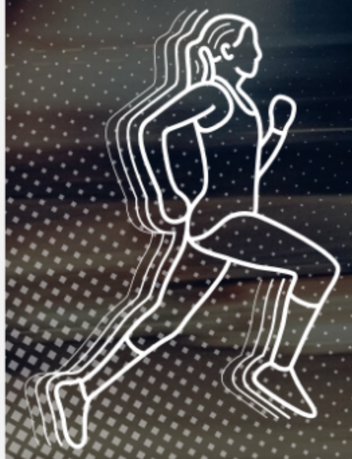
LECTURE 01

प्रारंभ BATCH

CLASS XI - PHYSICS

MOTION IN A STRAIGHT LINE



Next Toppers

Yaad h ye sab?

- Mechanics
- Frame of Reference
- Rest and Motion
- Distance and Displacement
- Average Speed and Velocity
- Uniform Speed and Non-Uniform Speed
- Uniform Velocity and Non-Uniform Velocity

Mechanics deals with the motion of objects and it can be divided into two branches:

Kinematics

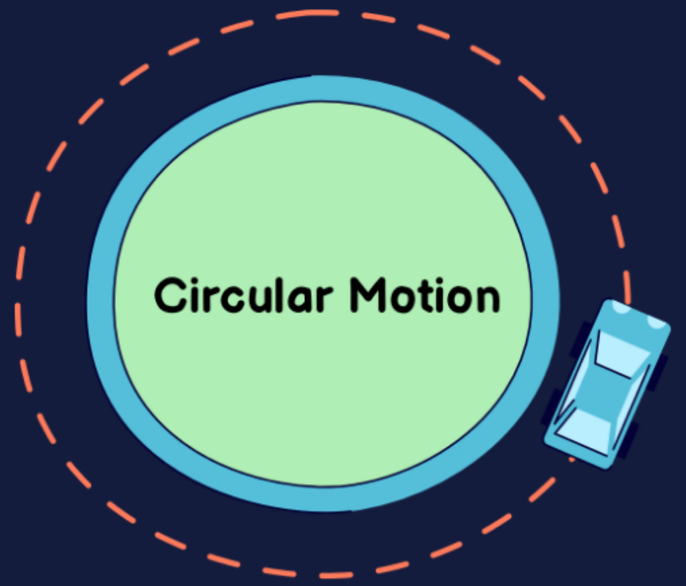
- Study of motion without considering the causes behind it.
- It explores how objects move, not why they move.

Dynamics

- Study of motion, along with the forces and reasons that cause it.
- It explains why objects move the way they do.

Examples of motion studied in Kinematics:

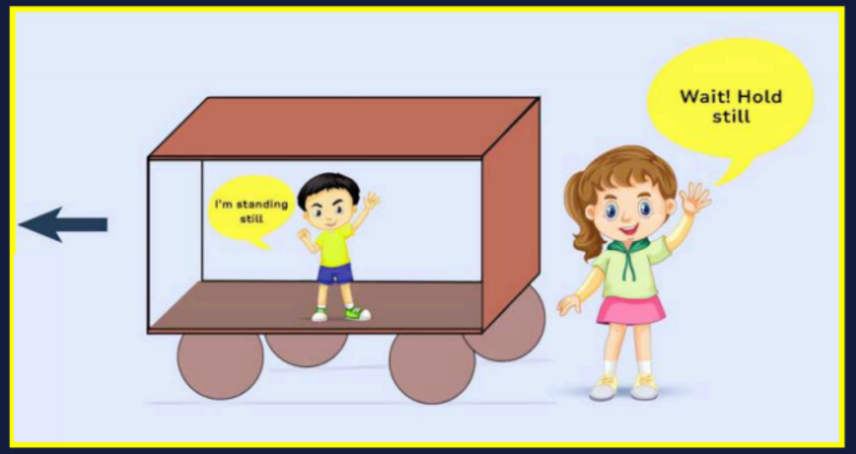
- Motion along a straight line (1D motion)
- Motion in a plane (2D motion)
- Circular motion

