SAK ACADEMY

XI XII NEET AIIMS IIT-JEE (MAIN+ADV.)

TOPICS:-

1.INTRODUCTION TO KINEMATICS
2.BASIC FACTS RELATED TO KINEMATICS
3.REST & MOTION
4.IMPORTANT TYPES OF MOTION
5.DISTANCE & DISPLACEMENT VECTOR
5.BASIC NUMERICALS BASED ON ABOVE FACTS

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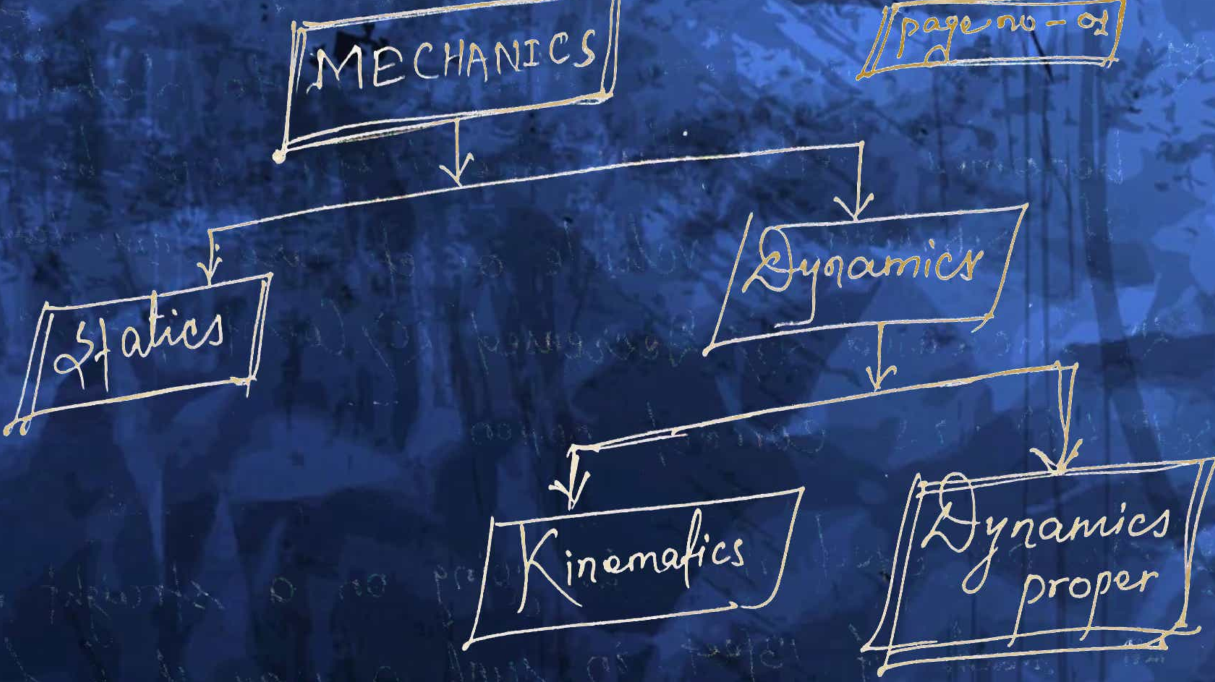


* **Mechanics** :→ Those branch of physics which deals with the study of bodies which are at rest or in motion is known as mechanics.

* **Statics** :→ That branch of mechanics which deals with the study of bodies at rest is called statics.

* **Dynamics** :→ That branch of mechanics which deals with the study of bodies ~~at~~ in motion is known as dynamics.

* **Kinematics** :→ That branch of dynamics which deals with the parameter which describe the motion of a body is called kinematics.

* **Dynamics proper** :→ That branch of dynamics which deals with the parameter or agent which describe the cause of motion of a body is called dynamics.

Q<01> If the road from Madhepura to Saharsa becomes better then the traffic will be ___ if population & vehicle or etc are constant.

<A> Increased <B> Decreased <C> Constant <D> All

Soln:- <B> is correct option.

