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MOTION

- **Rest:** A body is said to in rest when its position does not change with respect to a reference point.
- **Motion:** A body is said to be in state of motion when its position change continuosly with respect to a reference point.

Types of Motion

(i) Circulatory Motion / Circular Motion

(ii) Linear motion – In a straight line path

(iii) Oscillatory motion – To and fro path w.r.t. origin

★ Scalar quantity: Quantity which has magnitude but no direction is called Scalar quantity.
e.g. distance, speed.

★ Vector quantity: Quantity which has magnitude as well as direction is called Vector quantity.
e.g. displacement, Velocity

- **Distance :** The actual path or length travelled is called distance.

→ Distance is a scalar quantity, its has no direction.

- **Displacement :** The shortest length between initial point and final point travelled by any object is called displacement.

→ Displacement is a vector quantity, it has both magnitude & direction.

→ Displacement can be zero {when initial and final point are same} e.g. Circular motion

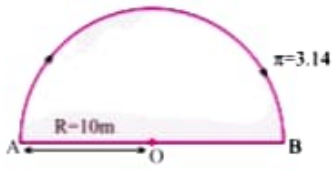
Distance	Displacement
(1.) Length of actual Path travelled by an object.	(1.) Shortest length between initial point and final point of an object.
(2.) It is scalar quantity	(2.) It is Vector quantity.
(3.) It remains positive can't be zero or negative.	(3.) It can be positive, negative or zero.
(4.) Distance can be equal or larger than displacement	(5.) Displacement can be equal to distance or its lesser than distance.

Example 1. *A body travels in a semicircular path of radius 10 m starting its motion from point 'A' to point 'B'. Calculate the distance and displacement.*

Solution : Total distance travelled by body, S = ?

Given, $\pi = 3.14, R = 10\,m$

$S = \pi R$



$= 3.14 \times 10\,m$

$= 31.4\,m$ **Ans.**

Total displacement of body, D = ?

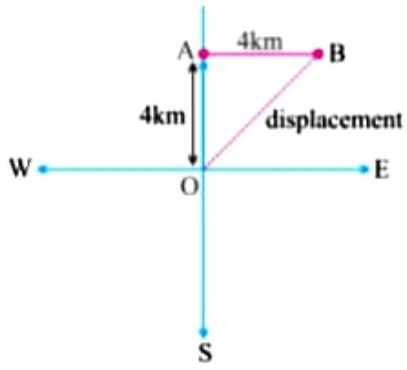
Given, $R = 10\,m$

$D = 2 \times R$

$= 2 \times 10\,m = 20\,m$ **Ans.**

Example 2. *A body travels 4 km towards North then he turn to his right and travels another 4 km before coming to rest. Calculate (i) total distance travelled, (ii) total displacement.*

Solution :



Total distance travelled $= OA + AB$

$= 4\,km + 4\,km$

$= 8\,km$ **Ans.**

Total displacement $= OB$

$OB = \sqrt{OA^2 + OB^2}$

$= \sqrt{(4)^2 + (4)^2}$

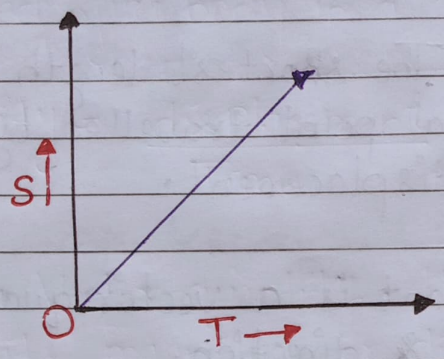
$= \sqrt{16 + 16}$

$= \sqrt{32}$

$= 5.65\,km$ **Ans**

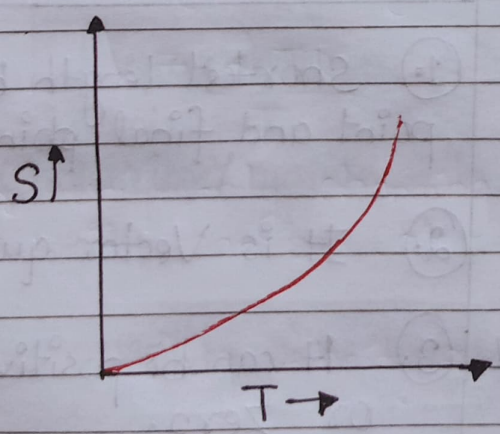
• Uniform Motion :