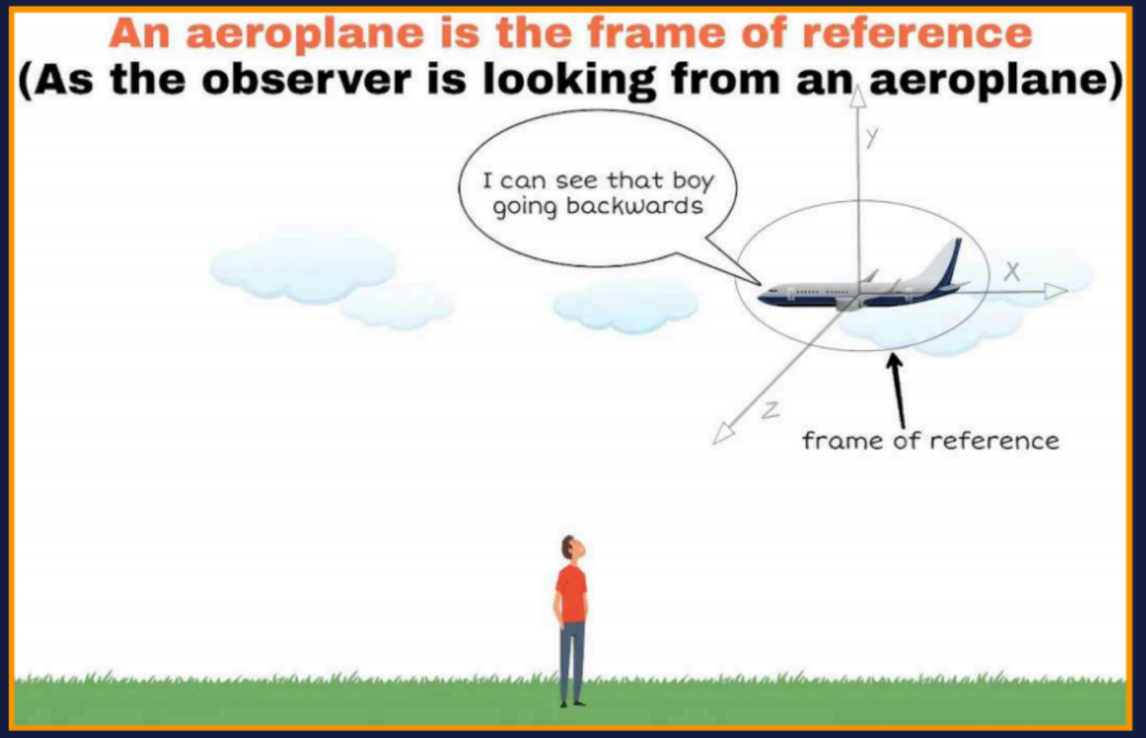


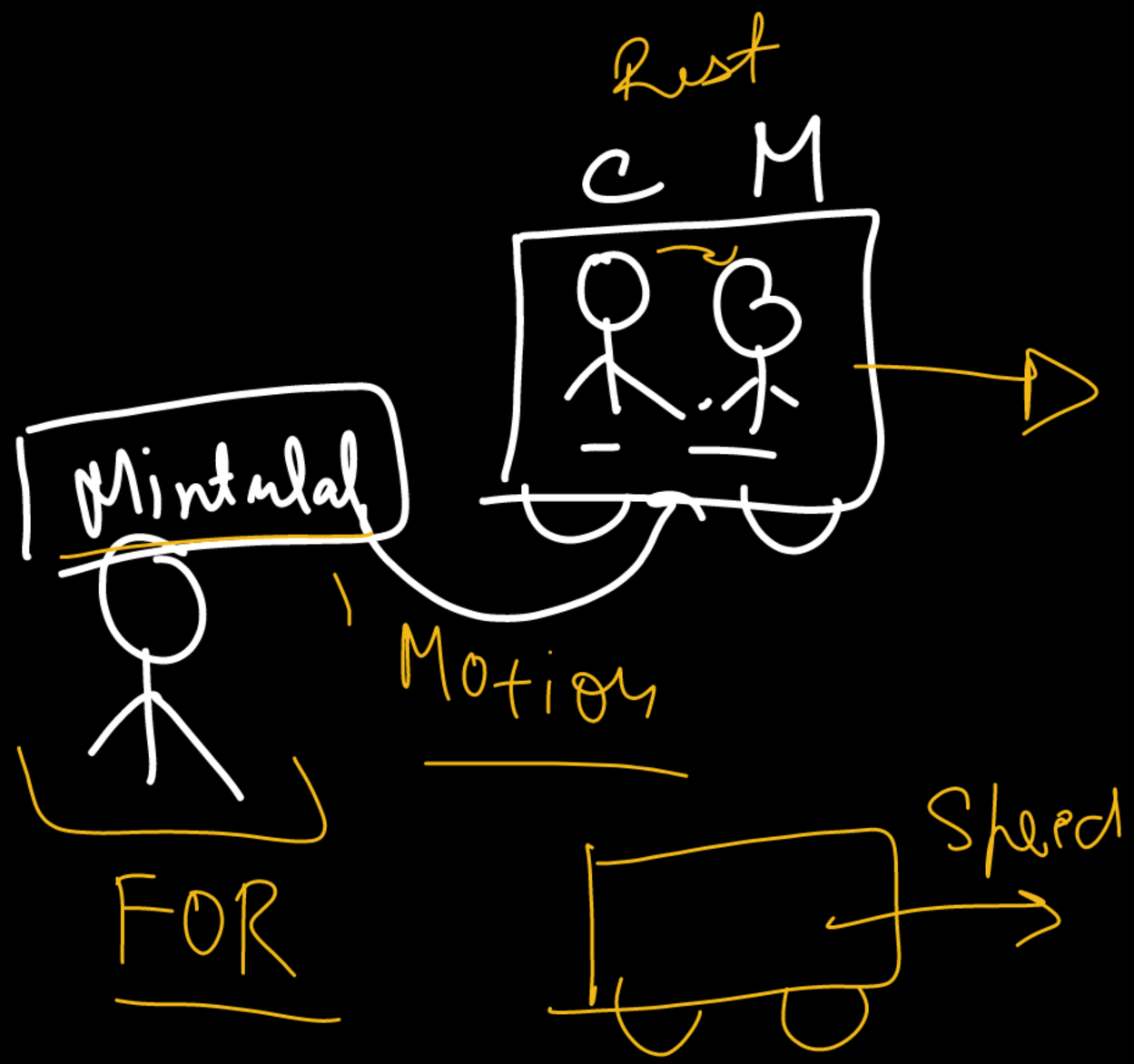
Frame of Reference

A *frame of reference* is a system used to describe the position, velocity, and motion of objects.

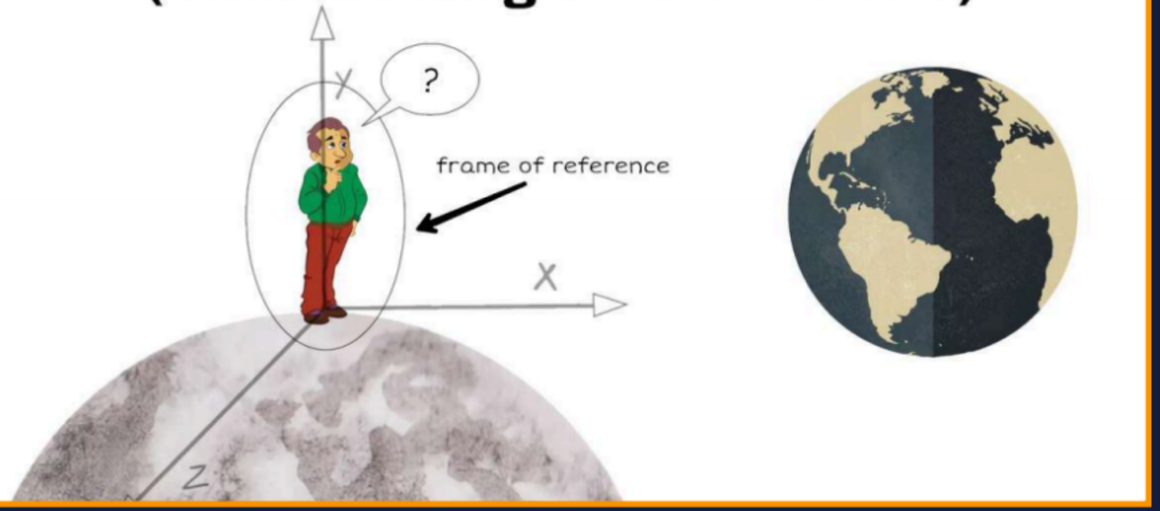
Everything depends on where you stand!