Q 02 A pie eyed man is going on a straight rod ~~rim~~ ~~such~~ of 13feet in such a way that he goes 5m ahead and then he comes ~~back~~ 3feet back. ~~If~~ he takes one second to travell a distance of one feet. ~~then~~ If a pit is on the way just after 13feet then the time taken by the man when he will fall down in the pit.

<A> 13 second <B> 26 second <C> 37 second <D> None of these

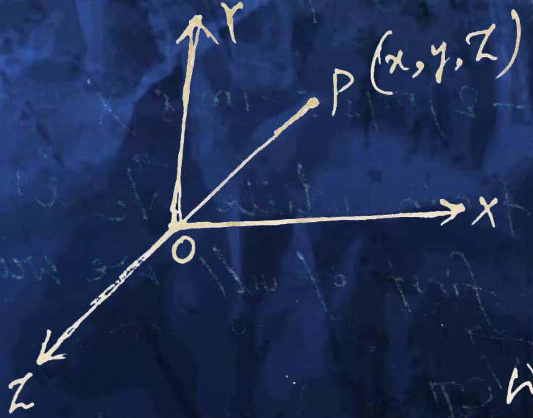
MOTION IN ONE DIMENSION

Frame of reference :-> A system of coordinate axes which defines the position of a particle or an event in two or three dimensional space is called a frame of reference.

OR

The frame in which an observer sits and make observations. is known as frame of reference.

Frame of reference for position of a particle P is specified by its three coordinates x, y and z as shown in the figure



In this figure, point O can be considered as frame of reference because of position of P is specified w.r.t point O.

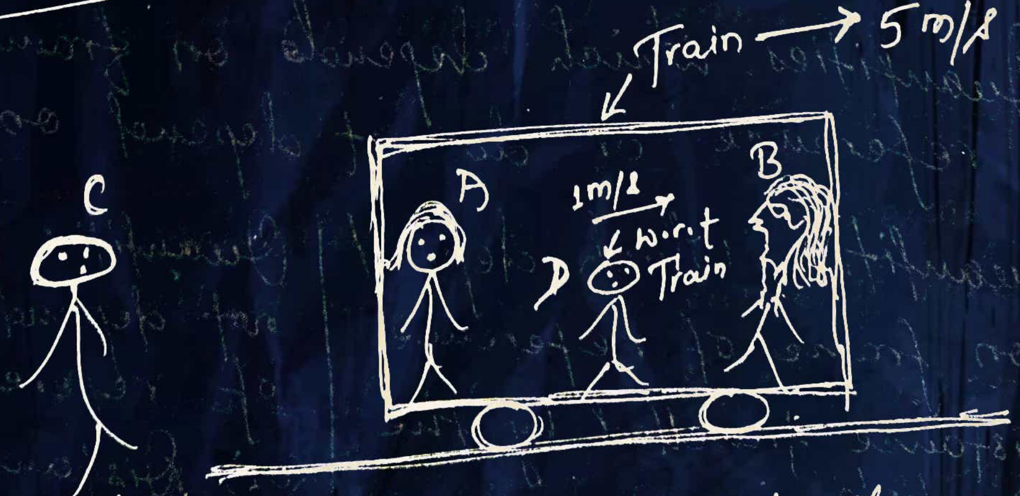
To understand this, let us take an example. but before taking an example, We know that velocity of A w.r.t B is written as

$$\vec{V}_{AB} = \vec{V}_{AS} - \vec{V}_{BS}$$

Here, B observes A in the same frame

> Note:- Velocity of A and velocity of B is taken in the same frame.