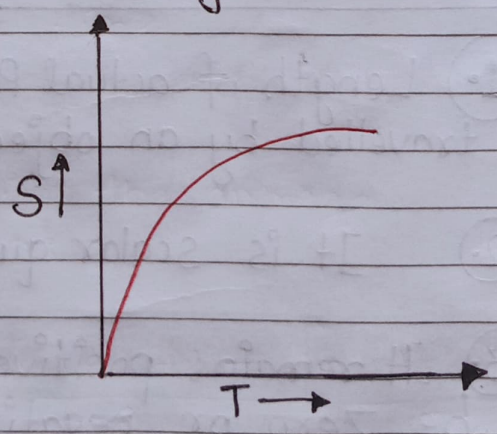
When a body travels equal distance in equal interval of time, then the motion is said to be uniform motion.



• Non Uniform Motion :

When a body Covers unequal distance in equal interval of time, then the motion is non uniform motion.





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Delta

Non - uniform Motion is of two types :

(i) Accelerated motion : When motion of a body increases with time .

(ii) De - accelerated motion : When motion of a body decreases with time .

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

$$V = \frac{S}{t}$$

- SI unit = m/s { meter Per Second }
- Uniform motion है तो constant Speed होगी ।
- अगर Non uniform motion है तो speed will not remain Constant .
- इसलिए Non - uniform motion के लिए we consider the concept of Average speed .

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

Example : *What will be the speed of body in m/s and km/hr if it travels 40 kms in 5 hrs ?*

Solution :

Distance (s) = 40 km

Time (t) = 5 hrs.

$$\text{Speed (in km / hr)} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{40\text{ km}}{5\text{ hrs}}$$

$$= 8\text{ km/hr}$$ **Ans.**

Speed (in m/s) = ?

40 km = 40 × 1000 m = 40,000 m

5 hrs = 5 × 60 × 60 sec.

$$= \frac{40 \times 1000\text{ m}}{5 \times 60 \times 60\text{ s}}$$

$$= \frac{80\text{ m}}{36\text{ s}}$$

$$= 2.22\text{ m/s}$$ **Ans.**

VELOCITY

It is the speed of a body in a given direction.

$$\text{Velocity} = \frac{\text{displacement}}{\text{Time}}$$

- Velocity is a Vector quantity. Its value changes when either its magnitude or direction changes.
- for non uniform motion, average velocity will be calculated in the same way as we done in avg. speed.

$$\text{Average Velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

- for uniformly changing velocity the average velocity can be calculated as :

$$\text{Avg velocity} = \frac{\text{Initial Velocity} + \text{final Velocity}}{2}$$

$$V_{avg} = \frac{u+v}{2}$$

Velocity can be +ve, -ve or Zero.

Example 1 : *During first half of a journey by a body it travel with a speed of 40 km/hr and in the next half it travels with a speed of 20 km/hr. Calculate the average speed of the whole journey.*

Solution : Speed during first half (v_1) = 40 km/hr

Speed during second half (v_2) = 20 km/hr

$$\text{Average speed} = \frac{v_1 + v_2}{2}$$

$$= \frac{40 + 20}{2} = \frac{60}{2}$$

$$= 30 \text{ km/hr}$$

Average speed by an object (body) = 30 km/hr. **Ans.**

Example 2 : *A car travels 20 km in first hour, 40 km in second hour and 30 km in third hour. Calculate the average speed of the train.*

Solution : Speed in Ist hour = 20 km/hr, *Distance travelled during 1st hr = 1 × 20 = 20 km*

Speed in IInd hour = 40 km/hr, *Distance travelled during 2nd hr = 1 × 40 = 40 km*

Speed in IIIrd hour = 30 km/hr, *Distance travelled during 3rd hr = 1 × 30 = 30 km*

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

$$= \frac{20 + 40 + 30}{3} = \frac{90}{3} = \frac{20 + 40 + 30}{1 + 1 + 1}$$

$$= 30 \text{ km/hr}$$ **Ans.**

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ACCELERATION

The rate of change of velocity with time is known as Acceleration.