Rest
C M
Mintulal
Motion
FOR
Shed

Why does the earth appear to be moving? (While looking from the moon)



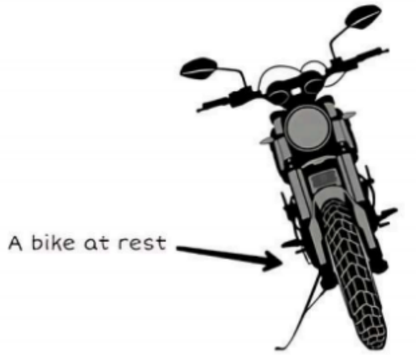
A skateboard is the frame of reference (As the observer is looking from a skateboard)

Types of Frames of Reference:

Inertial frame of reference:

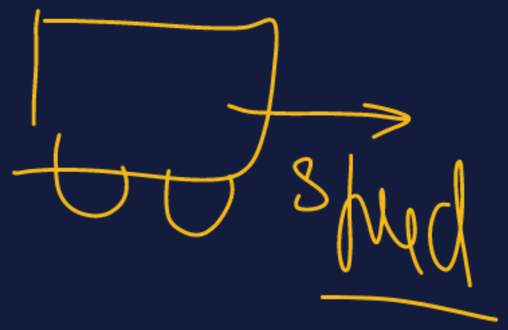
An *inertial frame of reference* is a concept in physics that refers to a frame in which Newton's first law of motion holds true.

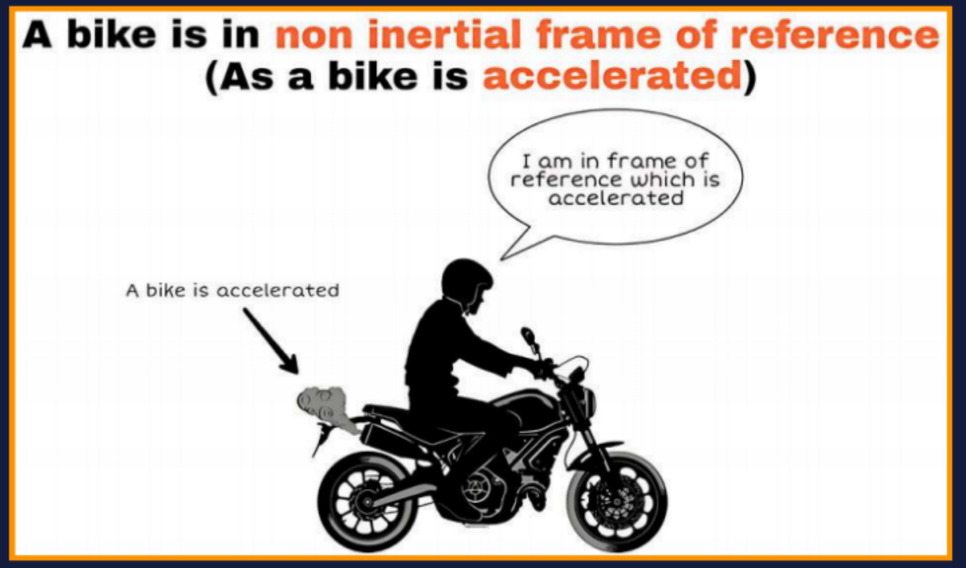
A bike is in inertial frame of reference
(As a bike is at rest)



Non-inertial reference frame:

A *non-inertial reference frame* is a concept in physics that refers to a frame of reference that is subjected to acceleration.



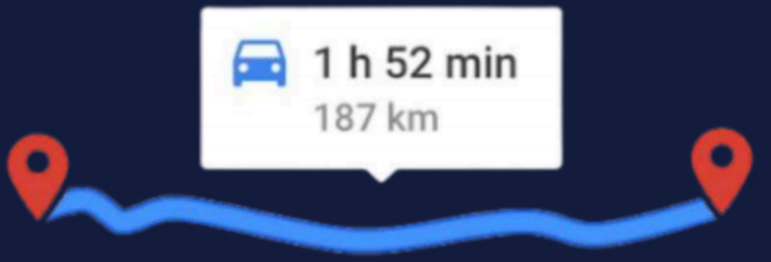


Distance

Distance is the total length of the actual path traveled by an object, irrespective of direction.

SI Unit = meter (m).

Example = Walking 3m east and then 4 m north → Distance = 3 + 4 = 7m.



Displacement

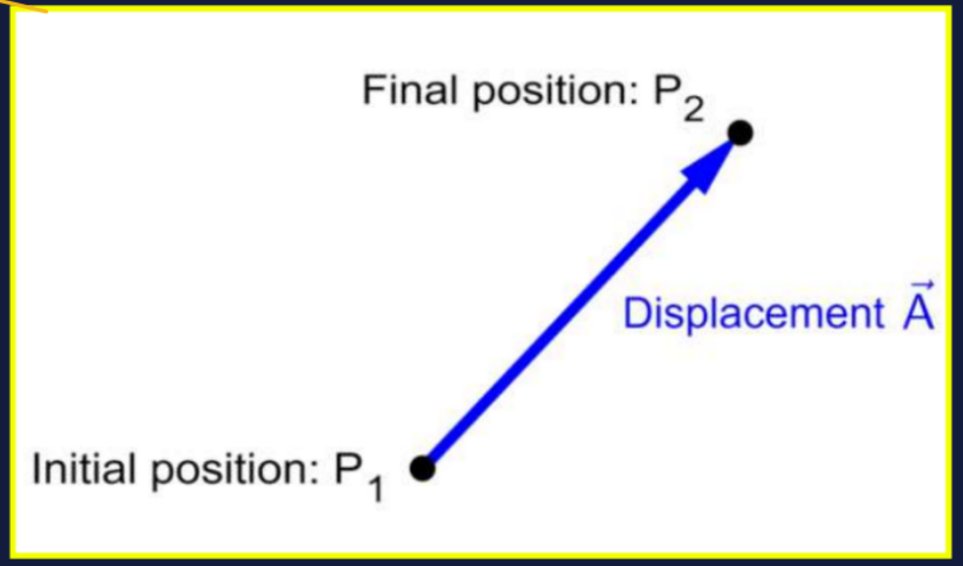
Displacement is the shortest straight-line distance from the initial to the final position of the object, considering direction.

$\sqrt{9+16} = \sqrt{25} = 5$

= 7 Km

SI Unit = meter (m).

Formula = $\Delta s = s_2 - s_1$ (change in position).

