Physics Notes

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Class:10+1
Unit: II
Topic: Kinematics

SYLLABUS: UNIT-II-A,B

Frame of reference. Motion in a straight line: Position-time graph, speed and velocity, Uniform and non-uniform motion, average speed and instantaneous velocity.

Uniformly accelerated motion, velocity-time, position-time graphs, relations for uniformly accelerated motion (graphical treatment).

Elementary concept of differentiation and integration for describing motion.

Scalar and vector quantities: Position and displacement vectors, general vectors and notation, equality of vectors, multiplication of vectors by a real number; addition and subtraction of vectors. Relative velocity.

Unit vector; Resolution of a vector in a plane – rectangular components, Motion in a plane, Cases of uniform velocity and uniform acceleration-projectile motion. Uniform circular motion.

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Q.1. Explain the following:

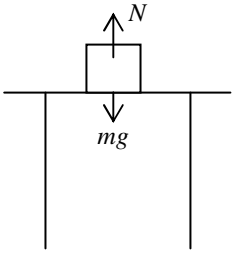
a) Statics

b) Kinematics

c) Dynamics

Ans.a) **Statics**:-

Branch of mechanics which deals with the study of objects at **rest**.

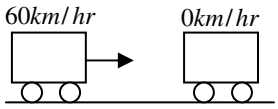


Example:-

Book on table study of forces reveals →
→ weight is acting downward
→ normal reaction is upward
Nothing changes with time.

b) **Kinematics**:-

Kinematics deals with objects in **motion** without taking into account factors which affect motion.

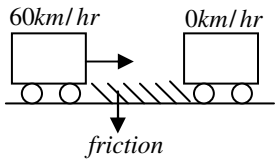


Example:-

A bus moving at 60 km/hr stops after same time. (Reasons not known).

c) **Dynamics**:-

Dynamics deals with the study & objects in motion taking into account factors which cause as affect the motion.



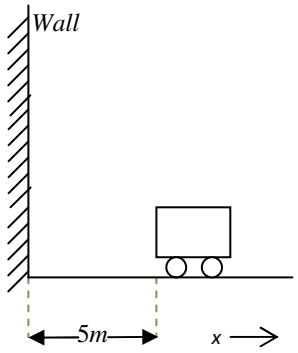
Example:-

A bus moving at 60 km/hr stops after sometime due to friction on floor after the engine is switched off.

Q.2. Explain:

a) Rest

b) Motion



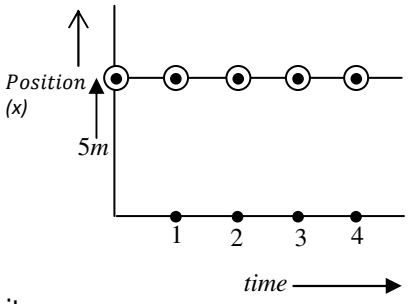
Ans.a) **Rest**:-

An object is said to be at rest if it does not change its position with time, with respect to its surroundings.

Example:-

Time	0 sec	1 sec	2 sec	3 sec
Position	5m	5m	5m	5m

Position time graph as shown in figure



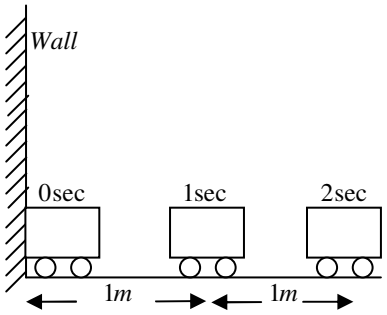
Velocity:- $v = \frac{d(x)}{dt}$

$v = \frac{d(5)}{dt}$

$v = 0$ i.e. Particle is at rest

b) **Motion**:-

An object is said to be in motion if it changes its position with time, with respect to its surroundings.



