UNIT 2

Kinematics

FRAME OF REFERENCE

- The frame of reference is a system of co-ordinates axes attached to an observer having a clock with him, with respect to which, the observer can describe position, displacement, acceleration etc of a moving body.

Types of Frame of References

- Inertial frame of reference
- Non-inertial frame of reference

- **Inertial frame of reference :** In which Newton's first law of motion holds good. For example, a frame of reference attached to a boy in a train at rest or moving with a uniform velocity along straight path.
- **Non-inertial frame of reference :** In which Newton's first law of motion does not hold good. For example a frame of reference attached to a boy in a train moving with variable velocity or moving with acceleration along a straight path.

MOTION

- A body is said to be in motion if it changes its position with time, with respect to its surroundings, *e.g.* a bird flying in air.
- Rest and motion are relative terms.
- **Motion in one dimension :** The motion of a body is said to be one dimensional if only one out of the three co-ordinates specifying the position of the body changes with respect to time. In such a motion, the body moves along a straight line. *e.g.* an object falling freely under gravity etc.
- **Motion in two dimensions :** The motion of a body is said to be two dimensional if two out of three co-ordinates specifying the position of the body change with respect to time. In such a motion, the body moves in a plane, *e.g.* an insect crawling over the floor of a room, a billiard ball moving over the billiard table.
- **Motion in three dimensions :** The motion of a body is said to be three dimensional if all the three co-ordinates specifying the position of the body change with respect to time. In such a motion, the body moves in a space, *e.g.* a bird flying in the sky, random motion of a gas molecule etc.

SCALAR QUANTITIES

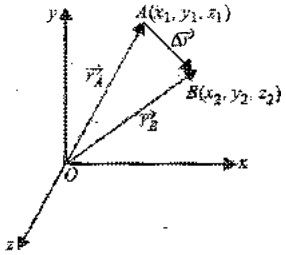
- The physical quantities which have only magnitude but no direction are known as scalar quantities *e.g.*, mass, work etc.

VECTOR QUANTITIES

- The physical quantities which have both magnitude as well as direction are known as vector quantities, *e.g.* force, velocity etc.

DISTANCE AND DISPLACEMENT

- The length of the actual path traversed by a body during its motion in a given interval of time is called distance travelled by the body.
- The displacement of a body is defined as the shortest distance between the two positions of the body in a particular direction. It is given by the vector drawn from the initial position to its final position.



Let a body be displaced from $A(x_1, y_1, z_1)$ to $B(x_2, y_2, z_2)$ then its displacement is given by vector $\overrightarrow{AB}$.

From ΔOAB, $\vec{r}_A + \overrightarrow{AB} = \vec{r}_B$ or $\overrightarrow{AB} = \vec{r}_B - \vec{r}_A$

$\therefore \quad \vec{r}_B = x_2\hat{i} + y_2\hat{j} + z_2\hat{k}$ and $\vec{r}_A = x_1\hat{i} + y_1\hat{j} + z_1\hat{k}$

$\therefore \quad \overrightarrow{AB} = (x_2 - x_1)\,\hat{i} + (y_2 - y_1)\,\hat{j} + (z_2 - z_1)\hat{k}$

or $\overrightarrow{AB} = \Delta x\hat{i} + \Delta y\hat{j} + \Delta z\hat{k}$

- Displacement is independent of the path.
- Distance is a scalar quantity whereas displacement is a vector quantity.
- The displacement of a body in a given time interval can be positive, negative or zero but the distance covered is always positive.
- The value of displacement can never be greater than the distance covered.

SPEED

- Speed of a body is defined as the rate of change of position of the body with time in any direction.

$$i.e., \quad \text{Speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

AVERAGE SPEED

- Average speed is defined as the ratio of the total distance travelled by the body to the total time taken.

$$i.e., \quad \text{Speed} = \frac{\text{distance travelled}}{\text{time taken}}$$