Motion in Straight Line

Mechanics- Branch of physics that deals with the conditions of rest or motion of the material objects around us.

Sub Branches-

Statics- Branch of mechanics that deals with the study of material objects at rest or equilibrium, even when they are under action of several forces. The measurement of time is not essential in statics.

Kinematics- It is a Greek Word "Kine" Means Motion and "Matics" Means Maths. Branch of mechanics that deal with the study of motion of material objects without considering the cause of motion. The measurement of time is essential in Kinematics.

Dynamics- it is a Greek word means Power. Brach of mechanics that deals with the study of motion of material objects with considering the cause of their motion. Dynamics is concerned with the forces that cause motion.

Rest and Motion

Rest- *if an object does not change its position with time with respect to the surroundings is said to be at rest. Eg. Book lying in your almirah.*

Motion- *If an object changes its position with time with respect to the surroundings is said to be in motion. Eg. Bus travelling on the road.*

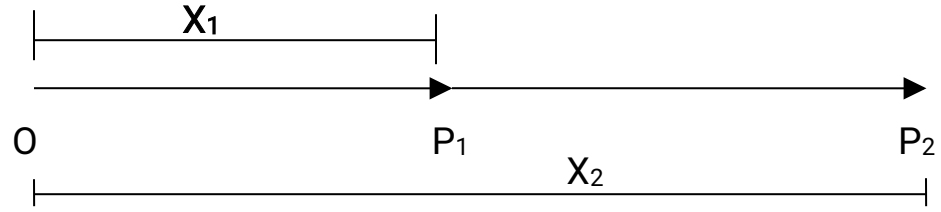
Rest and Motion are relative terms???????

Consider a case in which you are sitting in the moving car with your family members, so you are at rest with respect to your family members but you are in motion with respect to the environment outside the car. So at the same time you are at rest and also in motion *(it all depends on the reference point)*, hence motion and rest are relative terms.

Point Object- if the position of an object changes by distance much greater than its own size in a reasonable duration of time then the object may be regarded as a point object. *For a point object rotational and vibrational motion may be ignored when in motion. Eg. Earth may be considered as a point object for studying its motion around*

sun.

Rectilinear Motion- if objects move along a straight line only, then the motion is said to be a rectilinear or one dimensional or linear motion. Eg. Motion Free failing body and Motion of a train along a straight rail.



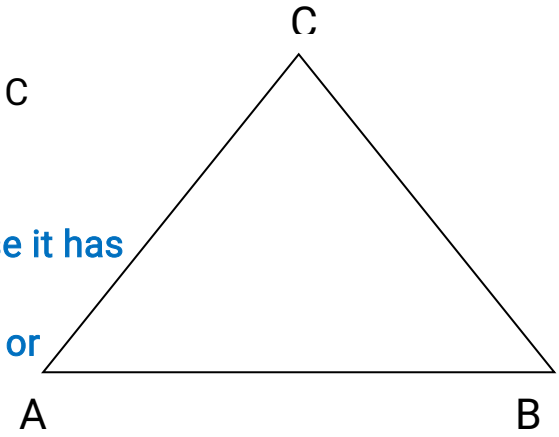
Two dimensional Motion- If an object moves in any two direction or two co-ordinates specifying its position with respect to time, then the motion is said to be a two dimensional motion. Eg. Circular motion, car moving in a zig-zag motion on a level road.

Three Dimensional Motion- If an object moves in all three direction or all three co-ordinates specifying its position with respect to time, then the motion is said to be a three dimensional motion. Eg. Kite flying on a windy day and motion of aeroplane in space.

Distance- the actual path travelled by an object between its initial and final position is known as distance or path length.

If a body moves from A to B through C

Then Distance =AC+CB



Distance is a scalar quantity because it has Only magnitude and no direction.
Distance covered is always Positive or Zero.
SI Unit is Meter "m" and CGS unit is Centimetre "cm"

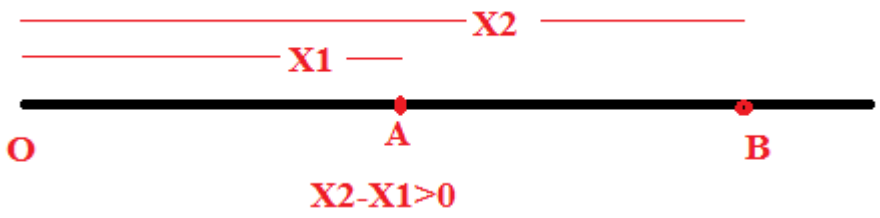
Displacement- it is defined as the shortest path measured in the direction from initial point to the final point. As displacement has both direction and magnitude, so it is a vector quantity.

Displacement may be positive, negative or zero, its SI unit is meter “m” and CGS unit is “cm”.