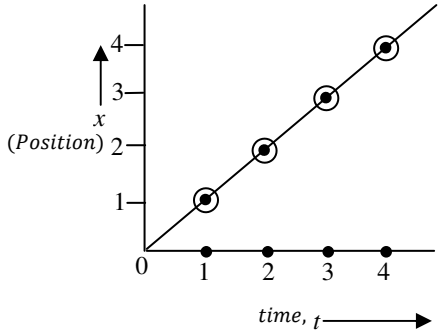
Example:-

x	0m	1m	2m	3m	4m
t	0	1	2	3	4

Position time graph is as shown in figure

Relationship for position - time

$x = t$



Velocity:- $v = \frac{\Delta x}{\Delta t}$

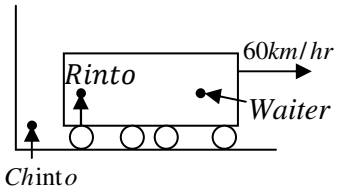
$= \frac{d(x)}{dt}$

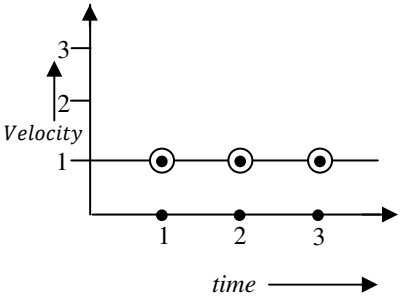
$= \frac{d(t)}{dt}$ $\left[\frac{dx^n}{dx} = n.x^{n-1}\right]$

$= 1.t^{1-1}$

$= 1.t^0$

$v = 1$





Rest and Motion are Relative

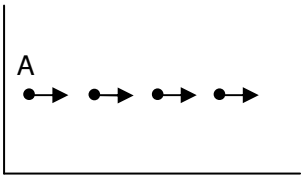
→ Waiter is at rest with respect to Rinto.

→ Waiter is moving at 60km/hr with respect to Chinto.

Q.3. Compare:

a) Rectilinear or Translatory
b) Circular or Rotatory motion
c) Oscillatory or Vibratory motion

Ans.a) **Rectilinear or Translatory**:-

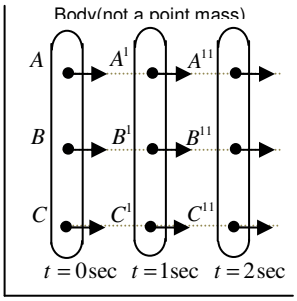


Rectilinear:-

Rectilinear motion is that motion in which a particle or point mass body is moving along straight line.

Example:-

Point mass A is moving in straight line.



Translatory:-

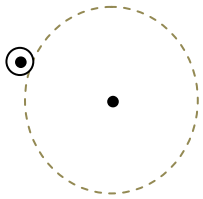
Motion in which a body, which is not a point mass body is moving. All points on the body move in parallel straight lines.

b) **Circular**:-

Motion in which point mass moves in a circle.

Example:-

A monkey moving in a circle in a big stadium.

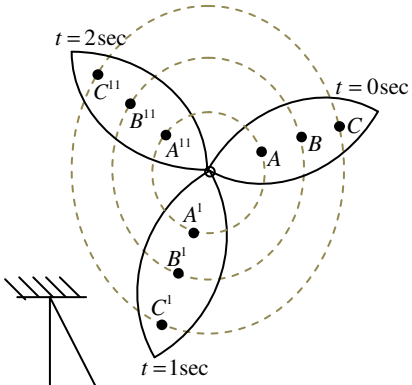


Rotatory:-

Motion in which a body, which is not a point mass body, is moving such that all its constituent particles move simultaneously along concentric circles, whose centre lie on line called axis of rotation and shift through equal angle in given time.

Example:-

Motion of a fan blade as shown in figure points *A*, *B* and *C* form concentric circles.

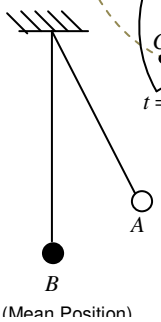


c) **Oscillatory**:-

Motion in which a body moves to and from or back and forth repeatedly about a fixed point (mean position) in a definite internal of time.

Example:-

Pendulum motion has "*High Amplitude*" and "*Low Frequency*". So, it is *oscillatory*.

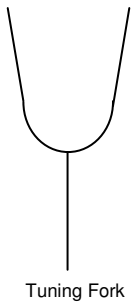


Vibratory:-

If in the oscillatory motion, the amplitude is very small i.e. microscopic, the motion of body is said to be vibratory motion.