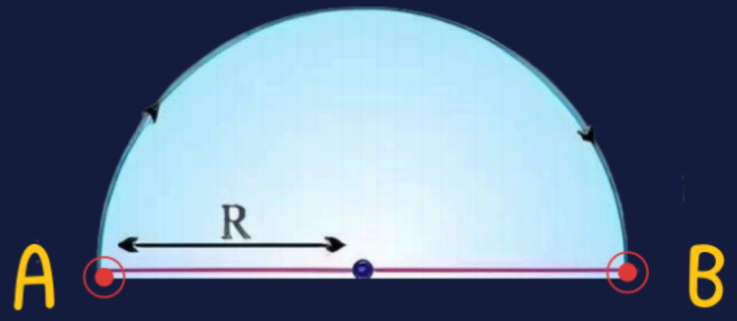


DISTANCE AND DISPLACEMENT IN CIRCULAR PATH:

$= 2\pi m$

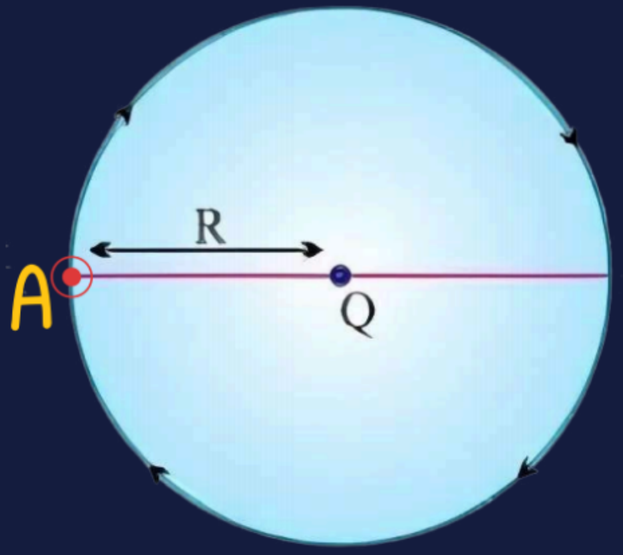
Semi Circle (A to B)

- Distance (D) = Circumference/2 = πr
- Displacement (s) = 2r



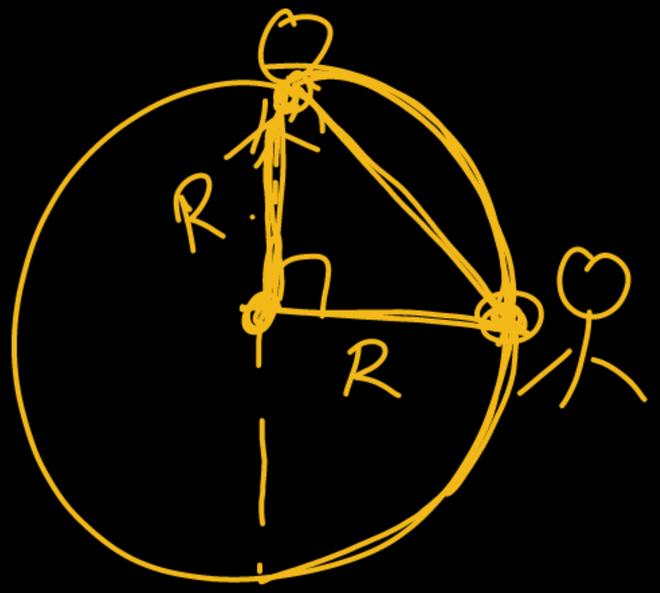
$= 2\pi m$

$= 2 \times \frac{22}{7} \times 7 = 44\,m$

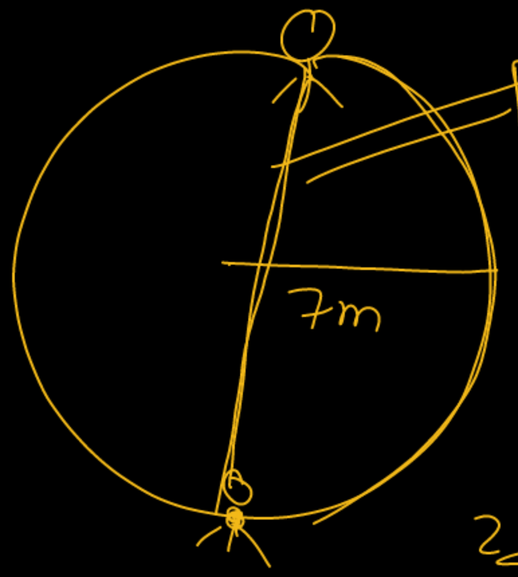


Full Circle(A to A)

- Distance (D) = Circumference = 2πr
- Displacement (s) = 0 (starts and ends at the same point).



$$\sqrt{49+49} = \sqrt{98}$$



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

$$\frac{22}{7} \times 7 = 22m$$

$$\pi \times r = \frac{\pi}{2} \times r$$

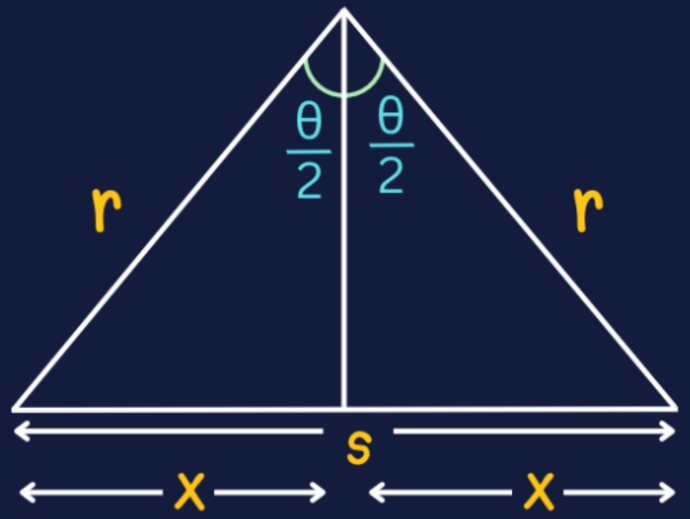
$$= \frac{22}{7 \times 2} \times 7$$

$$= \underline{11m}$$

DISTANCE AND DISPLACEMENT IN CIRCULAR ARC:

