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# Motion in a straight line

Vinu Sreedhar

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- Motion is change in position of an object with time.
- Branch of physics which deals with the motion of objects – Mechanics
- Mechanics is classified into
  i)Statics ii) Kinematics iii) Dynamics
- Statics deals with object at rest under the action of forces.
- In Kinematics, we study ways to describe motion without going into the causes of motion.
- Dynamics deals with objects in motion by considering the causes of motion.

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# Kinematics

- The study of the motion of an object without taking into consideration cause of its motion is called kinematics.
- The various aspects of motion of an object can be understood in terms of a few physical quantities say displacement, velocity, acceleration and time.

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## Frame of Reference

- A system of coordinate axis which defines the position of a particle or an event in two or three dimensional space is called a frame of reference.
- The simplest frame of reference is of course the familiar cartesian system of coordinates, in which the position of the particle is specified by its three coordinates x, y and z.
- Position: Location of an object with respect to a frame of reference is known as position of the object.

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## Rest

- If the position of an object does not change with respect to a frame of reference or its surroundings with the passage of time, it is said to be at rest.
- E.g. Book lying on the table, a person sitting on a chair, etc.

## Motion

- If the position of an object is continuously changing with respect to a frame of reference or its surroundings with the passage of time, then it is said to be in the state of motion.

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## Motion is classified as below

- One-dimensional Motion The motion of an object is considered as 1-D (one-dimensional), if only one coordinate is needed to specify the position of the object at any time.
- Two-dimensional Motion The motion of an object is considered as 2-D (two-dimensional), if two coordinates are needed to specify the position of the object at any time. In 2-D motion, the object moves in a plane.

- Three-dimensional Motion The motion of an object is considered as 3-D (three-dimensional), if all the three coordinates are needed to specify the position of the object. This type of motion takes place in the three-dimensional space.
- e.g. Butterfly flying in garden, the motion of water molecules, etc.

# Scalar and Vector Quantities

- Physical quantities are studied under two heads, scalars and vectors. Both types of quantities can be defined as follow

## 1. Scalar Quantity

If only the magnitude is required to specify a physical quantity, that physical quantity is known as scalar quantity.
e.g. Mass, length, time, speed, etc.

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## 2. Vector Quantity

If magnitude as well as direction both are required to specify a physical quantity, that physical quantity is known as vector quantity.

e.g. Displacement, velocity, acceleration, etc.

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## Distance

- The length of the path covered by the object in a given time-interval is known as its distance or path length travelled.
- It is a scalar quantity.
- Its unit is metre (m).

## Displacement

- The change in position of an object in a particular direction is termed as displacement, i.e. it is the difference between the final and initial positions of the object in a given time.
- It is denoted by Δx.

- Mathematically, it is represented by

  Displacement, $\Delta x = x_2 - x_1$

  where, $x_1$ and $x_2$ are the initial and final positions of the object, respectively.
- It is a vector quantity.
- Its unit is metre.
- Displacement of motion may be zero but path length or distance can never be zero.

# Uniform Motion in a Straight Line

- A body is said to be in a uniform motion if it travels equal distance in equal interval of time along a straight line.
- e.g. A vehicle running with the constant speed of 10 m/s will cover equal distances of 10 m in every second, so its motion will be uniform.

## Non-uniform Motion in a Straight Line

- A body is in non-uniform motion if it travels equal displacement in unequal intervals of time.
- During the non-uniform motion, the speed of the body or its direction of motion or both change with time.
- e.g. The velocity of the vehicle is different during different instants, so it has non-uniform motion.

## Speed

- The path length or the distance covered by an object divided by the time taken by the object to cover that distance is called the speed of that object.
  Speed = Distance travelled / Time taken
- Speed is a scalar quantity.
- Its SI unit is m/s.

## Average Speed

- Average speed of an object is defined as the total distance travelled divided by the total time taken.

  Average speed,

  $v_{av}$ = Total distance travelled/Total time taken

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- If a particle moves a distance at speed $v_1$ and comes back with speed $v_2$, then

$$V_{av} = 2v_1v_2/v_1+v_2$$

- If a particle moves in two equal intervals of time at different speeds v, and $v_2$ respectively, then

$$V_{av} = (V_1 + V_2)/2$$

## Instantaneous Speed

- Speed at an instant is defined as the limit of the average speed as the time interval (Δt) becomes infinitesimally small or approaches to zero.
- Mathematically, instantaneous speed at any instant of time (t) is expressed as Instantaneous speed, $S_i = ds/dt$ where, ds is the distance covered in time dt.
- Speed of an object is never negative, but its velocity can be negative, zero or positive.

## Velocity

- The rate of change in position or displacement of an object with time is called the velocity of that object.

  Velocity = Displacement/Time

- It is a vector quantity.
- Its SI unit is m/s.

$$1km/h = \frac{5}{18} m/s$$

## Average Velocity

- Average velocity of a body is defined as the total change in position or displacement ($\Delta x$) divided by the total time interval ($\Delta t$) in which that displacement occurs.

- Average velocity of body is given by

$V_{av} = \Delta x/\Delta t$

$$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

## Instantaneous Velocity

- Velocity at an instant is defined as the limit of average velocity as the time interval (Δt) becomes infinitesimally small or approaches to zero.
- Mathematically, instantaneous velocity at an instant of time (t) is given by

$v_i = dx/dt$

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

- Where, dx is displacement for time dt.

## Acceleration

- The time rate of change of velocity is known as acceleration.

  Acceleration = Change in velocity/Time taken

- It is a vector quantity.
- Its SI unit is $m/s^2$.

## Average Acceleration

- The average acceleration is the ratio of the change in velocity to the time taken to undergo this change.

$$\bar{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

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## Instantaneous Acceleration

- Instantaneous acceleration is the acceleration at any instant of time or at any given point.
- If we simply call velocity or speed or acceleration it means instantaneous one, respectively.

## Uniformly Accelerated Motion

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

- A motion, in which change in velocity in each unit of time is constant, is called uniformly accelerated motion. So, for uniformly accelerated motion, acceleration is constant.

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# THANK YOU…

Vinu sreedhar