Example:-



Velocity of train is 5 m/s and the man D whose velocity is 1 m/s w.r.t train then find ⟨i⟩ $\vec{V}_{BC}$ ⟨ii⟩ $\vec{V}_{DC}$ ⟨iii⟩ $\vec{V}_{DT}$ ⟨iv⟩ $\vec{V}_{CT}$

⟨v⟩ $\vec{V}_{AT}$

Sol^n ⟨i⟩ $\vec{V}_{BC} = \vec{V}_{BG} - \vec{V}_{CG} = 5\,m/s - 2\,m/s = 3\,m/s$

⟨ii⟩ $\vec{V}_{DC} = \vec{V}_{DT} - \vec{V}_{CG} = (1-2)\,m/s = -1\,m/s$ X

because $\vec{V}_D$ is w.r.t train while $\vec{V}_C$ is w.r.t ground then first of all we will have to find $\vec{V}_{CT}$

Thus (iv) $\vec{V}_{CT} = \vec{V}_{CG} - \vec{V}_{TG} = (2-5)\,m/s = -3\,m/s$

⟨ii⟩ $\vec{V}_{DC} = \vec{V}_{DT} - \vec{V}_{CT} = \{1-(-3)\}\,m/s = 4\,m/s$

⟨iii⟩ $\vec{V}_{DT} = \vec{V}_{DG} - \vec{V}_{TG} \Rightarrow 1 = \vec{V}_{DG} - 5 \Rightarrow \vec{V}_{DG} = 6\,m/s$

⟨iv⟩ $\vec{V}_{CT} = \vec{V}_{CG} - \vec{V}_{TG} = (2-5)\,m/s = -3\,m/s$

⟨v⟩ $\vec{V}_{AD} = \vec{V}_{AG} - \vec{V}_{DG} = (5-6)\,m/s = -1\,m/s$ OR

$\vec{V}_{AD} = \vec{V}_{AT} - \vec{V}_{DT} = (0-1)\,m/s = -1\,m/s$

✳ Quantities which depends on frame of reference or do not depend on F.R

⟨01⟩ Quantities which depend on frame of reference	Quantities which does not depend on frame of reference
⟨01⟩ Distance travelled by the particle	⟨01⟩ Distance between two particle
⟨02⟩ Displacement	⟨02⟩ Individual force.
⟨03⟩ Velocity	⟨03⟩ Time of event

Quantities which depend on frame of reference

<04> speed <05> Kinetic energy (K.E) <06> Acceleration (a)

<07> Work done ($W = \int \vec{F} \cdot d\vec{s}$)

TYPES OF FRAME OF REFERENCE

Frame of references are of two types

<i> Inertial frame of reference &

<ii> Non-inertial frame of reference.

<i> <u>Inertial frame of reference</u> :→ A frame of reference which is either at rest or moving with a constant velocity is called inertial frame of reference.

OR

A non-accelerating frame of reference is called an inertial frame of reference.

For example:- the surface of the Earth is almost an inertial frame.

<ii> <u>Non-inertial frame of reference</u> :→ An accelerating frame of reference is called non-inertial frame of reference.

OR A frame of reference that undergoes acceleration with respect to an inertial frame is called non-inertial frame of Reference. Example Pseudo-forces and centrifugal force are ~~exp~~ example of non-inertial frame of reference.

Rest :→ A body is said to be at rest if it does not change its position with respect to frame of reference or surrounding with the passage of time.

Example :- A book lying on the table is at rest w.r.t table.

Motion :→ A body is said to be ~~at~~ in the state of motion if it changes its position with respect to frame of reference or surrounding with the passage of time.

Example :- The walking man, crawling insects, water flowing down a dam ...etc are examples of motion with respect to ground.

Rest and motion are relative terms :→ An object can be at rest for an observer but the same object at the same time can be in motion with respect to other ~~object~~ observer, this phenomena is known as rest and motion are relative terms.

For example :- A person sitting in his house is at rest w.r.t. earth but is in motion w.r.t. moon.

CLASSIFICATION OF MOTION :- on the basis of the number of coordinates required to specify ~~of~~ the ~~object~~ motion of objects can be classified into mainly three classes :—

(01) One dimensional motion (1-D motion)
(02) Two dimensional motion (2-D motion)
(03) Three dimensional motion (3-D motion)

(01) **One dimensional motion** :→ The motion of a body in a straight line is called one dimensional motion.