$l = r \times \theta$

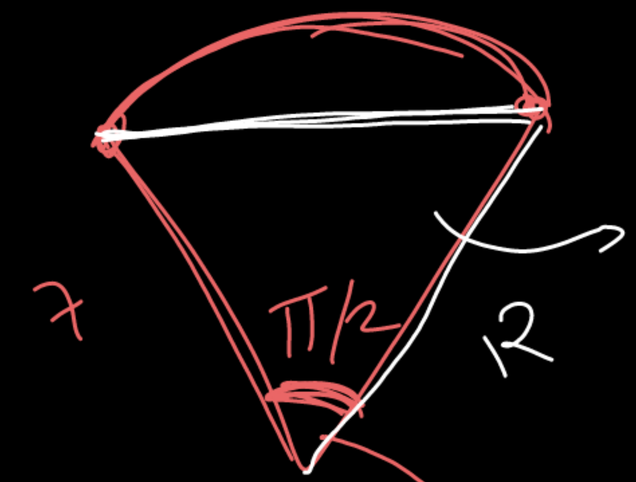
- Arc Length (Distance): D = Rθ (θ in radians)
- Displacement (chord length): $\Delta = 2R\sin\left(\frac{\theta}{2}\right)$



Since, $\sin\theta = \frac{P}{H}$

$$\sin\left(\frac{\theta}{2}\right) = \frac{x}{R} \Rightarrow x = R\sin\left(\frac{\theta}{2}\right) \Rightarrow \Delta = 2x = 2R\sin\left(\frac{\theta}{2}\right)$$

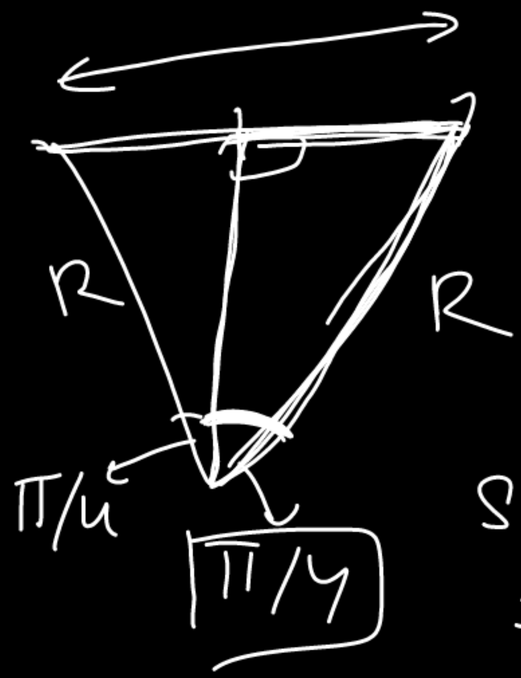
(8)



$$l = 7 \times \frac{\pi}{2}$$

$$l = 7 \times \frac{22}{7 \times 2}$$

$$l = 11m$$

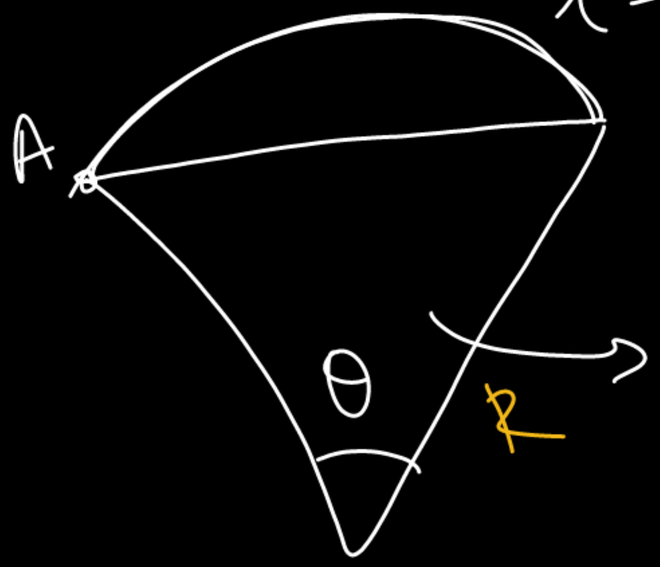


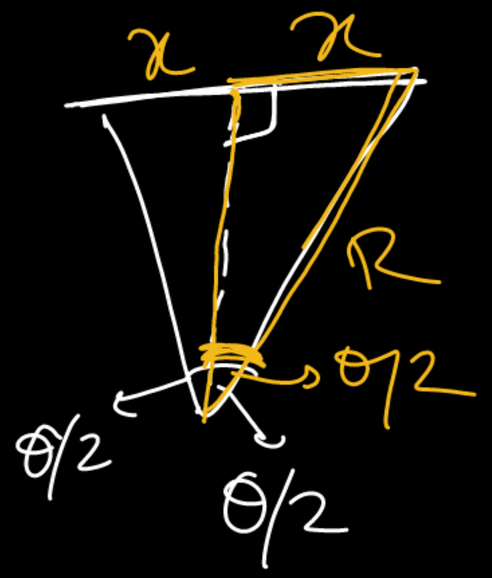
$$\sin \pi/4 = \frac{P}{R}$$

$$P = R \times \sin \pi/4$$

$$2R \sin \pi/4$$

$l = R\theta$



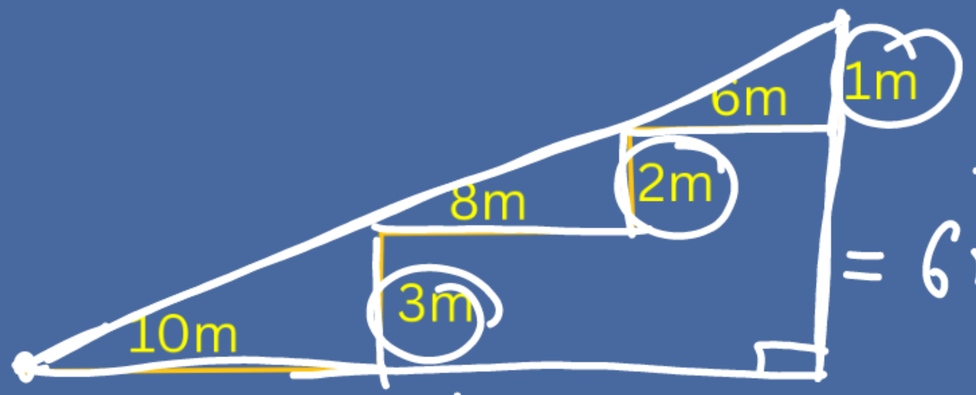


$$\sin\left(\frac{\theta}{2}\right) = \frac{x}{R}$$

$$x = R\sin\left(\frac{\theta}{2}\right)$$

$$= 2R\sin\left(\frac{\theta}{2}\right)$$

Ques. find distance and displacement ?



