Equilibrium of Forces | Definition, Examples, and Types

If the body is under the action of several forces and is at rest or moving with a uniform velocity it is said to be in equilibrium. Equilibrium of forces has different types.

Topic Related Video:

What is equilibrium in physics

Types of equilibrium

- Static equilibrium
- Dynamic equilibrium

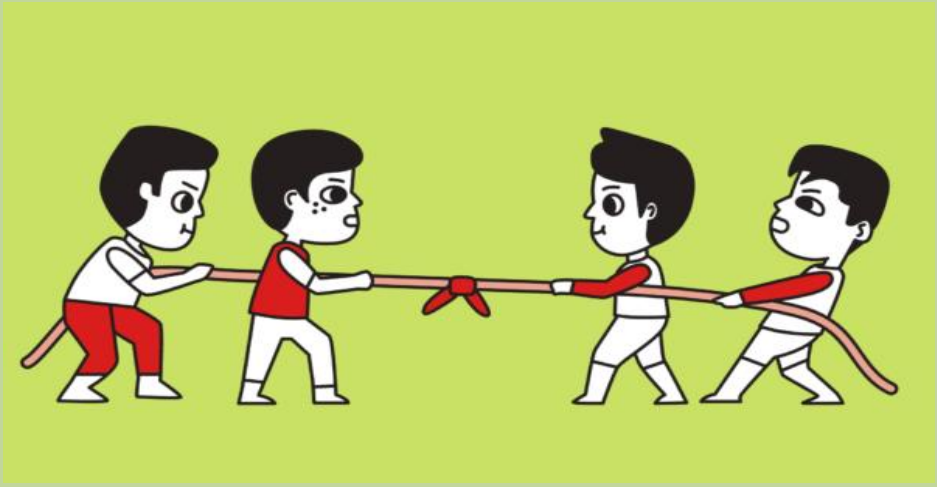
Static equilibrium

If the body is at rest (zero velocity and zero acceleration) it is said to be in static equilibrium.

Examples:

- **A book lying on the table**

Tug of war



In the tug of war, two teams pull a rope in opposite directions. When the force applied by one team is balanced by the force applied by another team, then there is no motion. So the rope is in equilibrium

Dynamic equilibrium

If a body is moving with uniform velocity or rotating with uniform angular velocity, then the body is in the state of dynamic equilibrium

Examples:

- Paratrooper jumping from an airplane

When a paratrooper jumps out of an airplane, he opens his parachute after a free fall. After some time paratrooper starts descending with uniform velocity because the force of gravity acting downward on the paratrooper is balanced by the reaction of air on the parachute upward. Now the body is moving with uniform velocity.

Translational equilibrium

When a body is moving with uniform linear velocity there is no linear acceleration, the body is said to be in translational equilibrium

Rotational equilibrium

When a body is moving with uniform angular velocity there is no angular acceleration then the body is said to be in rotational equilibrium

Coplanar forces

If all forces lie in a common plane then such forces are called coplanar.

The first condition of equilibrium

When a body is moving with uniform linear velocity there is n linear acceleration, the body is said to be in translational equilibrium

Mathematically $\sum F = 0$

For coplanar forces

This condition is usually expressed in terms of the x and y components of the forces

- $\sum Fx = 0$, the sum of the x-component of all the forces must be zero
- $\sum Fy = 0$, the sum of the y-component of all the forces must be zero

Right-hand forces are taken as positive and left-hand side forces are taken as negative

Similarly, upward forces are taken as positive and downward forces are taken as negative

Equilibrium of torques

A physical quantity that produces an angular acceleration in a body about the axis of rotation is called torque

The second condition of equilibrium

When a body is moving with uniform angular velocity there is no angular acceleration, the body is said to be in rotational equilibrium

Mathematically $\sum \tau = 0$

Complete equilibrium

when ist condition is satisfied, there is no linear acceleration and the body will be in translational equilibrium

when the second condition is satisfied, there is no angular acceleration and the body will be in rotational equilibrium.

For a body to be in complete equilibrium, both conditions should be satisfied, i.e, both linear and angular acceleration should be zero