MECHANICS

Mechanics: The branch of physics which deals with the objects which are in state of rest or in a state of motion is called mechanics.

Kinematics: The branch of physics which deals with the description of motion of object without reference to the force or agent causing motion is called kinematics.

Rest: If a body does not change its position with respect to its surrounding than it is said to be in a state of rest. OR
If co-ordinates of position of object remains same than it is said to be in state of rest.
Example:
A box placed at one corner
A bus standing at the bus stop

Motion:
If a body changes its position with respect to its surrounding than it is said to be in a state of motion. OR
If the co-ordinates representing the position of an object changes tune to time that it is said to be in a state of motion.
e.g.: Motion of train on platform
Motion of car on street

Kinds of motion:
(1) Transitory motion / Linear motion:
A motion of a body in which every particle of the object is being displaced by the same amount is called translational motion. OR
If an object moves in a straight line than if is said to be in a state linear motion.
E.g.: Motion of falling body
Motion of car on road
(2) Rotational motion / Circular motion:
When an object spins or rotates about a fixed point or axis, its motion is called rotation motion.
OR The motion of body in a circular orbit is called circular or rotational motion.
E.g.: Motion of electric fan
Motion of planet around the sun

(3) Oscillatory Motion / Vibratory Motion:

When a pendulum swings from one side to other side and back motion is said to oscillatory or vibratory motion. OR

To and from motion abbot the mean position is called vibratory or oscillatory motion.

E.g.: Motion of simple pendulum

Motion of stretched string

(4) Projectile Motion:

Motion of an object in a curve path is called projectile motion. OR

When an object moves in a parabolic path and falls under the action of gravity than its motion is said to be projectile motion.

E.g.: Motion of projectile

A ball thrown horizontally with certain angle.

Distance:

Gap or space covered by a body between two points in any direction is called distance.

Units of displacement:

System	Units	Symbols
M.K.S System	**Meter**	**m**
C.G.S. System	**Centimeter**	**cm**
F.P.S. System	**Foot**	**ft**

Displacement:

Minimum shortest distance covered by a body between two points in a straight line in **A** direction of one another is called displacement. It is denoted by **S**.

OR

Least possible distance between points in the direction of one another is called Displacement. Displacement must be in straight line i.e. unidirectional. It is denoted by $\vec{S}$.

Units of displacement:

System	Units	Symbols
M.K.S System	**Meter**	**m**
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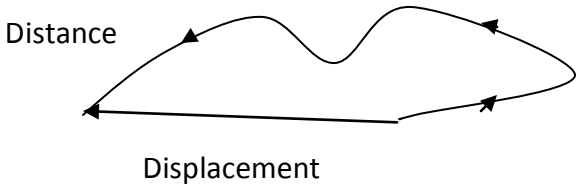

Speed:

"Rate of covering distance is called speed."

OR

"Distance covered by a body in a unit time (one second) is called speed."

OR

"The ratio of distance with respect to time is called speed."

Average Speed:

"The ratio of total distance covered by a body to the total time required to cover it is called average speed."

OR

"The average speed is determined by the amount of distance traveled by the body in the given time duration."

Mathematically,

Average Speed = Total Distance Covered x Total time taken

Symbolically V = S x T

Units of Speed:

System	Units	Symbols
M.K.S System	**Meter/Second**	**ms^{-1}**
C.G.S. System	**Centimeter/second**	**Cms^{-1}**
F.P.S. System	**Foot/second**	**Fts^{-1}**

Velocity:

"Speed of a body in a specified direction is called velocity." OR

"Rate of change of displacement is called velocity." OR

"Distance covered by a body in a unit time (one second) in a particular direction is called velocity."

Average Velocity:

"The ratio of total displacement covered by the body to the total time require to cover it is called average velocity." OR

"The average velocity of a moving is given by the displacement divided by the time elapsed."

Mathematically, **average velocity = Total displacement / Total time**

Symbolically **$V_{av} = S / t$**

Units of Velocity:

System	Units	Symbols
M.K.S System	**Meter/Second**	**ms^{-1}**
C.G.S. System	**Centimeter/second**	**Cms^{-1}**
F.P.S. System	**Foot/second**	**Fts^{-1}**

Uniform Velocity:

"If the velocity remains same at the different interval and equal interval of time than it is said to be uniform velocity in specified direction." OR

"The velocity of the body is said to be uniform if it covers equal distance in equal interval of time in specified direction."

Variable Velocity:

"If the velocity change at the different intervals of time than it is said to be variable velocity."

OR

"The velocity of the body is said to be variable if it do not equal distance in equal intervals of time in specified direction."

Acceleration:

"Rate of change of velocity is called acceleration." OR

"Change of velocity in a unit time (one second) is called acceleration." OR

"The ratio of change in velocity to the time requires producing that changes is called acceleration." Acceleration is denoted by symbol **a**. It is taken positive when velocity is increasing and negative when velocity is decreasing.

Acceleration can be calculated with the following mathematical equation.

