CH # 06 EQUILIBRIUM

STATIC:

"Statics is the branch of physics that deal with the bodies at rest under the influence of a number of forces. It also deal with equilibrium of bodies and the condition of equilibrium"

RESULTANT FORCE:

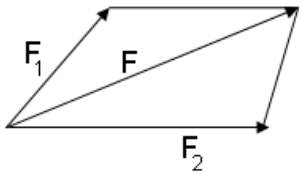
"Resultant of two or more forces is single forces which produce the same effects as produced all giving forces combine together."

PARALLELOGRAM OF FORCE:

"If two forces acting on a body makes same angel with each other than their resultant can be found by parallelogram of forces."

LAW OF PARALLELOGRAM OF FORCE:

"If two adjacent sides of a parallelogram represent magnitude and direction of two forces then its diagonal represents the resultant force."



PARALLEL FORCES:

"When number of forces act on a body and if their directions are parallel, they are called parallel forces."

LIKE PARALLEL FORCES:

"Parallel forces which act in the same direction are called like parallel forces."

UNLIKE PARALLEL FORCES:

"Parallel forces which act in opposite direction are called unlike parallel forces."

COUPLE:

"Two equal but opposite parallel forces which act at different points on the body make together a couple."

- A couple is a pair of equal, parallel and unlike forces.

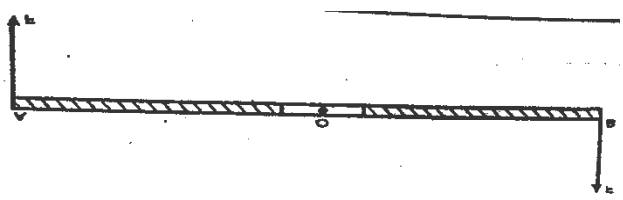
MOMENT OF COUPLE:

"The product of one of the force and the arm of the couple, which show the turning effect of the body is called moment of couple.

EXPLANATION:

Consider two equal, unlike parallel forces each of magnitude F, acting at A and B as shown in fig. The moments of two forces are given by:

The moment of the force F at A = F x OA
The moment of the force F at B = F x OB



Both these moments have the same direction i.e. counter clockwise, so the total moment of the two forces is equal to the sum of the two moments.

Moment of the couple = F x OA + F x OB
Moment of the couple = F x (OA + OB)
∴ OA + OB = AB

Moment of the couple = F x AB

Where AB is the perpendicular distance between two forces which is called arm of couple. Thus the moment of couple is equal to the arm of couple and one of the forces.

TOPICS RELATED TO EQUILIBRIUM:

- Equilibrium.
- Types of equilibrium.
- States of equilibrium.
- Conditions of equilibrium.

- **EQUILIBRIUM:**

"If a body is at rest or moves with uniform velocity it is said to be in equilibrium."

- **TYPES OF EQUILIBRIUM:**

1. **STATIC EQUILIBRIUM:**

"If a body is at rest it is said to be in static equilibrium."

Example:

- A book lying on a table.
- Building of your school etc.

2. ***DYNAMIC* -EQUILIBRIUM:**

"If a body moves with uniform velocity it is said to be in Dynamic equilibrium."

Example:

- A paratrooper jumping from an airplane falls down with a uniform velocity.

- **CONDITION OF EQUILIBRIUM:**

1. **FIRST CONDITIONS OF EQUILIBRIUM:**

"An object is said to be in equilibrium if the sum of all the forces acting on it in one direction balances the sum of all forces acting in the opposite direction."

$$\sum Fx = 0$$
$$\sum Fy = 0$$

EXPLANATION:

Hence the algebraic sum of x-components of all the forces must be zero; similarly the algebraic sum of y-components of all the forces must also be zero. When the first condition of equilibrium is satisfied acceleration of the body will be zero and the body will be either at rest or move with uniform velocity.

APPLICATION:

In physics the first condition of equilibrium is used to determine the magnitude and the direction of unknown force acting on a body if all the other forces are known.

TRANSLATIONAL EQUILIBRIUM:

"If first condition of equilibrium is satisfied then the body is said to be in translational equilibrium."