OR

The motion of an object is considered as one dimensional motion if only one coordinate is needed to specify the position of the object.

Example :- (i) A boy running on a straight line

(ii) Motion of freely falling body etc.

(iii) $\vec{V} = 2\hat{i}$, $\vec{V} = 2\hat{i} + 3\hat{j}$ & $\vec{V} = 2\hat{i} + 3\hat{j} + 5\hat{k}$ are 1-D motion.

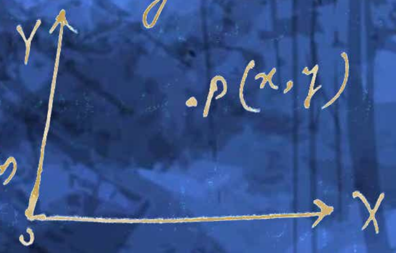
(02) **Two dimensional motion** :→ The motion of a body in a plane is called two dimensional motion. OR

The motion of an object is considered as two dimensional motion, if two coordinates are needed to specify the position of the object.

Example :- (01) Motion of a car on a circular turn.

(ii) The motion of a satellite revolving around the earth.

Two dimensional motion (2-D motion) as shown in fig.



(03) <u>Three dimensional motion</u> :→ The motion of a body in a space is called three dimensional motion.

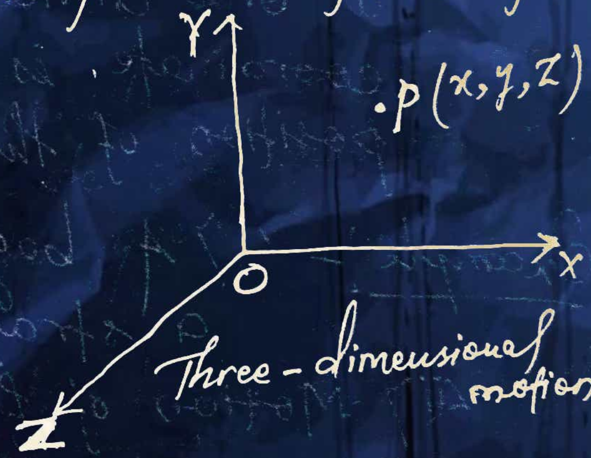
OR

The motion of an object is considered as three dimensional motion, if all the three coordinates are needed to specify the position of the object.

eg. (i) Motion of flying kite.

(ii) Motion of flying insect.

(iii) The motion of water molecules etc.



* <u>Some basic terms related to motion</u>:

(i) <u>Particle or point mass or point object</u> :→ The smallest part of a matter with zero dimension which can be described by its mass and position is called a particle or point mass.

* If the size of a body is negligible in comparison to its range of motion then that body is known as a particle.

Note:- A body or a system of particle or group of particles can be treated as a particle, depends upon types of motion.

Example:- In a planetary motion around the sun the different planets can be presumed to be the particles.

When we treat a body as a particle, all parts of the body undergo same displacement and have same velocity and acceleration.

(ii) **System of particles:→** A group of particles or point mass is considered as system of particle.

(iii) **Discrete system of particle:→** A system of particle in which particles are separated from each-other is called discrete system of particle.

(iv) **Continuous system of particles:→** A system of particle where the separation of particles is very small such that it approaches zero is called continuous system of particle.

(v) **Rigid body:→** A body is said to be rigid body if on which the distance between two points never changes whatever be the force applied on it.

OR A solid body is said to be rigid body if the deformation of the body is zero or so small it can be neglected.

Note:- The distance between any two given points on a rigid body remains constant in time regardless of external forces or moments exerted on it.

⇒ rigid body is usually considered as a continuous distribution of mass.

~~✳ Define important types of motion~~

SOME IMPORTANT TYPES OF MOTIONS

- Translatory motion
  - Rectilinear motion
  - Curvilinear motion
- Circular motion
- Rotational motion
- Projectile motion
- Periodic motion
- Oscillatory motion
- S.H.M (Simple harmonic motion)

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Translatory motion :→ The motion of a body in which every point on the moving body moves through the same distance in the same interval of time is called Translatory motion.