$= 30m$

$= 6m$

SOLUTION

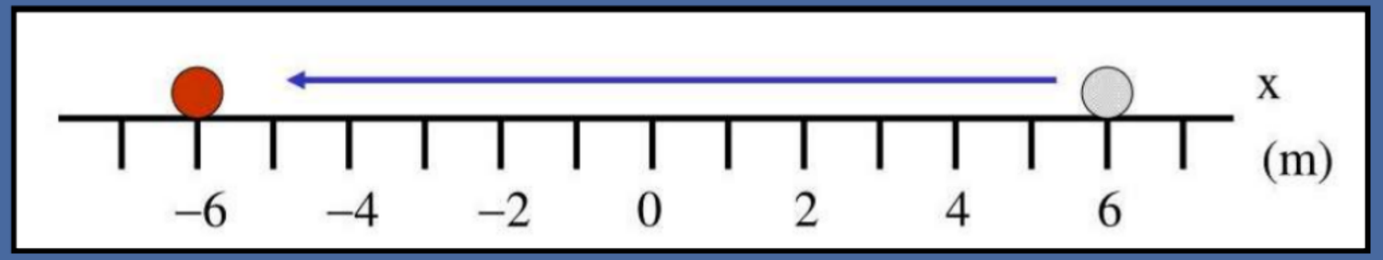
$24m$

$\sqrt{36+(24)^2}$

576

$\sqrt{612}$

Ques. Calculate displacement.

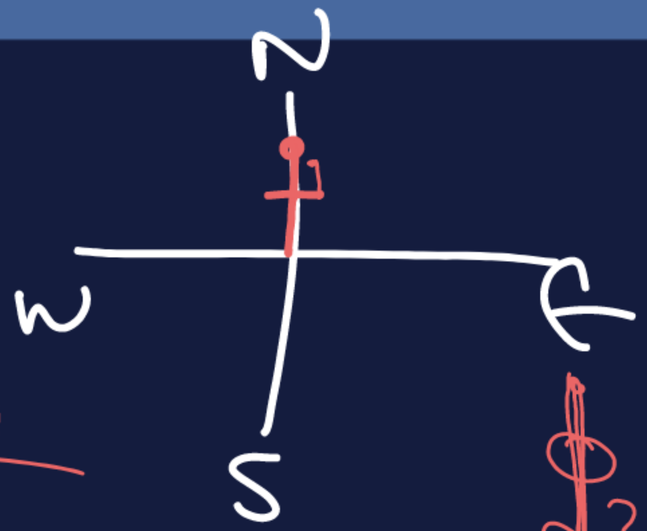


SOLUTION

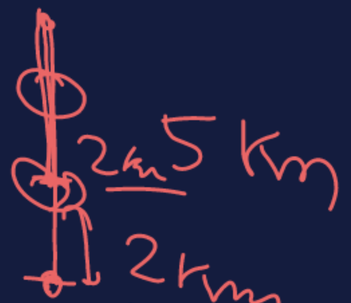
Ques. A person walks 5 km north, then 3 km south, and finally 2 km north.

(i) What is the total distance travelled?

(ii) What is the displacement of the person from the starting point?



= 4 km



10 Km

Ques. A person walks along a circular path of radius 10 m for an angle of 90°. Calculate distance and displacement.

SOLUTION

$\theta = 90^\circ \Rightarrow \pi/2$

$r = 10m$

$l = 10 \times \frac{\pi}{2}$

$s = 2R \sin\left(\frac{\theta}{2}\right)$

$= 2 \times 10 \sin(45^\circ)$

$= 20 \times \frac{1}{\sqrt{2}}$

$= 10\sqrt{2}$

Speed → Scalar

Speed is the rate of change of distance with respect to time.

It tells us how much distance an object covers in a given time interval.

SI Unit = m/s

Formula = $$\text{Speed} = \frac{\text{Distance traveled}}{\text{Time taken}}$$

Velocity

Vector

Velocity is the rate of change of displacement with respect to time.

Unlike speed, velocity considers direction, making it a vector quantity.

SI Unit = m/s

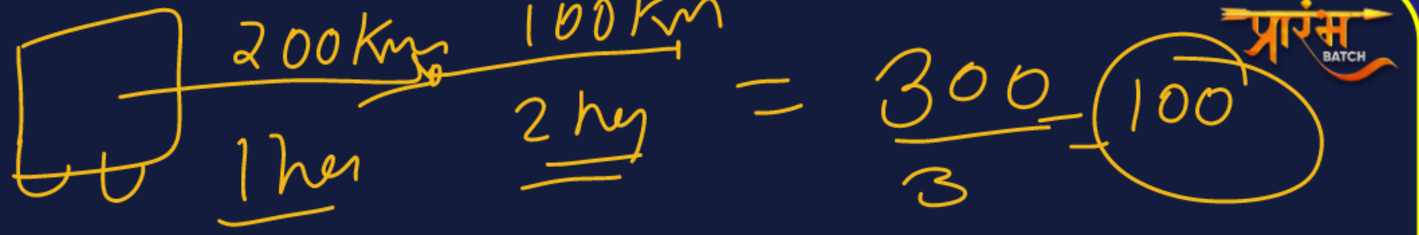
Formula = $\text{Velocity} = \frac{\text{Displacement}}{\text{Time taken}}$

R → Straight line Motion

S = V

distance = displacement

AVERAGE SPEED:

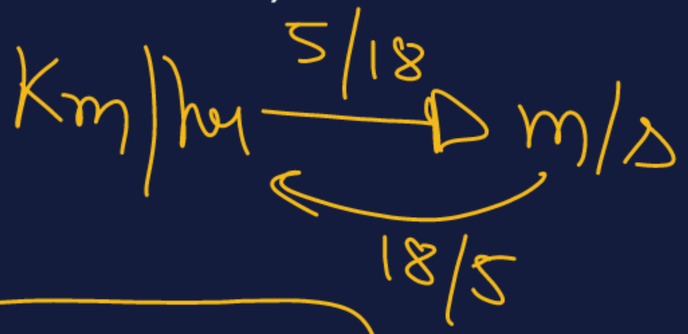


The total distance traveled by an object divided by the total time taken. It gives the rate at which an object covers distance.

Nature: Scalar quantity (only magnitude, no direction).

SI Unit: meters per second (m/s).

Dimensional Formulae: LT^{-1}



$$\text{Avg. Speed} = \frac{\text{Total Distance}}{\text{Total Time Taken}}$$

AVERAGE VELOCITY:

The total displacement of an object divided by the total time taken. It gives the rate at which an object changes its position.