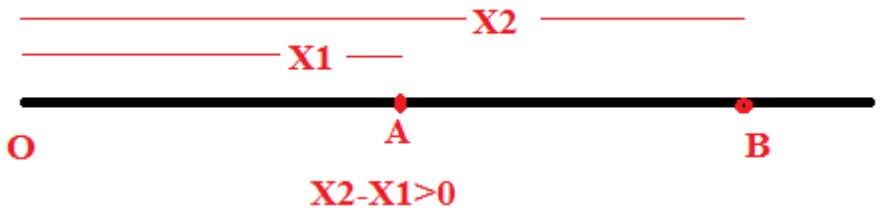
Displacement in above example = AB

Imp Points-

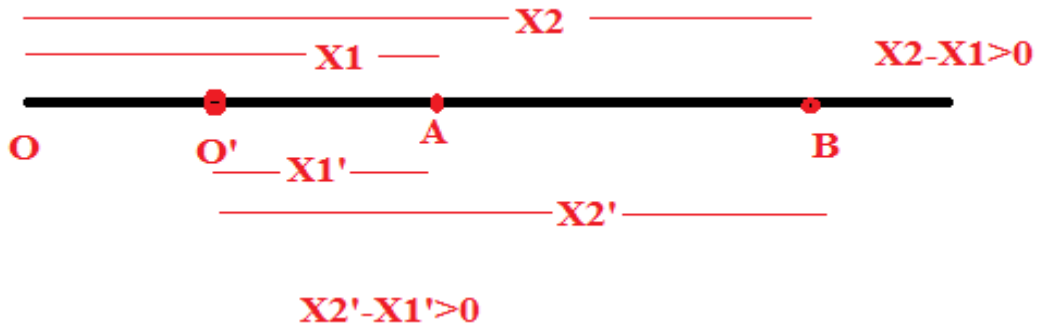
1. Displacement and Distance have same units.
2. **Positive Displacement-** When an object moves towards right with time t_1 to t_2 its displacement is positive as shown in fig.



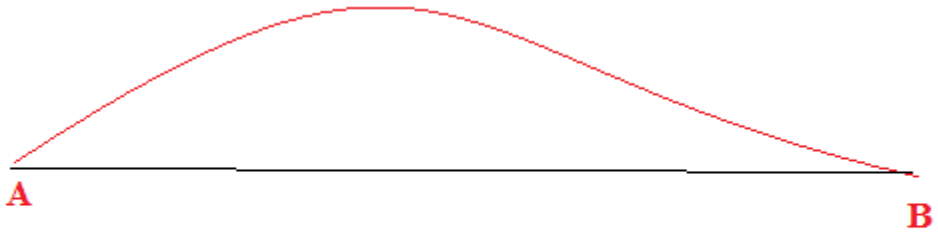
3. **Negative Displacement-** When an object moves towards left with time t_1 to t_2 its displacement is negative as shown in fig.



4. **Zero Displacement-** when an object remains stationary or first moves towards right then towards left same distance its displacement will be zero.
5. Displacement is independent of the choice of origin O of the position coordinates.

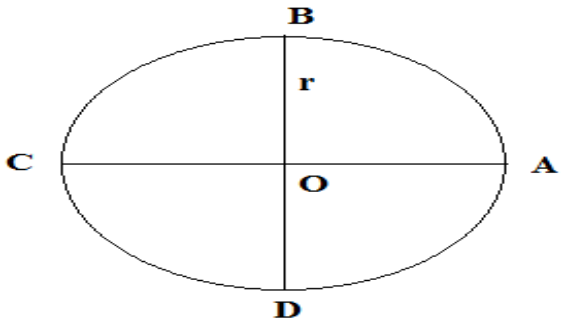


6. The distance travelled by an object in given time interval is always Greater than or equal to displacement. The distance travelled by an object can never be less than the displacement.
7. Displacement is the unique path travelled by an object from its initial to final positions.
8. Displacement does not give any information between regarding the shape of actual path.
9. Displacement is a vector quantity so it is independent of the actual path followed by an object from initial to final position. Displacement is the shortest distance between initial point to final point.

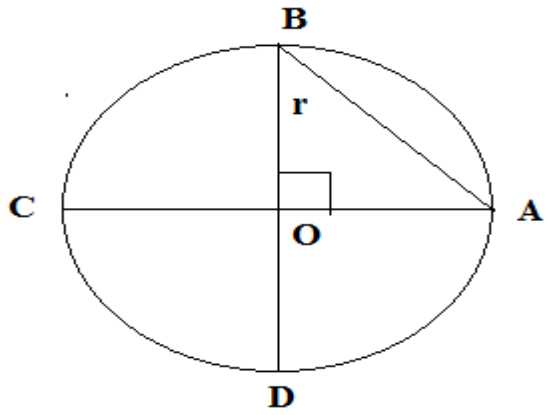


Displacement=AB Straight Line
Distance=AB Curved Path

Ex.1. A particle moves in a circular path of radius "r" as shown in fig. in the anti-clockwise direction. Find the distance travelled when object moves from (i) A to B (ii) A to C (iii) A to D. Also find magnitude of displacement in each case.