Translatory motion are of two types :-

<i> Rectilinear motion <ii> Curvilinear motion

<i> **Rectilinear motion** :→ The motion of a point mass OR point object along a straight line is known as rectilinear motion.

<ii> **Curvilinear motion** :→ The motion of an object OR a system of particle moving in a curved path is called curvilinear motion.

Circular motion :→ The movement of an point object along the circumference of a circle or rotation along a circular path is known as circular motion.

Projectile motion :→ A type of two dimensional motion or motion in a plane of an object thrown or projected with some initial velocity into air, subject to only the acceleration of gravity is called projectile motion.

Example :- <i> A bullet fired from a gun.
<ii> A football kicked in a game
<iii> The flight of a golf ball

* **Rotational motion** :→ The motion of a rigid body or system of particle which takes place in such a way that all of its particles move in circles about an axis with a common angular velocity is known as rotational motion.

Examples :- <i> the fixed speed of rotation of the Earth about its axis
<ii> A ceiling fan <iii> A potter's wheel.

* **Periodic motion** :→ The motion of a body which repeats itself after a fixed intervals of time is called periodic motion.

Examples; <i> motion of hands of the clock,
<ii> motion of planets around the sun,
<iii> motion of pendulum --- etc

Note:- The fixed interval of time in periodic motion is known as time period of the period motion.

* **Oscillatory motion** :→ The to and fro motion of an object from its mean position is known as oscillatory motion.

For example :- <i> Oscillation of simple pendulum
<ii> Vibrating strings of musical instruments
<iii> Movement of spring etc.

Note:- ~~<i> Oscillatory motion is a type of periodic motion~~
<ii> All oscillatory motions can be or can not be periodic but all periodic motion need not to be oscillatory.

<iii> All the oscillatory motions will be periodic if and only if when there is no lose of energy during oscillations. unless All the oscillatory motions will not be periodic.

<iv> General equation of oscillations:
$F = -Kx^n$ where $n = 1, 3, 5 ---$

Simple harmonic motion (S.H.M) :→ Simple harmonic motion (S.H.M) is defined as a special type of periodic motion in which the restoring force is directly proportional to the displacement of the body from its mean position.

Note: <i> Restoring force :→ A force which acts to bring a body to its equilibrium position is called restoring force.

<ii> The direction of restoring force is always towards the mean position.

<iii> $F = -Kx$ where F = Restoring force &
x = displacement of particle from equilibrium position

<iv> The acceleration of a particle executing SHM is given by $a = -\omega^2 x$ where ω = angular velocity of the particle.

DISTANCE AND DISPLACEMENT

Distance → The actual length of the path covered by a moving particle or object from initial to final position in any direction in a given time interval, is known as its distance or distance covered by the particle.

Some important facts about distance.

(i) The unit of distance is meter (m) in SI or MKS system and centimetre in CGS system.

(ii) The dimensional formula of distance is $[M^0LT^0]$.

(iii) The distance is a scalar quantity.

(iv) The distance is always positive never becomes negative or zero.

Displacement → The shortest distance travelled by the moving particle or object from initial to final position in a particular direction is known as displacement.

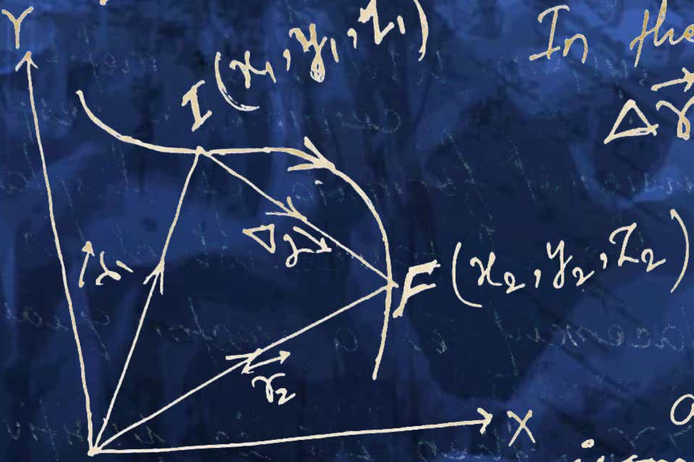
OR

The change in position vector of an object from initial to final position in a certain direction is known as displacement.

