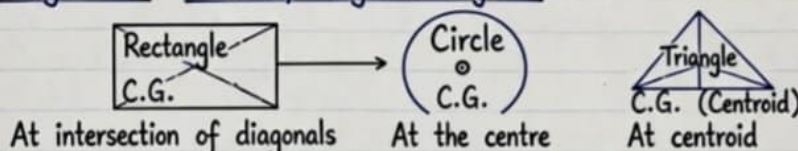
Factors affecting Centre of Gravity

- Shape of the body — affects position of C.G.
- Distribution of mass — if mass is more concentrated on one side, C.G. shifts towards that side.

Centre of Gravity of Regular Objects

- Uniform Rod → C.G. is at the midpoint of the rod.
- Rectangular plate / Square → C.G. is at the intersection of the diagonals.
- Circular disc / Circle → C.G. is at the centre of the circle.
- Triangular plate → C.G. is at the centroid (point where the three medians meet).

Diagram 5: C.G. of Regular Objects



9. Stability & Equilibrium

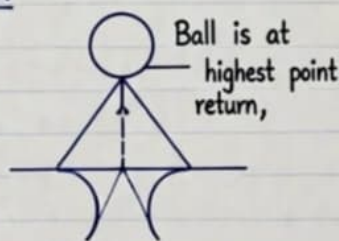
- The stability of a body refers to its ability to regain its original position after being slightly disturbed.
- There are three types of equilibrium based on stability:

Three Types of Equilibrium



(a) Stable Equilibrium

- If disturbed, body returns to original position.
- Centre of Gravity rises when disturbed, then falls back.



(b) Unstable Equilibrium

- If disturbed, body does not return, falls away.
- Centre of Gravity falls when disturbed.



(c) Neutral Equilibrium

- If disturbed, body remains in new position.
- Centre of Gravity remains at same height.

10. Conditions for Stability

- A body is more stable if:
 - (i) Its Centre of Gravity is low.
- Lower the C.G. and wider the base → greater the stability.

Example: for stability; racing cars have wide base & low C.G.

11. Applications of Stability

- Centre of Gravity is the point where weight acts downward.
- Stability depends on C.G. position and base area.
- Stable equilibrium is safest/most stable in real life applications.

*End of Chapter — Force: Turning Effect, Moment, Couple & Stability *