ये सिर्फ Non uniform Motion में होता है, क्योंकि Velocity तो वही change होती है ना

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

$$a = \frac{v-u}{t}$$

V = final Velocity
u = initial Velocity
और t तो time होता है

If $v > u$, then a will be (+ve)

- **Retardation / Deacceleration :**

Deacceleration is seen in non uniform motion during decrease in velocity with time. It has same defination as acceleration.

$$a' = \frac{v-u}{t}$$

If $v < u$ then a will be negative (-ve)

तो इसमें Velocity decrease होती है।

Example 1 : *A car speed increases from 40 km/hr to 60 km/hr in 5 sec. Calculate the acceleration of car.*

Solution :

$$u = \frac{40\text{ km}}{\text{hr}} = \frac{40\times5}{18} = \frac{100}{9} = 11.11\ \text{ms}^{-1}$$

$$v = \frac{60\text{ km}}{\text{hr}} = \frac{60\times5}{18} = \frac{150}{9} = 16.66\ \text{ms}^{-1}$$

$a = ?$ $t = 5$ sec.

$$a = \frac{v-u}{t}$$

$$= \frac{16.66-11.11}{5}$$

$$= \frac{5.55}{5}$$

$$= 1.11\ \text{ms}^{-2}$$ **Ans.**

Example 2. *A car travelling with a speed of 20 km/hr comes into rest in 0.5 hrs. What will be the value of its retardation ?*

Solution :

$v = 0$ km/hr

$u = 20$ km/hr

$t = 0.5$ hrs

Retardation, $a' = ?$

$$a' = \frac{v-u}{t}$$

$$= \frac{0-20}{0.5}$$

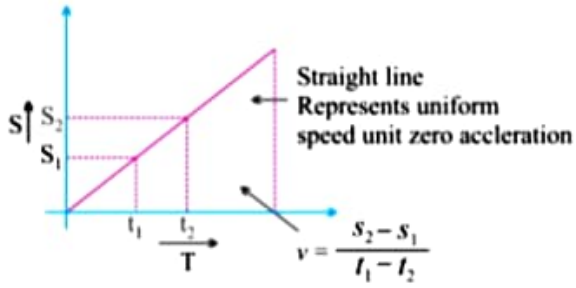
$$= -\frac{200}{5}$$

$$= -40\ \text{km/hr}^2$$ **Ans.**

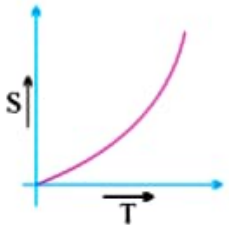
Graphical Representation of Equation

(i) Distance-Time Graph : *s/t* graph :

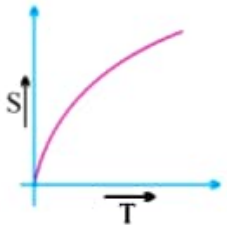
(a) *s/t* graph for uniform motion :



(b) *s/t* graph for non-uniform motion :

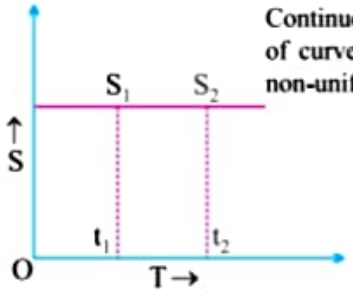


Continuous increase in slope of curve indicates accelerated non-uniform motion.