If $\vec{r}_1$ and $\vec{r}_2$ are the initial and final position vectors of particle respectively.

Then, the displacement of the particle is given by $\boxed{\Delta\vec{r} = \vec{r}_2 - \vec{r}_1}$

Proof :-



In the given figure
$\Delta\vec{r}$ = Displacement
$\vec{r}_1$ = Initial position vector and their coordinates is I (x_1, y_1, z_1) and
$\vec{r}_2$ = final position vector and their coordinates is $F(x_2, y_2, z_2)$.

Then, the triangle law of vector addition of two vectors $\vec{r}_1 + \Delta\vec{r} = \vec{r}_2$

$$\Rightarrow \boxed{\Delta\vec{r} = \vec{r}_2 - \vec{r}_1}$$ Proved

Since, $\vec{r}_1 = x_1\hat{i} + y_1\hat{j} + z_1\hat{k}$ & $\vec{r}_2 = x_2\hat{i} + y_2\hat{j} + z_2\hat{k}$

Then, $\Delta\vec{r} = (x_2\hat{i} + y_2\hat{j} + z_2\hat{k}) - (x_1\hat{i} + y_1\hat{j} + z_1\hat{k})$

$$\boxed{\Delta\vec{r} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}}$$

↳ vector form of displacement

$$\boxed{|\Delta\vec{r}| = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}}$$

↳ Magnitude of displacement vector

Some important facts about displacement

(i) The unit of displacement is same as the distance in SI or MKS system as well as in C.G.S system. which is metre and centimetre respectively.

(ii) The dimensional formula of displacement is same as the distance. which is $[M^0 L T^0]$

(iii) The displacement is a vector quantity.

(iv) (a) If $r_2 > r_1$, then Δr is positive;

(b) If $r_1 > r_2$, then Δr is negative;

(c) If $r_1 = r_2$, then Δr is zero.

Hence, the displacement of an object in motion can be positive, negative or zero.

(v) If $\vec{s}_1, \vec{s}_2, \vec{s}_3$ ------ $\vec{s}_n$ are the displacement of a body then the total (net) displacement is the vector sum of the individuals displacements. i.e. $\vec{s} = \vec{s}_1 + \vec{s}_2 + \vec{s}_3 + \text{-----} + \vec{s}_n$

✳ Comparison between distance and displacement

(i) The magnitude of displacement is equal to minimum possible distance between two positions and it is possible if a particle moves in a straight line without change in direction, the magnitude of displacement is equal to the distance travelled otherwise displacement is always less than distance.

Thus, |Displacement| ≤ Distance

(ii) For a moving particle distance can never be negative or zero while displacement can be.

Note:- (a) Zero displacement means that the body after motion has come back to initial position.

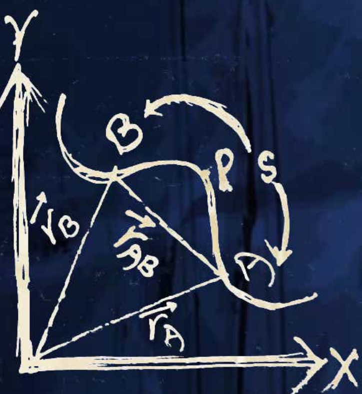
i.e. Distance > 0 but Displacement >, = or < 0

(iii) For motion between two points, displacement is single valued while distance depends on actual path and so can have many values.

(iv) For a moving particle ~~distance~~ distance can never decrease with time while displacement can.

Note:- Decrease in displacement with time means body is moving towards the initial position.

