

## SYNOPSIS:

- ▲ **Motion:** Change in position of an object with time.
- ▲ **Rectilinear motion :** The study of motion of objects along a straight line, also known as **rectilinear motion**.
- ▲ **Path length:** The total length of path traversed by an object.
- ▲ **Displacement:** It is the change in position  $\Delta X = X_2 - X_1$ . It has both magnitude and direction, represented by vectors.
- ▲ **Uniform motion:** An object moving along the straight line, covers equal distances in equal intervals of time.
- ▲ **Acceleration:** Change of velocity divided by the time interval i.e.  
$$\bar{a} = \Delta v / \Delta t .$$
- ▲ **Speed** is greater than the magnitude of the velocity.
- ▲ **Average speed:** The total path length travelled divided by the total time interval during which the motion has taken Place.  
**Average speed=Total path length / Total time interval**

- ▶ **Instantaneous velocity** : The limit of the average velocity as the time interval  $\Delta t$  becomes infinitesimally small.

$$v = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t} = dx/dt.$$

- ▶ **Kinematic equations:**  $v = v_0 + at$ .

- ▶  $x = v_0 t + \frac{1}{2} at^2$

- ▶  $v^2 = v_0^2 + 2ax$

- ▶  $t_r = \sqrt{\frac{2d}{g}}$

- ▶ **Relative velocity:** Consider two objects  $A$  and  $B$  moving uniformly with average velocities  $v_A$  and  $v_B$  in one dimension along  $x$ -axis, then the velocity of object  $B$  relative to object  $A$  is  $v_B - v_A$ .

$$v_{BA} = v_B - v_A$$

- ▶ **Scalar** : A quantity which is independent of certain classes of coordinate systems.
- ▶ **Vector:** A quantity that has both a magnitude and a direction and obeys the **triangle law of addition** or **parallelogram law of addition**.

- ▲ **Displacement Vector:** The straight line joining the initial and final positions and does not depend on the actual path undertaken by the object between the two positions.
- ▲ **Magnitude of displacement:** It is either less or equal to the path length of an object between two points.
- ▲ **Equality of Vectors:** Two vectors **A** and **B** are said to be equal if, and only if, they have the same magnitude and the same direction.
- ▲ **Multiplication of Vectors :** Multiplying a vector **A** with a positive number gives a vector whose magnitude is changed by the factor  $\lambda$  but the direction is the same as that of vector **A**.
- ▲ **Head-to-tail method:** In the procedure of vector addition, They are arranged head to tail. This graphical method is called the head-to-tail method.
- ▲ **Null vector or a zero vector:** If the magnitude of two vectors are same but direction are opposite then the resultant vector has zero magnitude.
- ▲ **Unit vectors:** Vector of unit magnitude and points in a particular direction. It has no dimension and unit. It is used to specify a direction only.

- ▲ **Velocity:** The average velocity ( $\mathbf{v}$ ) of an object is the ratio of the displacement and the corresponding time interval.
- ▲ **Acceleration:** The average acceleration  $\mathbf{a}$  of an object for a time interval  $\Delta t$  moving in  $x$ - $y$  plane is the change in velocity divided by the time interval.
- ▲ **Relative velocity in two dimensions:** Suppose that two objects A and B are moving with velocities  $\mathbf{v}_a$  and  $\mathbf{v}_b$  (each with respect to some common frame of reference). Then, velocity of object A relative to that of B is called relative velocity in two dimensions (plane).
- ▲ **Projectile motion:** An object that is in flight after being thrown or projected is called a projectile. Such type of motion is called projectile motion.
- ▲ **Uniform circular motion:** When an object follows a circular path at a constant speed.
- ▲ **Centripetal acceleration:** Acceleration of an object moving with speed  $v$  in a circle of radius  $R$  has a magnitude  $v^2/R$  and is always directed towards the centre.

- ▶ **Aristotelian law of motion:** An external force is required to keep a body in motion. An object moving on a frictionless horizontal plane must neither have acceleration nor retardation, i.e. it should move with constant velocity.
- ▶ **Inertia:** Resistance to change.
- ▶ **First Law of motion:** Every body continues to be in its state of rest or of uniform motion in a straight line unless compelled by some external force to act on it.
- ▶ **Newton's second law of motion:** The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts.  
 $F = k m a$  **newton** : 1 N = 1 kg m s<sup>-2</sup>.
- ▶ **Impulsive force:** A large force acting for a short time to produce a finite change in momentum.  
Impulse = Force × time duration = Change in momentum
- ▶ **Newton's third law of motion:** Every action, there is always an equal and opposite reaction.  $F_{AB} = -F_{BA}$
- ▶ **Conservation of momentum:** The total momentum of an isolated system of interacting particles is conserved.

- ▲ **Friction:** The force resisting the relative lateral (tangential) motion of solid surfaces.
- ▲ **Rolling friction:** A body like a ring or a sphere rolling without slipping over a horizontal plane will suffer no Friction.
- ▲ **Circular motion:** Acceleration of a body moving in a circle of radius  $R$  with uniform speed  $v$  is  $v^2/R$  directed towards the centre.
- ▲ **KEPLER'S first Law of orbits:** 'All planets move in elliptical orbits with the Sun situated at centre of the ellipse'.
- ▲ **KEPLER'S second Law of areas:** 'The line that joins any planet to the sun sweeps equal areas in equal intervals of time'.
- ▲ **KEPLER'S third Law of periods :** 'The square of the time period of revolution of a planet is proportional to the cube of the semi-major axis of the ellipse traced out by the planet'.

- ▲ **Newton's universal law of gravitation:** The gravitational force of attraction between any two particles of masses  $m_1$ , and  $m_2$ , separated by a distance  $r$  has the magnitude.

$$F = -GM_1M_2 / r^2.$$

where  $G$  is the universal gravitational constant.

It has the value  $6.672 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$ .

- ▲ **Acceleration due to gravity of the earth:**

$$g = F / m = GM_E / R_E^2$$

- ▲ **Gravitational potential energy:** The energy stored in the body at a given position. If the position of the particle changes on account of forces acting on it, then the change in its potential energy is just the amount of work done on the body by the force.

- ▲ **Conservative forces:** Forces for which the work done which is independent of the path. The force of gravity is a conservative force and we can calculate the potential energy of a body arising out of this force which is called as gravitational potential energy.

$$V = -GM_1M_2 / r$$

- ▲ **Escape speed:** Throwing an object with high initial speeds which does not fall back to the Earth.

$$V = \sqrt{2gr_E}$$

- ▲ **Geostationary satellites:** Satellites in a circular orbits around the earth in the equatorial plane with  $T = 24$  hours.
- ▲ **Phenomenon of weightlessness:** when an object is in free fall. it is weightless.