Continuous decrease in slope of curve indicates decelerate non-uniform motion.

(c) *s/t* graph for a body at rest :



Continuous decrease in slope of curve indicates deaccelerate non-uniform motion.

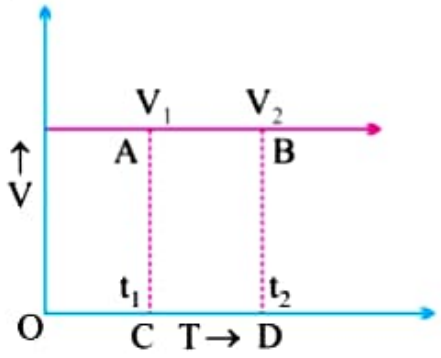
$$v = \frac{s_2 - s_1}{t_2 - t_1}$$

But, $s_2 = s_1$

$$\therefore \quad v = \frac{0}{t_2 - t_1} \quad \text{Or} \quad v = 0$$

(ii) Velocity-Time Graph : *v/t* graph :

(a) *v/t* graph for uniform motion :



distance (s) = AC x CD

= area of rectangle ABCD

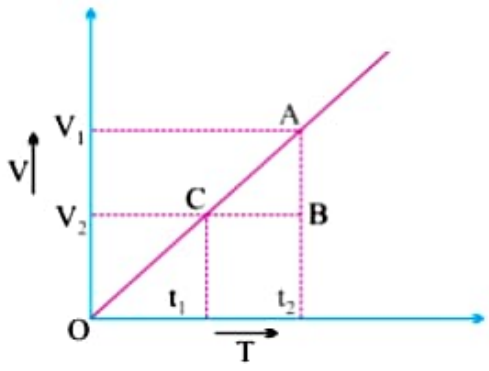
$$a = \frac{v_2 - v_1}{t_2 - t_1}$$

But, $v_2 = v_1$

$$\therefore \quad a = \frac{0}{t_2 - t_1} \quad \text{Or} \quad a = 0$$

(b) *v/t* graph for non-uniform motion :

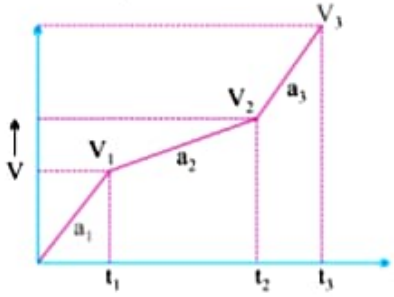
(A) *v/t* graph for accelerated (uniform) motion :



$$a = \frac{v_2 - v_1}{t_2 - t_1}$$

In uniformly accelerated motion, there will be equal increase in velocity in equal interval of time throughout the motion of body.

(B) *v/t* graph for accelerated (non-uniform) motion :



Here if, $t_2 - t_1 = t_2 - t_3$

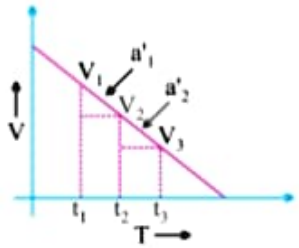
Then, $v_2 - v_1 \neq v_3 - v_2$

$$\frac{v_2 - v_1}{t_2 - t_1} \neq \frac{v_3 - v_2}{t_3 - t_2}$$

Or

Or $a_2 \neq a_1$

(C) *v/t* graph for decelerated (uniform) motion :



Here, $v_2 - v_1 = v_3 - v_2$

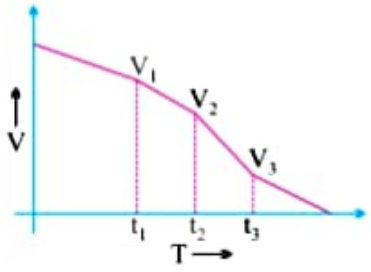
If $t_2 - t_1 = t_3 - t_2$

$$\frac{v_2 - v_1}{t_2 - t_1} = \frac{v_3 - v_2}{t_3 - t_2}$$

Then,

Or $a'_1 = a'_2$

(D) *v/t* graph for decelerated (non-uniform) motion :