(v) If $\vec{r}_A$ and $\vec{r}_B$ are the position vectors of particle initially and finally.



Then displacement of the particle $\vec{r}_{AB} = \vec{r}_B - \vec{r}_A$ and s is the distance travelled if the particle has gone through the path APB.

~~F) SOME IMPORTANT QUESTIONS BASED ON DISTANCE AND DISPLACEMENT~~

~~Q.01 A man walks 3m in east direction, then 4m in north direction. Find distance covered and the displacement covered by man.~~ ~~Ans: 7m, 5m, θ=53° north~~

(vi) For the given figure the displacement of particle

$$\vec{AC} = \vec{AB} + \vec{BC}$$

But

$$|\vec{AC}| = \sqrt{AB^2 + BC^2 + 2\cdot AB\cdot BC\cdot \cos 90}$$
$$= \sqrt{AB^2 + BC^2}$$

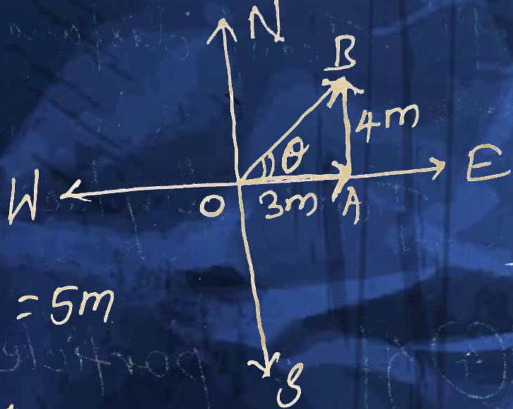
(vii) If $\vec{s}_1, \vec{s}_2, \vec{s}_3 \cdots \vec{S}_n$ are the displacements of a body then the total (net) displacement is the vector sum of the individuals.

$$\vec{s} = \vec{s}_1 + \vec{s}_2 + \vec{s}_3 + \cdots + \vec{s}_n$$

Some important questions based on distance & displacement.

Q(01) A man walks 3m in east direction, then 4m in north direction. Find distance covered and the displacement covered by man.
(A) 7m (B) 5m (C) 7m, 5m, 53° (D) None of these

Soln:- The distance covered by man is the length of path = 3m + 4m = 7m.



$$|\vec{s}| = \sqrt{(OA)^2 + (AB)^2}$$
$$= \sqrt{(3m)^2 + (4m)^2}$$
$$= \sqrt{9m^2 + 16m^2} = \sqrt{25m^2} = 5m$$

For direction, $\tan\theta = \frac{4m}{3m} = \frac{4}{3}$

$$\theta = \tan^{-1}(4/3) = 53°$$

Hence, The displacement is directed at an angle 53° north of east.

Ans: 7m, 5m at θ = 53° north of east

Q.2 A person in his morning walk moves on a semicircular track of radius 40m. Find the distance travelled and the displacement, when he starts from one end of the track and reaches the other end.

Ans: 125.6m, 80m

Soln:-

Distance = $2\pi r/2 = \pi r$
$= (3.14 \times 40)m = 125.6m$

Displacement = diameter
$= 2 \times r = (2 \times 40)m$
$= 80m$

Q(3) Find the distance and displacement of a particle travelling from one point to another, say from pt. A to B in a give path. (JEE MAIN)

Ans: (B)

<A> 60m, 90m <B> 185m, 105m <C> 10m, 50m <D> 55m, 40m

Soln: Total distance travelled = 10+50+55+(40-10)

= 185m

Total displacement = 50+55 = 105m

Q(4) If a particle travels a distance of 5m in straight line and returns back to the initial point, then find

<i> total distance travelled

<ii> Total displacement

Ans: <i> 10m <ii> 0m

Soln: Total distance travelled = (5+5)m = 10m

Total displacement = (5-5)m = 0m

Q(5) A man goes 10m towards North, then 20m towards east then displacement is

(A) 22.5m (b) 25m (c) 25.5m (d) 30m [KCET(Med.)199.. JIPMER-1999 AFMC-2003]

