PHYSICS FORMULAS
For Motion Theory

MOTION:

Any kind of movement in a body is known as motion. **A body is said to be in motion when its position or state changes continuously** with respect to a stationary object taken as a reference point. Motion is a relative term.

REST:

A body is said to be at rest when its position or state does not change with respect to a stationary object taken as a reference point. Rest is also a relative term.

TYPES OF MOTION

(i) Linear motion (or translatory motion) : The motion of a moving car, a person running, a stone being dropped.

(ii) Rotational motion : The motion of an electric fan, motion of earth about its own axis.

(iii)Oscillatory motion : The motion of a simple pendulum, a body suspended from a spring (also called to and fro motion).

DIFFERENCE BETWEEN SCALAR AND VECTOR QUANTITIES:

S. No.	Scalar quantities	Vector quantities
1.	Scalar quantities are described by magnitude only.	Vector quantities are described by magnitude as well as direction.
2.	Scalar quantities change with change in magnitude only.	Vector quantities change with the change in magnitude or with the change in direction or both.
3.	Scalar quantities can be added or subtracted using ordinary rules of algebra.	Vector quantities cannot be added or subtracted using ordinary rules of algebra.
4.	Scalar quantities are represented by ordinary letter. e.g. A	Vector quantities are represented by letters having arrow over them. e.g. $\vec{A}$.

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DIFFERENCE BETWEEN DISTANCE AND DISPLACEMENT

S. No.	Distance	Displacement
1.	Distance is the actual length of the path travelled by the particle in a given interval of time.	Displacement is the shortest distance between the initial position and the final position of the moving particle in a particular direction.
2.	Distance travelled by the particle in a given interval of time is always positive.	Displacement of the particle in a given interval of time may be positive, negative or zero.
3.	Distance travelled by the particle depends upon the path followed by the particle in going from initial position to the final position.	The displacement of the particle between initial position and final position of the particle does not depend upon the path followed by it.
4.	Distance is scalar quantity	Displacement is a vector quantity.

SPEED:

Speed of a body is defined as the **distance travelled by it per unit time irrespective of direction**. It is a **scalar quantity**.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

or $v = \frac{s}{t}$

Where *v* is the speed, *s* is the distance covered and '*t*' is the time taken.

VELOCITY:

Velocity of a body is defined as the **displacement travelled by it per unit time.** In other words velocity of a body is its speed in a given direction. It is a **vector quantity**.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

or $\vec{v} = \frac{\vec{s}}{t}$

where $\vec{v}$ is the velocity

$\vec{s}$ is the distance travelled

't' is the time taken

i.e. $\text{Average velocity} = \frac{\text{Initial velocity} + \text{final velocity}}{2}$

or $$\vec{v} = \frac{\vec{u} + \vec{v}}{2}$$

where, $\vec{v}$ is the average velocity

$\vec{u}$ is the initial velocity

$\vec{v}$ is the final velocity

Instantaneous Velocity:

The velocity of an object at any given instant of time at particular point of its path is called its instantaneous velocity.

$$\vec{V} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t} = \frac{d\vec{x}}{dt}$$

ACCELERATION:

The rate of change of velocity with time is known as acceleration. In other words, the acceleration is defined as the change in velocity per unit time.

i.e. $$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}}$$

or $$\text{Acceleration} = \frac{\text{Final Velocity} - \text{Initial velocity}}{\text{Time}}$$

or $$\vec{a} = \frac{\vec{v} - \vec{u}}{t}$$

Where $\vec{a}$ = Acceleration of the body

$\vec{v}$ = Final velocity of the body

$\vec{u}$ = Initial velocity of the body

t = Time taken for this change in velocity

- A body is said to be accelerating if its velocity is changing
- S.I. unit of acceleration is ms^{-2} **(metre per second square).**
- Acceleration is a **vector quantity**.
- When a body is moving with uniform velocity, its acceleration is zero (or no acceleration).
  This is because there is no change in velocity as Initial velocity = Final velocity.
- A body moving with non-uniform velocity is said to be in accelerated motion.

First Equation of motion : $v = u + at$

Second Equation of motion : $s = ut + \frac{1}{2}at^2$

Third Equation of motion : $v^2 - u^2 = 2as$

Where u = initial velocity of the body

v = final velocity of the body

a = uniform acceleration of the body
t = time taken
s = distance travelled

MOTION UNDER GRAVITY:

(i) Motion under gravity means an object is in motion in space under the force of gravity alone.

(ii) Motion under gravity is a uniformly accelerated motion. So equations of motion for uniformly accelerated motion can be used which are

$$\vec{v} = \vec{v}_0 + \vec{a}t$$

$$\vec{s} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$$

$$v^2 = v_0^2 + 2\vec{a}.\vec{s}$$

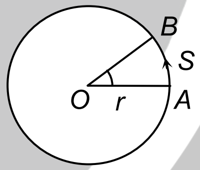
(iii) Here acceleration will be acceleration due to gravity.
In SI-unit $g = 9.8$ m/s^2
In c.g.s. unit $g = 980$ cm/s^2

(iv) When an object is thrown upward or downward, in both cases same acceleration 'g' will be experienced by the object, which acts in downward direction.

(v) Here air resistance is neglected. In a real experiment air resistance cannot be neglected. It is an ideal case. Such motion is referred to as free fall.

LINEAR SPEED AND ANGULAR VELOCITY:

Let a body is moving in a circular path of radius 'r' with a uniform linear speed 'v' when the body moves from point A to point B covering a distance 's' in time 't'.
Then the linear speed v is given by:



$$\text{Linear speed} = \frac{\text{Distance traveled}}{\text{Time taken}}$$

i.e. $$v = \frac{s}{t}$$

When the body moves on circular path from A to B in time t. It also moves through an angle θ, which is known as the angular displacement of the body.

ANGULAR VELOCITY:

It is defined as the angular displacement per unit time

i.e. $$\text{Angular velocity} = \frac{\text{Angular displacement}}{\text{time taken}}$$

or (Omega), $$\omega = \frac{\theta}{t}$$

where ω = angular velocity
θ = Angle in radian, through which the body moves.

S.I. unit of angular velocity is rad s^{-1}.

RELATION BETWEEN LINEAR SPEED AND ANGULAR VELOCITY:

Linear speed = Angular velocity × Radius of the circular path

- Rest and motion are relative terms. An object may be at rest with respect to one surroundings but may be in motion with respect to other surroundings.

- State of Rest
- State of Motion
- Scalar quantities
- Vector quantities
- Displacement
- Distance
- Conditions for displacement to be equal to distance
- Uniform Motion
- Non uniform Motion
- Displacement time graph
- Velocity-time graph.
- Acceleration time graph
- Uniform circular motion
- Non-uniform circular motion
- Speed and angular speed relation
- Centripetal Acceleration and

- Velocity
- Speed
- Acceleration
- Retardation
- Average velocity
- Average Speed
- Distance time graph
- Speed time graph
- Accelerated motion
- Equations of motion