Here, $v_2 - v_1 \neq v_3 - v_2$

Equation of Motion (For Uniformly Accelerated Motion)

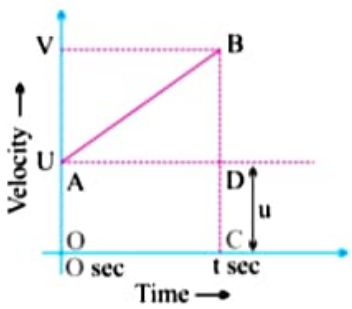
(i) First Equation

$$v = u + at$$

Or Final velocity = Initial velocity + Acceleration × Time

Graphical Derivation :

Suppose a body has initial velocity 'u' (*i.e.*, velocity at time $t = 0$ sec.) at point 'A' and this velocity changes to 'v' at point 'B' in 't' secs. *i.e.*, final velocity will be 'v'.



For such a body there will be an acceleration.

$$a = \frac{\text{Change in velocity}}{\text{Change in time}}$$

$$a = \frac{OB - OA}{OC - 0} = \frac{v - u}{t - 0}$$

$$a = \frac{v - u}{t}$$

Or

Or $v = u + at$

(ii) Second Equation

$s = ut + \frac{1}{2}at^2$

Distance travelled by object = Area of OABC (trapezium)

= Area of OADC (rectangle) + Area of ΔABD

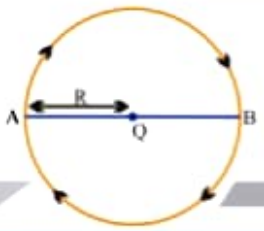
$= OA \times AD + \frac{1}{2} \times AD \times BD$

$= u \times t + \frac{1}{2} \times t \times (v - u)$

$= ut + \frac{1}{2} \times t \times at$

$\left(\because \frac{v - u}{t} = a \right)$ so [v-u = at]

$s = ut + \frac{1}{2}at^2$



Chapter - 8

Motion

CONCEPT MAPPING

Physical State

- **Rest** (No change in potion)
- **Motion** (change in potion)

Uniform Motion — Equal distance travelled in equal time intervals.

Non-uniform Motion — Unequal distance travelled in equal time intervals.

- **Accelerated Motion** — Increase in motion with time
  - Uniformly Accelerated Motion
  - Non Uniformly Accelerated Motion
- **Deaccelerated Motion** — Decrease in motion with time
  - Uniformly Deaccelerated Motion
  - Non Uniformly Deaccelerated Motion

Linear Motion — Straight line path

Circulatory Motion — Circulatory path

- **Distance** — Actual path travelled by a body
  - **Speed** — Distance traveled in a unit time. Unit m/s It is Scalar (only Magnitude)
- **Displacement** — Shortest distance between Initial and final position
  - **Velocity** — Displacement traveled in a unit time. Unit - m/s It is vector (both magnitude and direction

Equations of Motion

- $V = u + at$ — First Equation
- $S = Ut + 1/2at^2$ — Second Equation
- $V^2 = U^2 + 2as$ — Third Equation

Where :

v = Final velocity
u = Initial velocity
a = Acceleration
t = Time taken
s = Distance covered

$s = ut + \frac{1}{2}at^2$

(iii) Third Equation

$$v^2 = u^2 + 2as$$

s = Area of trapezium OABC

$$s = \frac{(OA + BC) \times OC}{2}$$

$$s = \frac{(u+v) \times t}{2}$$

$$s = \left(\frac{u+v}{2}\right) \times \left(\frac{v-u}{a}\right)$$

Or

$$\left(\because \frac{v-u}{t} = a\right)$$

$$s = \frac{v^2 - u^2}{2a}$$

$\therefore$

Or $$v^2 = u^2 + 2as$$

Example 1. *A car starting from rest moves with uniform acceleration of 0.1 ms^{-2} for 4 mins. Find the speed and distance travelled.*

Solution : $u = 0$ ms^{-1} $\because$ car is at rest.

