

Engineering Mechanics

Fundamental of Mechanics

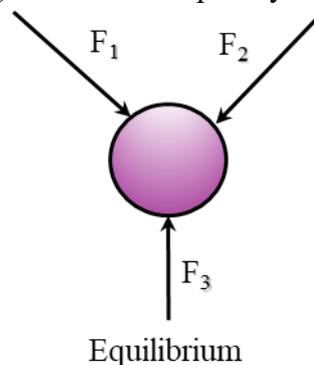
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Introduction

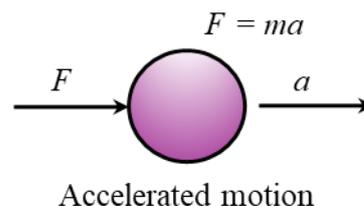
- Mechanics is the branch of engineering dealing with the state of rest or motion of bodies that are subjected to the action of forces.
- In general, this subject can be subdivided into three branches.
 - Rigid-body mechanics
 - Statics
 - Dynamics
 - Deformable-body mechanics
 - Fluid mechanics
- **Statics:** It deals with the equilibrium of bodies. Bodies are either at rest or move with constant velocity
- **Dynamics:** It is concerned with the accelerated motion of the bodies.
- Statics is the special case of dynamics, in which acceleration is zero; However, statics deserves separate treatment in engineering education since many objects are designed with the intention that they remain in equilibrium.

Newton's Law of Motion

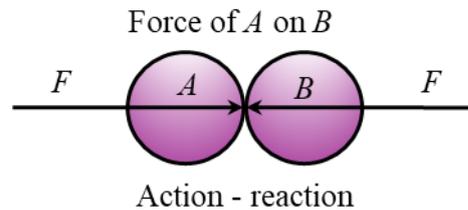
- Newton's law of motion applies to the motion of a particle as measured from a *non-accelerating* reference frame.
- **First Law (Law of inertia):** An object remains at rest or continues to move at a constant velocity (straight line) unless acted upon by a net external force.



- **Second Law (Law of acceleration):** A particle acted upon by an unbalanced force (F) experiences an acceleration (a) that has the same direction as the force and a magnitude that is directly proportional to the force.



- **Third Law (Law of acceleration):** For every action, there is an equal and opposite reaction.



Newton's Law of Gravitational Attraction

- Every particle attracts every other particle in the universe with force directly proportional to the product of the masses and inversely proportional to the square of the distance between them. Stated mathematically,

$$F = G \frac{m_1 m_2}{r^2}$$

Where, F is force of gravitation between the two particles

G is universal constant of gravitation. The value of G is $66.73 \times 10^{-12} \text{ N}\cdot\text{m}^2/\text{kg}^2$

m_1, m_2 is the mass of the two particles

r is the distance between the two particles

- The Universal Gravitational Law can explain almost anything, right from how an apple falls from a tree to why the moon revolves around the earth.

Mass and Weight

- Mass (m) is the amount of matter in a body, while weight is the gravitational force acting on that mass.
- Weight is calculated as $W = mg$, where, m is the mass and g is the gravitational acceleration (9.81 m/s^2).
- Mass remains constant regardless of location, but weight changes depending on the gravitational field. For example, an object with mass m , weighs more on Jupiter because its gravitational acceleration is about 23.10 m/s^2 , greater than Earth's.

Example 1

- Calculate the gravitational force of attraction between the Earth and a 70 kg man standing at a sea level, a distance of $6.38 \times 10^6 \text{ m}$ from the earth's centre.

Solution:

m_1 is the mass of earth = $5.98 \times 10^{24} \text{ kg}$

m_2 is the mass of man = 70 kg

Distance (d) = $6.38 \times 10^6 \text{ m}$

Universal constant of gravitation (G) = $6.673 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

From the Gravitational force formula,

$$F = 6.673 \times 10^{-11} \frac{5.98 \times 10^{24} \times 70}{6.38 \times 10^{-11}} = 685 \text{ N}$$

Basic Dimension and Units of Mechanics:

- The three basic primary or independent dimensions are length, mass and time.
- **Dimension:**
 - [L] Length (Concept for describing size quantitatively)
 - [M] Mass (A property of matter)
 - [T] Time (Concept for ordering the flow of events)

Common System of Unit:

Cgs		SI or MKS	
Length	Centimetre	Length	Meter
Mass	Gram	Mass	Kilogram
Time	Second	Time	Second
Force	Dyne	Force	Newton

English or FPS		American practices	
Length	Foot	Length	Foot
Mass	Pound-mass	Mass	Slug or pound
Time	Second	Time	Second
Force	Pondal	Force	Pound-force

Example 2:

- Convert the density of steel 7.85 g/cm^3 to kg/m^3 ?

Solution:

$$1 \text{ kg} = 1000 \text{ gm}$$

$$1 \text{ m} = 100 \text{ cm}$$

$$7.85 \frac{\text{g}}{\text{cm}^3} = \left(\frac{7.85 \text{ g}}{\text{cm}^3} \right) \left(\frac{1 \text{ kg}}{1000 \text{ g}} \right) \left(\frac{100 \text{ cm}}{1 \text{ m}} \right)^3$$
$$= 7.85 \times 10^3 \text{ kg/m}^3$$