Example:-

Tuning fork, car engine have *vibratory motion* as they have "*Low Amplitude*" and "*High Frequency*"



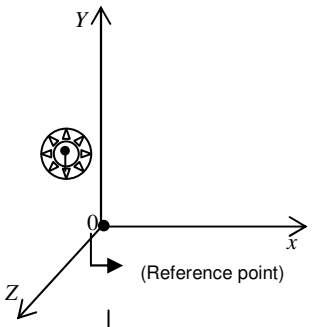
Q.4. a) What is frame of reference?

b) What do you mean by

i) Inertial Frame

Ii) Non-Inertial Frame

Is earth inertial frame or non-inertial frame?



Ans.a) **<u>Frame of reference</u>**:-

Frame of reference is co-ordinate system (x, y, z) along with a clock (time).

Frame of reference is used to specify position (x, y, z) and time of an event.

b) i) **<u>Inertial Frame</u>**:-

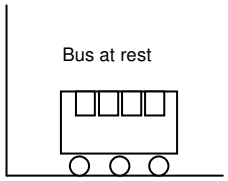
Inertial frame of reference is one in which Newton's 1st law holds good.

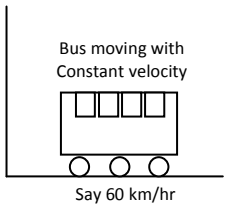
<u>Examples</u>:-

Frame of reference having "ZERO" acceleration.

1. Velocity, $\vec{v}$ = 0
2. Velocity, $\vec{v}$ = Constant (say 60)

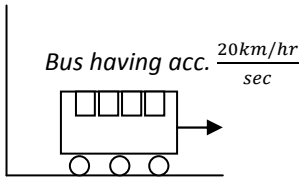
$\vec{v}$ = Constant, Acceleration = 0





ii) **<u>Non Inertial Frame</u>**:-

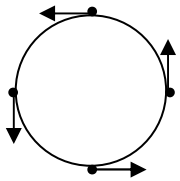
Non-Inertial Frame of reference is one in which Newton's 1st Law of motion does not hold good.



<u>Example</u>:-

A bus acc, a = $\frac{20\ km/hr}{sec}$

Velocity, $\vec{v}$ i.e. not a Constant



Is Earth inertial frame or non-inertial frame?

Ans. Earth is rotating about it's own axis and also moving around Sun. Motion of Earth is rotational (i.e. circular). Any object in rotational (circular) motion is accelerated. As earth is accelerated, so it is "*non-inertial*" frame. Practically, observes is also on Earth. So, Earth appears to be at rest. So, it is taken as "*inertial*" for all practical purposes.

Q.5. What is

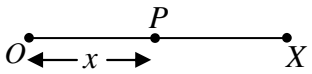
i) 1-D Motion?

ii) 2-D Motion?

iii) 3-D Motion?

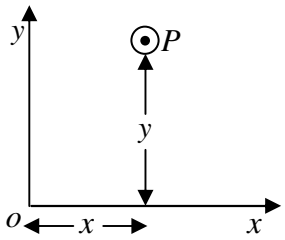
Ans.i) **<u>1-D Motion</u>**:-

The motion of an object is said to be one dimensional if only one coordinate specifying the position of the object changes with respect to time. Here only *x* co-ordinate to specify the position of an object.



<u>2-D Motion</u>:-

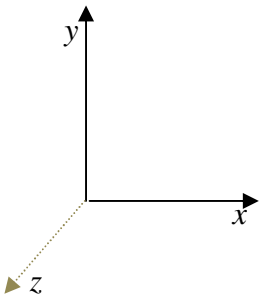
The motion of an object is said to be two dimensional, if two coordinates specifying the position of object change with respect to time. Here *x* and *y*, two co-ordinates are required to specify the position of an object.



<u>Example</u>:- Insert '*P*' crawling over the floor.

<u>3-D Motion</u>:-

The motion of an object is said to be three dimensional if all the three coordinates specifying the position of object, change with respect to time. Here *x*, *y* and *z*, three co-ordinates required to specify the position of an object.



<u>Example</u>:- Kite flying in the sky.

State in the following, whether the motion is one, two or three dimensional motion.