Nature: Vector quantity (has both magnitude and direction).

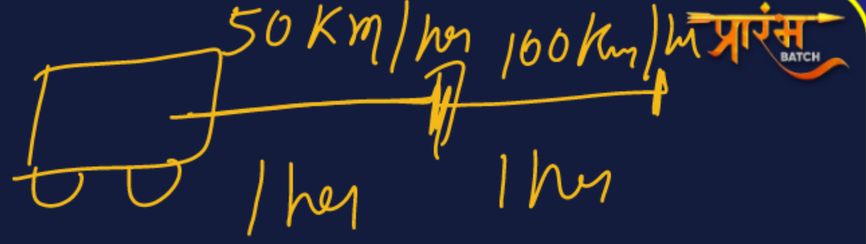
SI Unit: meters per second (m/s).

Dimensional Formulae: LT^{-1}

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

$$\text{Avg. Velocity} = \frac{\text{Total Displacement}}{\text{Total Time Taken}}$$

SPECIAL CASES:

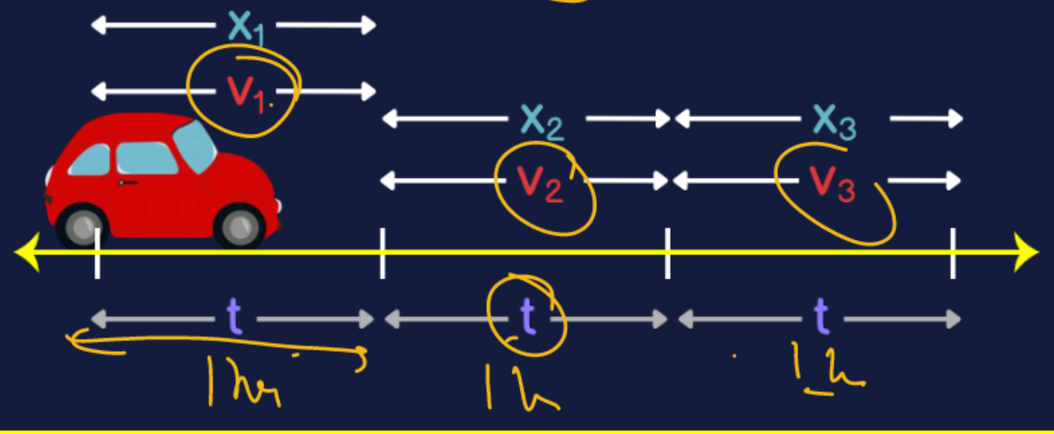


1. Case When Time Intervals Are Equal

If a journey is divided into equal time intervals t, but different speeds are maintained in each segment:

$$V_{avg} = \frac{V_1 + V_2 + V_3 + \ldots + V_n}{n}$$

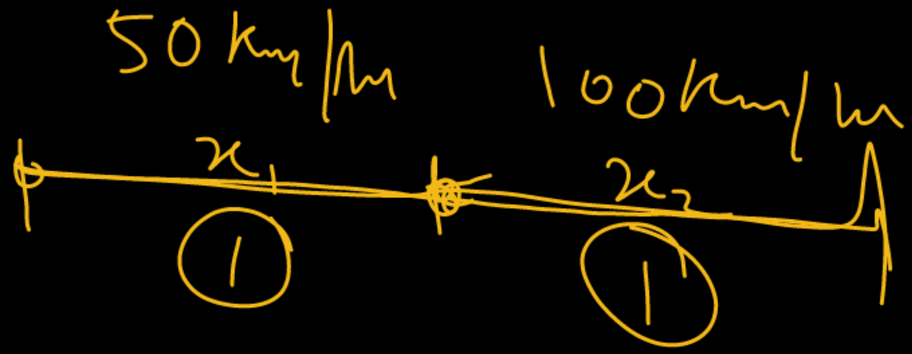
$$\frac{V_1 + V_2 + V_3 \cdots}{3}$$



$$\frac{\text{Total } d}{\text{total } t} = \frac{150}{2} = 75 \text{ Km/hr}$$

$x_1 = 50 \times 1$

$x_1 = 50 \text{ Km}$



$\Rightarrow 2 \text{ hr}$

$x_2 = 100 \times 1$

$= 100 \text{ Km}$

Distance in each segment: $x_i = V_i \cdot t$

Total distance:

$$D = x_1 + x_2 + ... + x_n = t(V_1 + V_2 + ... + V_n)$$

Total time:

$$T = nt$$

So,

$$V_{avg} = \frac{D}{T} = \frac{t(V_1 + V_2 + \ldots + V_n)}{nt} = \frac{V_1 + V_2 + \ldots + V_n}{n}$$

2. Case When Distance Segments Are Equal

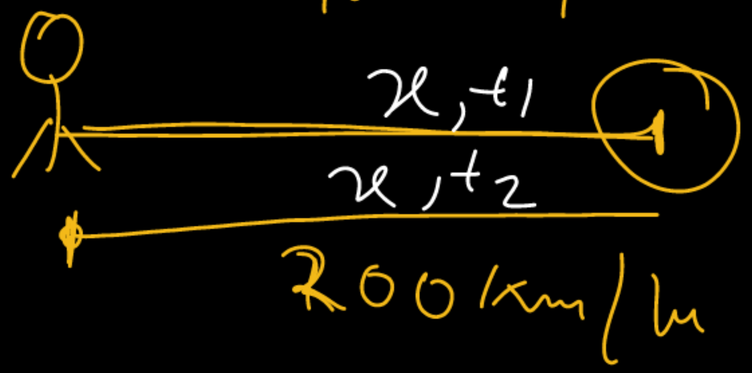
If a journey is divided into equal distance intervals, but at different speeds:

- Let each segment have a distance x
- Speeds: $V_1, V_2, V_3, \ldots, V_n$
- Time taken in each segment: $t_1 = \frac{x}{V_1}, \quad t_2 = \frac{x}{V_2}, \ldots$

So,

$$V_{\text{avg}} = \frac{\text{Total Distance}}{\text{Total Time}} = \frac{n \cdot x}{\frac{x}{V_1} + \frac{x}{V_2} + \cdots + \frac{x}{V_n}} = \frac{n}{\left(\frac{1}{V_1} + \frac{1}{V_2} + \cdots + \frac{1}{V_n}\right)}$$