Acceleration = Change in velocity /Time interval

$$\boldsymbol{a = \Delta v / \Delta t}$$

$$a = \frac{V_f - V_i}{\Delta t}$$

Hence a is the acceleration, $\mathbf{V_i}$ is the interval velocity, $\mathbf{V_f}$ is the final velocity and **Δt** is the time interval.

Units of Acceleration:

System	Units	Symbols
M.K.S System	**Meter/Second. Second**	**ms^{-2}**
C.G.S. System	**Centimeter/second. second**	**Cms^{-2}**
F.P.S. System	**Foot/second. second**	**Fts^{-2}**

Average Acceleration:

"The ratio between total change in velocity and the time require producing that change is called Average Acceleration." Mathematically,

$$Acceleration = \frac{Change\ in\ Velocity}{Time}$$

$$a_{av} = \frac{\Delta V}{\Delta t}$$

Uniform Acceleration:

"If the velocity of a body moving along a straight line changes uniform in equal intervals of time, however short the interval may be, the acceleration so produced is called uniform acceleration." OR

"If acceleration remains same at the different interval of time than it is called uniform acceleration."

Positive Acceleration:

"If the speed is increasing than acceleration is called positive acceleration." Its direction is in the direction of motion."

Negative Acceleration:

"If the speed is decreasing than acceleration is negative and is called negative acceleration." It is also called deceleration or retardation.

Equations Of Uniformly Acceleration Rectilinear Motion:

They are three basic equations connecting acceleration, velocity, distance, and in case of uniformly accelerated rectilinear motion.

First Equation of Motion: Let a body starts its motion with velocity "V_i". Let after time "t "its velocity becomes "V_f ". During such duration it covered distance with uniform acceleration "a", By definition, acceleration is given as

$$Acceleration = \frac{change\ in\ Velocity}{Time}$$

$$a = \frac{\Delta V}{\Delta t} \_\_\_\_\_ (1)$$

Where, ΔV is the change in velocity given as?

$$\Delta V = Vf - Vi \_\_\_\_\_ (2)$$

Substituting (2) in (1)

$$a = \frac{Vf - Vi}{Vt}$$

$$at = Vf - Vi$$

$$Vi + at = Vf \qquad \text{OR}$$

$$Vf = Vi + at$$

Second Equation of Motion:

Let a body start its motion with velocity V_i. Let after time "t "its velocity becomes "V_f ".During such duration it covered a distance "S "with uniform acceleration "a ".We know that, distance covered by a body with average velocity is given as:

$$S = V_{av} . t \quad \_\_\_\_\_ (1)$$

Where V_{av} is the average velocity given as

$$V_{av} = \frac{Vi + Vf}{2} \quad \_\_\_\_\_ (2)$$

Using first equation of motion:

$$Vf = Vi + at \quad \_\_\_\_\_ (3)$$

Substituting (3) in (2)

$$V_{av} = \frac{Vi + (Vi + at)}{2}$$

$$V_{av} = \frac{2Vi + at)}{2}$$

$$V_{av} = \frac{2Vi}{2} + \frac{at}{2}$$

$$V_{av} = V_i + \frac{at}{2} \quad \_\_\_\_ (4)$$

Substituting (4) in (1)

$$S = (Vi + \frac{at}{2}) t$$

$$S = V_i t + \frac{at^2}{2} \quad \_\_\_\_\_ (5)$$

Equation (5) is called second equation of motion.

Third Equation of Motion:

Let a body start its motion with a velocity " V_i " let after time " t " its velocity becomes " V_f ". During such duration its covered distance "S "with uniform acceleration "a ".

We know that distance covered by average velocity is given by:

$$S = V_{av} t \quad \_\_\_\_\_ (1)$$

Where V_{av} is the average velocity given as:

$$V_{av} = \frac{Vi + Vf}{2}$$

OR

$$V_{av} = \frac{Vf + Vi}{2} \quad \_\_\_\_\_ (2)$$

Using first equation of motion:

$$V_f = V_i + at$$

OR

$$t = \frac{\mathrm{Vf} - \mathrm{Vi}}{a} \quad \text{_____}(3)$$

Substituting (2) and (3) in (1)

Equation (1) becomes:

$$S = \frac{Vf + Vi}{2}\frac{Vf - Vi}{a}$$

$$S = \frac{(Vf + Vi)(Vf - Vi)}{2a}$$

$$2aS = (Vf + Vi)(Vf - Vi) \text{____} (4)$$

$$2aS = Vf^2 - Vi^2$$

Equation (4) is called 3rd equation of motion.

Motion under Gravity: (Free Fall Motion)

"When body fall in such a way that no other force accept the weight acting on it, then such motion is called free fall motion and body is said to be free fall body." OR

"When body fall only because of gravitation attractive force of earth and except that no other force acting in it than such motion is called motion is called motion under gravity or free fall motion."

If we drop a ball from certain height, if falls to the ground and its velocity increases continuously till strikes the ground. Such acceleration is called acceleration due to gravity. It is denoted by "g ", it is taken positive when upward object moves. Its value in different systems of units is as follows:

MKS System g = 9.8 m/s2
CGS System g = 980 cm/s2
FPS System g = 32 ft/s2