Example	Dimensional Motion
A Kite flying on a windy day	Three dimensional
A speeding car on a long straight highway	One dimensional
A carom rebounding from one side of the board	Two dimensional
A planet revolving around its star	Two dimensional

Q.6. Define scalar and vector quantities.

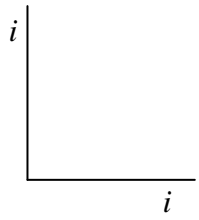
Ans. **Scalar**:-

Physical quantity having magnitude but no direction.

Example:- Mass, Time, Speed, etc.

Vector:-

Physical quantity having magnitude as well as direction.



Example 1.:- Velocity $\vec{v}$, acc $\vec{a}$ ---- etc.

Example 2:-

A particle moving with speed 5m/sec along x axis.

$$\boxed{\vec{v} = 5.\hat{\imath}}$$

Conversation One:-

Rinto : What time is it?
Chinto: 11:00 AM
Rinto: In which Direction?

Rinto's second question does not make any sense, because time does not have a direction. So, time is '*Scalar Quantity*'.

Conversation Two:-

Rinto: Where is bus stand?
Chinto: It is 2km from here.
Rinto: In which direction?
Chinto: It is towards North.

Rinto's second question regarding direction is right. Displacement is '*Vector Quantity*' as it has a direction.

Q.7. Explain and compare distance and displacement.

Ans. **Distance**:-

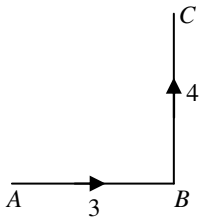
Distance is total length of path covered in given time.

Example 1:-

Distance covered = AB + BC

= 3 + 4

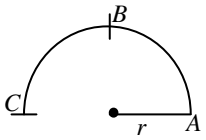
= 7



Example 2:-

As one moves from *A* to *C* via *B*

Distance = π r



Displacement:-

Displacement is change in position of object i.e.

The shortest distance between the final and initial position of object in given time.

Example 1:-

A person moves from *A* to *B* to *C*

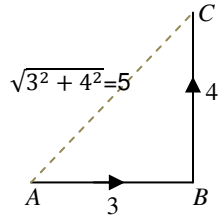
Distance = AB + BC

= 3 + 4

= 7

|Displacement| = $\left|\overrightarrow{AC}\right|$

= 5



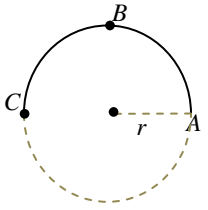
Example 2:-

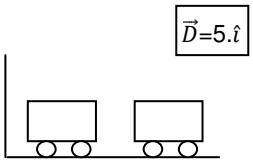
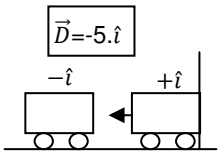
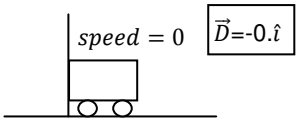
A person moves from *A* to *C* via *B*

Distance = π r

|Displacement| = $\left|\overrightarrow{AC}\right|$

= 2r



DISTANCE	DSIPLACEMENT
1. It is the **actual path** traveled by the object in the given time.	1. It is the **shortest distance** between the initial and final position of object in given time.
2. It is a **scalar** quantity.	2. It is **vector** quantity.
3. Distance can never be *–ve* but can be *+ve* or *zero*.	3. Displacement can be *+ve*, *-ve* or *zero* Exm 1:  Exm 2:  Exm 3: 
4. The distance is either equal or greater than displacement but never less than displacement.	4. The displacement can be equal or less than distance but never greater than distance.
5. The distance covered by an object can have many values, depending upon path followed.	5. The displacement of an object between two positions does not tell the type of path followed. It has unique value.
6. The distance travelled by the object between two positions tell the type of path followed.	6. The displacement of an object between two positions does not tell the type of path followed.

Q.8. a) Define speed? What are its Units & Dimensions?
b) Explain
- **i) Uniform Speed**
- **ii) Variable Speed**
- **iii) Average Speed**
- **v) Instantaneous Speed**

Ans.a) **Speed**:-

Ratio of distance to time

$$\text{Speed} = \frac{distance}{tme}$$

Unit = m/sec

Dimensions = $[v] = \frac{L}{T}$

$$[v] = [M^0 L^1 T^{-1}]$$

b) **Uniform Speed**:-

An object is said to be moving with a uniform speed, if it covers equal distances in equal intervals of time.