2. **SECOND CONDITIONS OF EQUILIBRIUM:**

"For an object to be in equilibrium the sum of torques producing clockwise rotation must be equal to the sum of torques producing anticlockwise rotation."

$$\sum \tau = 0$$

EXPLANATION:
Hence if the body is in equilibrium, the algebraic sum of all the torques acting on it is zero. A body satisfying the second condition will either not rotate at all or rotate with constant angular velocity.

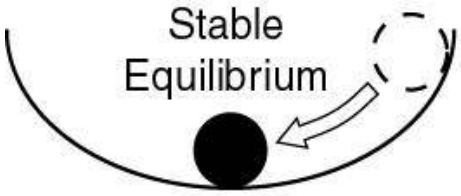
APPLICATION:
Second condition of equilibrium is also used to determine the magnitude and the direction of unknown force acting on a body if all the other forces are known.

ROTATIONAL EQUILIBRIUM:
"If second condition is of equilibrium is satisfied then the body is said to be in rotational equilibrium."

- **STATES OF EQUILIBRIUM:**

1. **STABLE EQUILIBRIUM:**

"A body is said to be in stable equilibrium if it comes back to its initial position as soon as the applied force is removed."



CONDITION FOR STABLE EQUILIBRIUM:
If the application of any force raises the centre of gravity of the body it will be in stable equilibrium.

EXAMPLE:
- Table, chairs and the book lying on the table etc.

2. **UNSTABLE EQUILIBRIUM:**

"A body is in unstable equilibrium if it does not return its initial position as soon as the applied force is removed."

CONDITION FOR UNSTABLE EQUILIBRIUM:
Force tends to lower the centre of gravity of the body then it will be in unstable equilibrium.

EXAMPLE:
- A stick standing on the tip of the finger is an example of unstable equilibrium.

3. **NEUTRAL EQUILIBRIUM:**

"The body has no tendency to move in any direction when the applied force is removed then it is said to be in neutral equilibrium."

CONDITION FOR NEUTRAL EQUILIBRIUM:
If the application of any horizontal force does not change the position of the centre of gravity of a body then the body will be in neutral equilibrium.

EXAMPLE:
- A ball lying on a table is an example of neutral equilibrium.

TOPICS RELATED TO TORQUE:

- Torque.
- Factors of torque.
- Types of torque.

TORQUE:

"The turning effect of a force produced in a body about an axis of rotation is known as torque."

FORMULA:

Torque = force x moment arm

$\tau = F \times d$

- Where τ (Tau) represents torque.
- Torque is also known as moment of force.

Unit:

In S.I or M.K.S system unit of torque is Newton-meter (N-m).

FACTORS ON WHICH TORQUE DEPENDS:

Toque or moment of force depends on two factors:

i) The magnitude of the force
ii) Moment arm

i) MAGNITUDE OF THE FORCE:

It can be observed that greater the magnitude of the force greater will be torque.

ii) PERPENDICULAR DISTANCE FROM AXIS OF ROTATION:

The turning effect of the force is greater the farther is the line of action of the force from the axis of rotation.

EXAMPLES OF TORQUE OR EXPLANATION OF FACTORS OF TORQUE:

1. **ROTATION OF WHEEL:**
   Consider the rotation of wheel. It is common experience that the wheel can be rotated more easily and quickly by applying a force perpendicular to far from axis of rotation than by applying the same force at near to the axis of rotation.

2. **ACTION ON BAR:**
   If a bar is capable of rotation about its midpoint, the perpendicular distance and force give the moment of couple which is called torque act on it.

TYPES OF TORQUE:

- **NEGATIVE TORQUE:**
  "If body will rotate clock-wise then torque is said to be negative torque."

- **POSITIVE TORQUE:**
  "If body will rotate counter-clock-wise then torque is said to be positive torque."

CENTER OF GRAVITY (COG):

"A point at which whole weigh of the body appears act is known as centre of gravity."

- Centre of gravity of regular shapes lies at their geometrical center
- Weight represent through center of gravity of the body.