Ans: (A)

Q(6) A body moves over one fourth of a circular arc in a circle of radius r. The magnitude of distance travelled and displacement will be respectively

Ans: (C)

(a) $\frac{\pi r}{2}, r\sqrt{2}$ (b) $\frac{\pi r}{4}, r$ (c) $\pi r, \frac{r}{\sqrt{2}}$ (d) $\pi r, r$

Q(07) The displacement of the point of the wheel initially in contact with the ground, when the wheel roles forward half a revolution will be (radius of wheel is R)

<A> $\frac{R}{\sqrt{\pi^2+4}}$ <B> $R\sqrt{\pi^2+4}$ <C> $2\pi R$ (D) πR

Ans: (B)

Q(08) A scooter is moving along a straight line AB covers a distance of 360m in 24s and returns back from B to C and covers 240m in 18s. Find the total distance travelled by scooter.

Ans: (A)

<A> 600 m (b) 400 m <C> 360m <D> 240 m.

Q(09) A wheel completes 2000 revolutions to cover the 9.5 km distance. Find the diameter of the wheel.

Ans: (B)

<A> 1m <B> 1.5m <C> 3m (D) 2m

Q(10) A man starts from his home and walks 50m towards north, then he turns towards east and walks 40m and then reaches to his office after moving 20m towards south.

<i> What is the total distance covered by the man from his home to office?

<ii> What is his displacement from his home to office?

Ans: <i> 110m <ii> 50m

Q(11) An object covers $\left(\frac{1}{4}\right)^{th}$ of the circular path, what will be the ratio of the distance and displacement of the object?

Ans: $\pi/2\sqrt{2}$

Q<12> Displacement of a person moving from X to Y along a semicircular path of radius r is 200m. What is the distance travelled by him?

Ans: 314m

Q(13) A particle moves in a circular track of radius R from A to B, as shown in figure. The distance covered by the object is

<A> $\frac{\pi R}{3}$ <B> $\frac{\pi R}{2}$ <C> $\frac{\pi R}{4}$ <D> πR

Q<14> A particle moves along a circular path of radius R. The distance and displacement of a particle after complete revolution is

<A> 0, $2\pi R$ <B> $2\pi R$, 0 <C> 0, πR <D> πR, 0 Ans (B)

Q(15) The numerical ratio of displacement to the distance covered is always Ans (C)

<A> less than one <B> equal to one <C> equal to or less than one <D> equal to or greater than one

Q<16> The numerical ratio of distance to the displacement covered by a particle is always <A> less than one <B> equal to one <C> equal to or less than one <D> equal to or greater than one. Ans (D)

Q(17) An aeroplane flies 400 m North and 300 m south and then flies 1200 m upwards then net displacement is Ans: (A)

<A> 1204 m <B> 1300 m <C> 1400 m <D> 1500 m

Q<18> A wheel of radius 1 m rolls forward half a revolution on a horizontal ground. The magnitude of the displacement of the point of the wheel initially in contact with the ground is <A> 2π <B> $\sqrt{2}\pi$ <C> $\sqrt{\pi^2+4}$ <D> π

Ans: (C)

Q<19> A person walks along the sides of a square field. Each side is 100 m long. What is the maximum magnitude of displacement of the person in any time interval? Ans: $100\sqrt{2}$ m

<A> $\sqrt{2}$ m <B> 100 m <C> $100\sqrt{2}$ m <D> 200 m

Q(20) A farmer moves along the boundary of a square field of side 10m in 40s. What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds from his initial position. [Ans: 14.143 m]

Q(21) During an experiment, a signal from a spaceship reached the ground station in five minutes. What was the distance of the spaceship from the ground station? The signal travels at the speed of light, that is, $3 \times 10^8 \, m s^{-1}$. [Ans: 9×10^{10} m]

Q(22) An athlete completes one round of a circular track of diameter 200m in 40s. What will be the distance covered and the displacement at the end of 2 minute 20 second? [Ans: 2200m, 200m]