Example:-

A car moving on a straight highway *A* to *B* distance 80km in 4hrs and covers 20km in one hour, then car is moving with uniform speed = 20km/hr.

Variable Speed:-

When object covers equal distances in unequal intervals of time or unequal distances in equal intervals of time.

Example:-

Car moving on straight highway *A* to *B* (80km), cover successive 20km distances in timings 1.5hr, 1.25hr, 1hr & 45min speed is different at different locations so it is variable speed.

Average Speed:-

Average speed is defined as the ratio of total distance travelled by the object to the total time taken.

$$\text{Average speed} = \frac{Total\ distance\ travelled}{Total\ time\ taken}$$

Case I:-**Equal Distance**:-

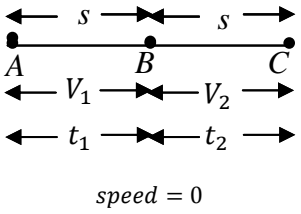
Find average speed for given case i.e. equal distance

$$U_{avg} = \frac{Total\ distance\ travelled}{Total\ time\ taken}$$

$$= \frac{S+S}{t_1+t_2}$$

$$= \frac{2s}{\frac{S}{V_1}+\frac{S}{V_2}}$$

$$\boxed{U_{avg} = \frac{s}{\frac{1}{V_1}+\frac{1}{V_2}}}$$



If 3 then $\boxed{U_{avg} = \frac{3}{\frac{1}{V_1}+\frac{1}{V_2}+\frac{1}{V_3}}}$

Example:-

A car moves from Bathinda to Chandigarh at a speed of 40km/hr and comes back at a speed of 50km/hr find average speed.

`

Sol:- $U_{avg} = \frac{3}{\frac{1}{V_1}+\frac{1}{V_2}} = \frac{3}{\frac{1}{40}+\frac{1}{50}} = \frac{3}{\frac{5+4}{200}} = \frac{3}{1} \times \frac{300}{9}$

$$= \frac{400}{9} = \boxed{44.45\ km/hr}$$

Case II:- **Equal Time**:-

Find average speed

$$U_{avg} = \frac{Total\ distance\ travelled}{Total\ time\ taken}$$

$$= \frac{V_1 t + V_2 t}{t+t}$$

$$U_{avg} = \frac{V_1 + V_2}{2}$$

$$U_{avg} = \frac{V_1 + V_2 + V_3 ------ + V_n}{n}$$

Example:-

A car travels at speed 40km/hr for 1hr anc 50km/hr for next 1hr. Find average speed.

Sol:- $U_{avg} = \frac{Total\ distance\ travelled}{Total\ time\ taken}$

$$= \frac{S_1 + S_2}{t_1+t} = \frac{\left(\frac{40km}{hr} x hr\right)+\left(\frac{50km}{hr} x hr\right)}{1hr + +hr} = \frac{90}{2}$$

Ans:- U_{avg} = 45 km/hr

Instantaneous Speed:-

The speed of an object at given instant of time is called Instantaneous Speed.

$$\boxed{U_{inst} = \frac{ds}{dt}}$$

Q.9. a) Define Velocity? What are its units & dimensions?
b) What is $\vec{V}_{avg}$ and $\vec{V}_{inst.}$?

Ans.a) **Velocity**:-

Ratio of displacement to time

$$\vec{V} = \frac{displacement}{time}$$

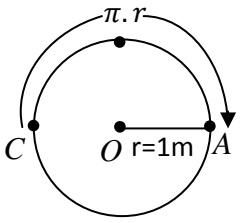
SI Units → m/sec

Dimensions → $\frac{L}{T}\,[M^0L^1T^{-1}]$

b) **Average Velocity**:-

$$\vec{V}_{avg} = \frac{Total\ displacement}{Total\ time}$$

Example:- A particle moves in a circle of radius 1m. It reached to diagonally opposite position in 2 seconds. Find V_{avg} and $\vec{V}_{avg}$.