3rd case



$$avg = \frac{\text{total } d}{\text{total } t} = \frac{2x}{}$$

$$= \frac{2x}{\frac{3x}{200}}$$

$$= \frac{400}{3} = 133.33$$

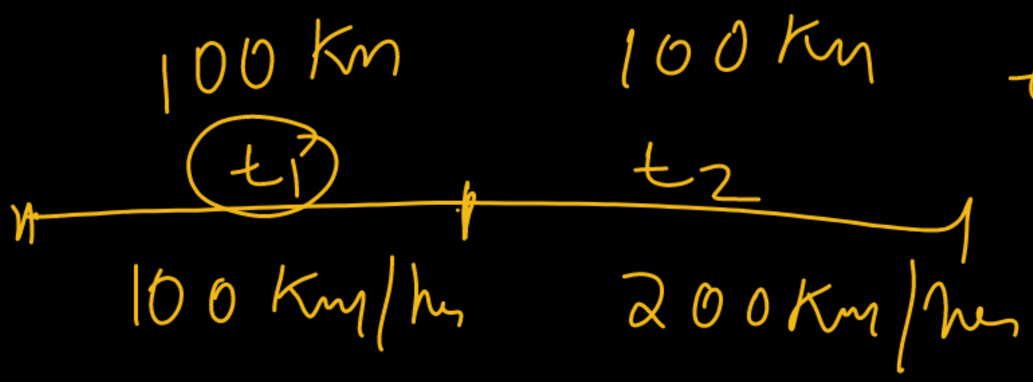
$$t_1 = \frac{x}{100}$$

$$t_2 = \frac{x}{200}$$

$$\rightarrow \frac{x}{100} + \frac{x}{200}$$

$$\boxed{\frac{3x}{200}}$$

$t_1 = \frac{100}{100} = 1 \text{ hr}$



$t_2 = \frac{100}{200} = \frac{1}{2} = 0.5$

$$Avg = \frac{\text{total } d}{\text{total } t} = \frac{200}{1.5} = 133.33$$

Ques. A car moves from point A to point B which is 100 m apart in a straight line. It then returns back from B to a point C which is 40 m away from A (on the same path).

The entire journey takes 20 seconds.

(i) What is the total distance travelled by the car?

(ii) What is the magnitude of displacement?

(iii) What is the average speed and average velocity?

Ques. A car travels 30km at a uniform speed of 40km/h and the next 30km at a uniform speed of 20km/h . Find its average speed

A. 26.7 Km/h

B. 2.67 Km/h

C. 48.7 Km/h

D. 267 Km/h

$$\frac{n}{\frac{1}{v_1}+\frac{1}{v_2}\cdots} = 2$$

SOLUTION

Ques. A car moves a distance of 200 km. it covers the first -half of the distance at speed 40 km/h and the second -half of distance at speed v km/h . the average speed is 48 km/h . Find the value of v [CBSE AIPMT 1991]

A.56 km/h

B. 60 km/h

C. 50 km/h

D. 48 km/h

$$\frac{n}{\frac{1}{v_1}+\frac{1}{v_2}} = \frac{2}{\frac{1}{40}+\frac{1}{v}} = 48$$

Ques. A car moves from X to Y with a uniform speed v_1, and returns to X with a uniform speed v_2. The average speed for this round trip is: [CBSE AIPMT 2007]

A) $2v_dv_u / (v_d + v_u)$

B) $(v_u\ v_d) / 2$

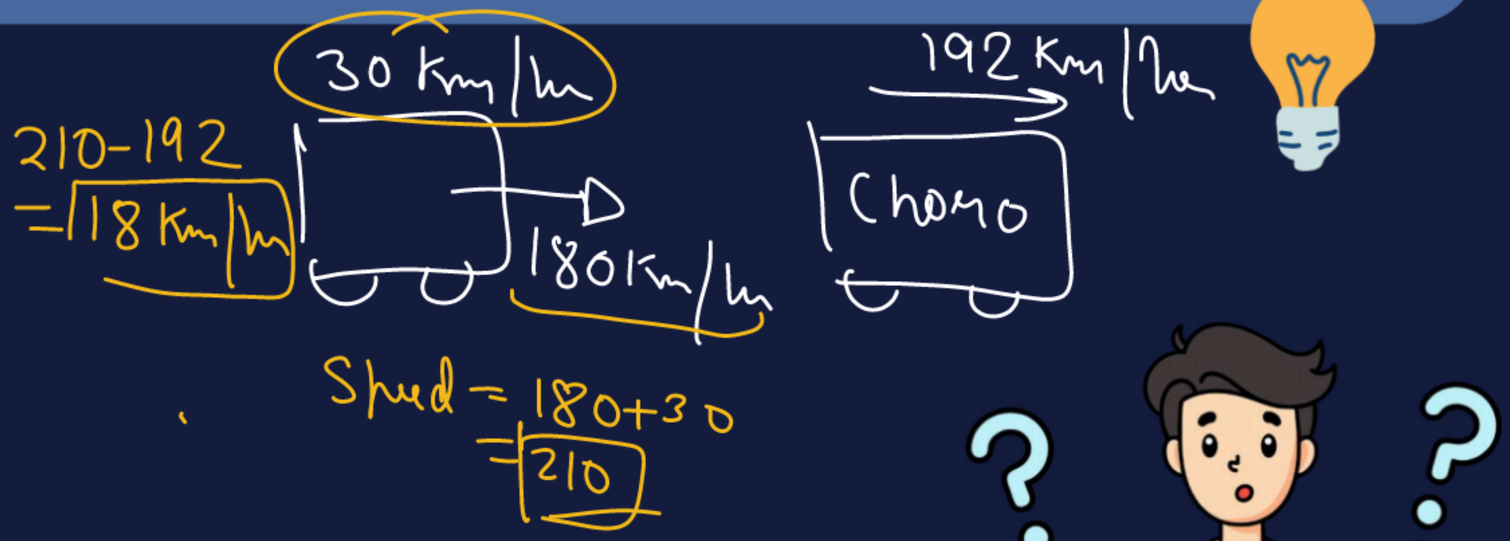
C) $\sqrt{(v_uv_d)}$

D) $(v_d + v_u) / 2$

SOLUTION

Reference Point

Ques. A police van moving on a highway with a speed of 30 km h^{-1} fires a bullet at a thief's car speeding away in the same direction with a speed of 192 km h^{-1}. If the muzzle speed of the bullet is 180 KM h^{-1}, with what speed does the bullet hit the thief's car ? (Note: Obtain that speed which is relevant for damaging the thief's car). [NCERT]



SOLUTION

Next Class se Hoga Level Up..