Solution-



(i) A to B-

As we know the circumference of circle is $2\pi r$.

So the total distance between A to B is

$$\text{Distance} = \frac{2\pi r}{4} = \frac{\pi r}{2}$$

$$\text{Displacement} = |\overline{AB}| = \sqrt{OA^2+OB^2} = \sqrt{r^2+r^2}$$

$$= r\sqrt{2}$$

(ii) A to C

$$\text{Distance} = \frac{2\pi r}{2} = \pi r$$

Displacement= 2r

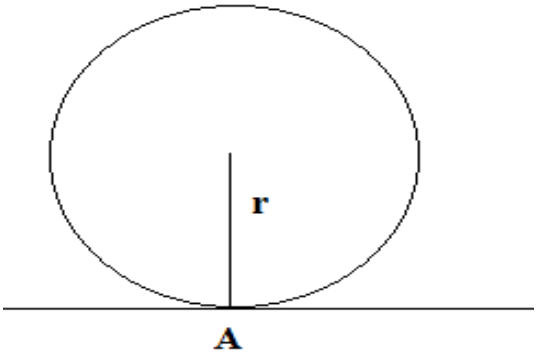
(iii) A to D

$$\text{Distance} = \frac{3}{4}\times 2\pi r$$

$$\text{Displacement} = |\overline{AB}| = \sqrt{OA^2+OB^2} = \sqrt{r^2+r^2}$$

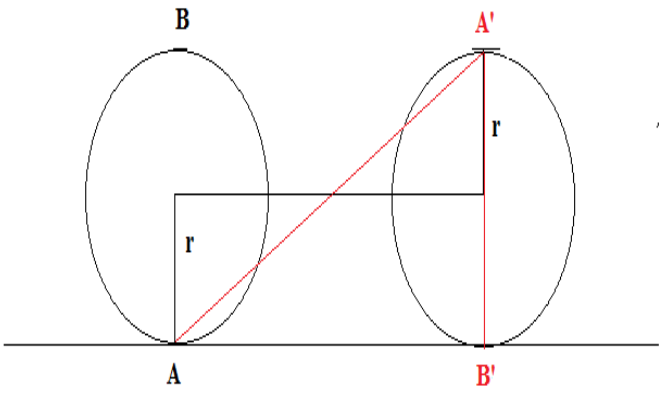
$$= r\sqrt{2}$$

Ex.2- A wheel of radius “r” is rolling on the floor in clockwise direction as shown in fig. Find the magnitude of displacement of point “A” after completion of half rotation.



Solution-

After completion of half rotation the new positions of point A and B are shown in the fig.



So the final position of point A will be A’.

The Displacement will be AA’ is given by

$AA' = \sqrt{AB'^2 + A'B'^2}$

AB’= πr (Half circumference of wheel).

A’B’= 2r (Diameter of Wheel)

$AA' = \sqrt{(\pi r)^2 + (2r)^2} = = r\sqrt{\pi^2 + 4}$

Speed- The distance travelled by an object per unit time is known as speed. It is a scalar quantity means has only magnitude but no direction.

Speed of an object may be positive or zero but not negative as distance can be positive or zero but not negative. Its SI unit is ms^{-1} and CGS unit cms^{-1}

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

Types-

1. **Uniform Speed-** if an object covers equal distances in equal time interval then object is said to be in uniform speed.
2. **Variable Speed-** if an object covers unequal distances in equal time intervals then the object is said to be in variable speed.
3. **Average Speed-** the average speed of an object moving with the variable speed is given by the total distance travelled by the object divided by the total time taken to cover the distance.

$$\text{Average Speed} = \frac{\text{Total Distance Travelled}}{\text{Total Time Taken}}$$

How to calculate average speed in different situations???

Situation 01- An object covers different distances with different speeds-

Suppose that an object covers distances s_1, s_2, s_3, ... with different speeds v_1, v_2, v_3 ...then its average speed will be

$$v_{av} = \frac{\text{total distance travelled}}{\text{total time taken}} = \frac{s}{t} = \frac{s1+s2+s3+\ldots}{t1+t2+t3+\ldots} = \frac{s1+s2+s3+\ldots}{\frac{s1}{v1}+\frac{s2}{v2}+\frac{s3}{v3}+\ldots}$$

Special case- if s1=s2=s

Then $v_{av} = \frac{2s}{\frac{s}{v1} + \frac{s}{v2}} = \frac{2v1v2}{v1+v2}$