Sol.:-i) $V_{avg} = \frac{Total\ distance}{Total\ time}$

$= \frac{\pi r}{t}$

$= \frac{\frac{22}{7}x1}{2}$

$= \frac{22}{7} \times \frac{1}{2} = \frac{11}{7}$ = 1.57 m/sec

ii) $|\vec{V}_{avg}| = \frac{Total\ displacement}{Total\ time}$

$= \frac{2r}{t}$

$= \frac{2\ x\ 1}{2}$ = 1m/sec

$|\vec{V}_{avg}|$ = 1m/sec

$\vec{V}_{avg}$ = 1m/sec from *A* to *C*

Instantaneous Velocity:-

$\vec{V}_{inst.}$ = Rate of change of displacement at any point of time.

$\vec{V}_{inst.} = \frac{d}{dt}\vec{s}$

Q.10. a) Write expression for relative velocity of particle *A* with respect to particle *B*.

b) Draw (x-t) graphs for

i) $V_A = V_B$

ii) $V_A > V_B$

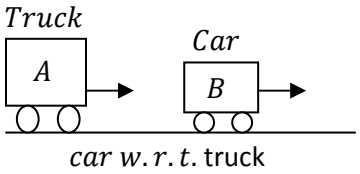
iii) $V_A < V_B$

***A* & *B* are moving along straight line.**

Ans.a) $\vec{V}_B$ w.r.t.A = $\vec{V}_B - \vec{V}_A$

Exapmle 1:- $\vec{V}_B$ = 60 $\hat{\imath}$ (car)

$\vec{V}_A$ = 40 $\hat{\imath}$ (truck)

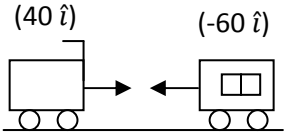


$\vec{V}_B$ w.r.t.A = $\vec{V}_B - \vec{V}_A$

= 60 $\hat{\imath}$ - 40 $\hat{\imath}$

= 20 $\hat{\imath}$

Example 2:- $\vec{V}_B$ w.r.t.A = $\vec{V}_B - \vec{V}_A$



= -60 $\hat{\imath}$ - (40 $\hat{\imath}$)

= -100 $\hat{\imath}$

Case I:-

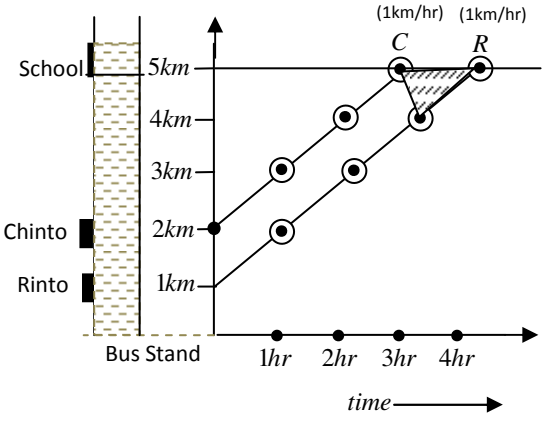
Rinto → cycle ($1km/hr$)

Chinto → cycle ($1km/hr$)

$\vec{V}_B$ w.r.t.A = $\vec{V}_B - \vec{V}_A$

= 1 km/hr - 1 km/hr

= 0



Case II:-

Rinto → scooter ($2km/hr$)

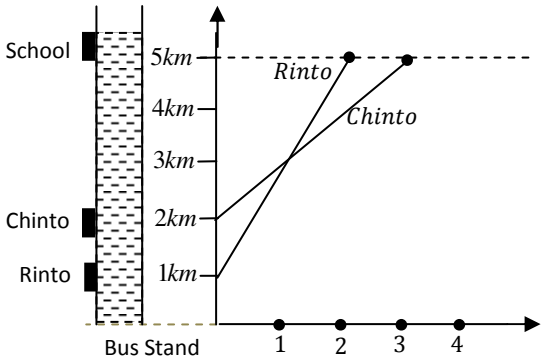
Chinto → cycle ($1km/hr$)

V_B w.r.t.A = $V_B - V_A$

= $V_{rinto} - V_{chinto}$

= 2 – 1

= 1 km/hr



Case III:-