$a = 0.1$ ms^{-2}

$t = 4 \times 60 = 240$ sec.

$v = ?$

From, $v = u + at$

$v = 0 + 0.1 \times 240$

Or $v = 24$ ms^{-1} **Ans.**

Example 2. *The brakes applied to a car produces deceleration of 6 ms^{-2} in opposite direction to the motion. If car requires 2 sec. to stop after application of brakes, calculate distance travelled by the car during this time.*

Solution : Deceleration, $a = -6$ ms^{-2}

Time, $t = 2$ sec.

Distance, $s = ?$

Final velocity, $v = 0$ ms^{-1} $\because$ car comes to rest.

Now, $v = u + at$

Or $u = v - at$

Or $u = 0 - (-6) \times 2 = 12$ ms^{-1}

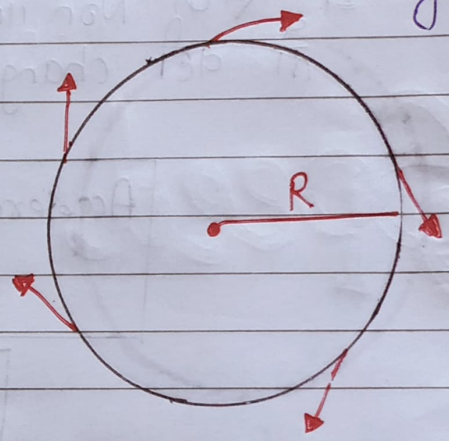
And, $s = ut + \frac{1}{2}at^2$

$= 12 \times 2 + \frac{1}{2} \times (-6) \times (2)^2$

$= 24 - 12 = 12$ m **Ans.**

Uniform Circular Motion

If a body is moving in a Circular path with Uniform speed then it is said to be executing Uniform Circular motion.



देखो इसमें speed तो same रहेगी पर Velocity हर point पे अलग होगी due to continuous change in direction.

"इसलिए Uniform Circular motion is an accelerated motion."

$$V = \frac{2\pi r}{T}$$

QUESTIONS

VERY SHORT ANSWER TYPE QUESTIONS

1. Change the speed 6 m/s into km/hr.
2. What do speedometer and odometer used for ?
3. What is the other name of negative acceleration ?
4. What does the slope of distance-time graph indicate ?
5. What can you say about the motion of a body if its speed-time graph is a straight line parallel to the time axis ?
6. Define Motion.
7. Is distance is a scaler or vector quantity? Why?
8. Is displacement is a scaler quantity? Why?
9. Define average speed.
10. What is difference between speed and velocity?

SHORT ANSWER TYPE QUESTIONS

1. A tortoise moves a distance of 100 m in 15 minutes. What is its average speed in km/hr ?
2. If a bus travelling at 20 m/s is subjected to a steady deceleration of 5 m/s^2, how long will it take to come to rest ?
3. What is the difference between uniform linear motion and uniform circular motion ?
4. Explain why the motion of a body which is moving with constant speed in a circular path is said to be accelerated.
5. Define velocity. What is SI unit of velocity?
6. What is meant by the term acceleration? Write its SI unit.
7. Write difference between 'distance' and 'displacement'.
8. Under what conditions can a body travel a certain distance and yet its resultant displacement be zero.
9. Is a uniform circular motion accelerated? Explain.
10. What type of motion is exhibited by a free falling body & why?

LONG ANSWER TYPE QUESTIONS

1. Derive the equations $v = u + at$, $s = ut + \frac{1}{2}at^2$ and $v^2 = u^2 + 2as$ graphically.

2. What is uniform circular motion ? Give two examples which force is responsible for that.

3. A car travels 30 kilometers at a uniform speed of 40 km/hr and next 30 km at a uniform speed of 20 km/hr. Find its average speed.

4. (a) Convert a speed of 54 km/hr into m/s.

   (b) Change the speed of 6 m/s into km/hr.

   (c) A driver decreases the speed of a car from 25 m/s to 10 m/s in 5 seconds. Find the acceleration of car.

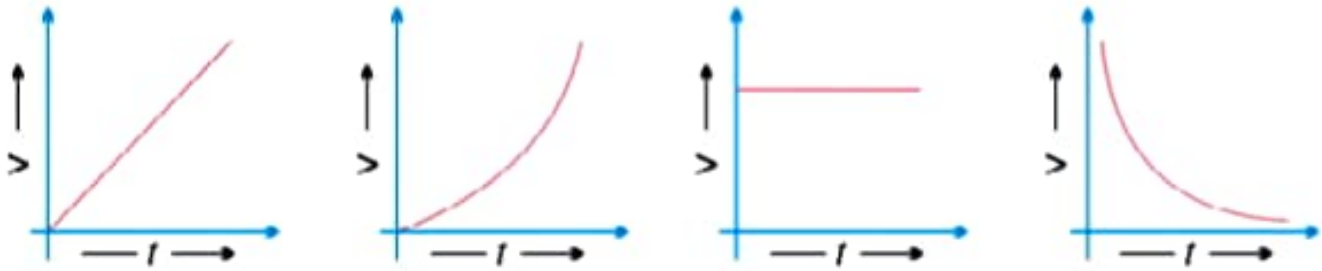
5. A scooter acquires a velocity of 36 km/hr in 10 seconds just after the start. Calculate the acceleration of the scooter.

[Hint : change speed in m/s, v = u + at].

A car increase its speed from 20 km/hr to 50 km/min 10 seconds. Fin acceleration. [Hint : convert km/hr to m/s. v = u + at].

A cyclist goes around a circular path once every 2 minutes. If the ra of the track is 105 metres. Calculate his speed. $\left[v = \frac{2\pi r}{t}, \pi \frac{22}{7}\right]$.

8. Which type of motion is represented by each one of the following graphs?



(a) (b) (c) (d)

Answer of Long Questions :

3. 26.6 km/hr.

4. (a) 15 m/s (b) 21.6 km/hr (c) $a = -3\ m/s^2$

5. $a = 1\ m/s^2$

6. $a = 0.83\ m/s^2$

7. $v = 5.5\ m/s$

OBJECTIVE TYPES QUESTIONS

MCQ

1. The numerical ratin of displacement to distance for a moning object is

(a) equal to or less than 1 (b) always equals to 1
(c) always less than 1 (d) always more than 1

2. Retanlation of a body is expressed in

(a) m (b) ms^{-1}
(c) $-ms^{-2}$ (d) ms^{-2}

3. If the displacement time graph of a particle is parallel to the time axis, the velocity of the particle is

(a) Unity (b) Infinity
(c) Zero (d) None of these

4. The slope of velocity-time graph gives

(a) the displacement (b) the distance
(c) the acceleration (d) the speed

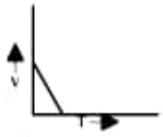
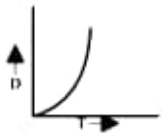
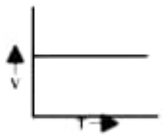
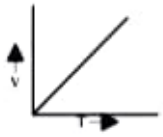
5. The distance covered by a bus moving with a speed of 36Km/hr is 15 min. is

(a) 0.9Km (b) 9 Km
(c) 90Km (d) 900Km

6. A body is thrown vertically upward with velocity 'u' the gracate height 'h' to which it will rise is,

(a) $\frac{u}{g}$ (b) $\frac{u^2}{2g}$ (c) $\frac{u^2}{g}$ (d) $\frac{u}{2g}$

7. Match the following :

Column I	Column II
a 	p. Constant velocity
b 	q. Non-uniform speed
C 	r. Body at rest
d 	t. uniform retardation
e