Mission LAKSHYA

Class 9th

MOTION

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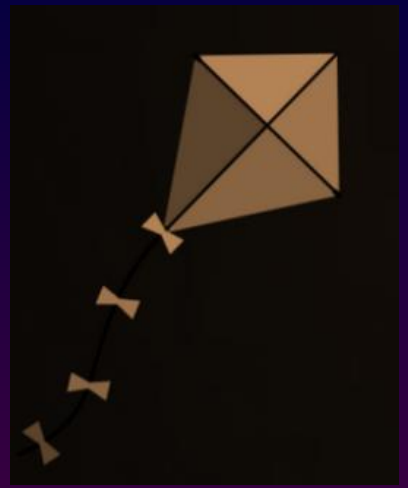
Topics To Be Covered

- Motion
- Distance and Displacement
- Speed and Velocity
- Uniform and Non-Uniform Motion

Motion

An object is said to be in **motion** if its position changes with time concerning a fixed point (called the **reference point** or **origin**).

E.g movement if of dust , leaves ,and branches



Rest

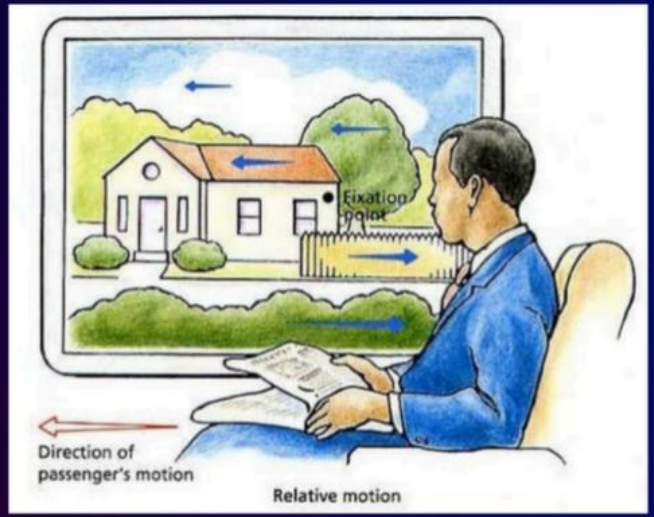
A body is said to be in state of rest when its position does not change with the time.

E.g. – Sleeping , sitting , standing , lying

Motion is Relative

A body can be moving for one observer, and at the same time at rest for another observer.

Example: For example, a person sitting in an airplane is at zero velocity relative to the airplane, but is moving at the same velocity as the airplane with respect to the ground.



Physical Quantity

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- A physical quantity is a property of a material or system that can be measured and quantified.
- For example: mass, represented by the symbol m, can be quantified as m = n kg, where ***n is the numerical value which is called magnitude*** and kg is the unit ***symbol***.

Scalar Quantity	Vector Quantity
It is the physical quantity having own magnitude but no direction.	It is the physical quantity that requires both magnitude and direction
Example: distance, speed.	Example: displacement, velocity.

Distance and Displacement

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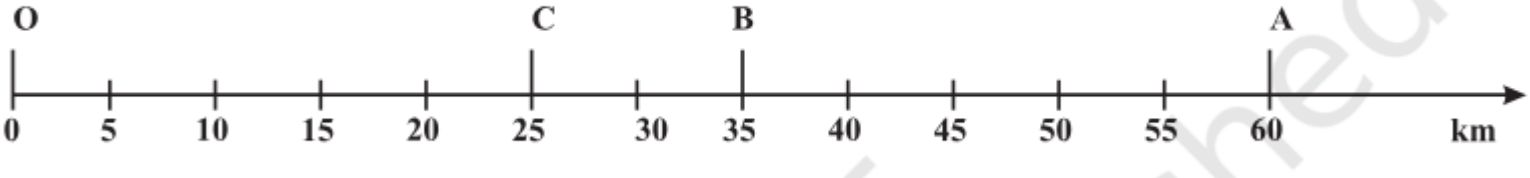
Shortest Path

Actual Path

Distance And Displacement

DISTANCE	DISPLACEMENT
Total path length covered by an object.	The shortest path covered by an object
Scalar quantity (only magnitude).	Vector quantity (magnitude + direction).
Always positive.	Can be positive, negative, or zero.

Q. Consider the motion of an object moving along a straight path. The object starts its journey from point O, which is treated as its reference point. Let A, B, and C represent the positions of the object at different instants. Initially, the object moves through points C and B, and then reaches point A. It then moves back along the same path and reaches point C through B.
What are the distance and displacement in this journey?



Question: An object moves along a circular path of radius r . What will be the **distance** and the magnitude of **displacement** of the object when it completes half a revolution?

A) Distance: $2\pi r$, Displacement:0

B) Distance: πr, Displacement: $2r$

C) Distance: $2r$, Displacement: πr

D) Distance: πr, Displacement: r

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Q. Can an object have zero displacement if it has moved a certain distance?

Speed

Speed is the rate of change of position of an object in any direction

$$v = \frac{s}{t}$$

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

SI unit of speed is meters per second (m/s)
Commercial unit : km/hr

The **Average Speed** of an object is defined as the **total distance** traveled divided by the **total time taken** to cover that distance.

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

Velocity

Velocity is the rate of change of an object's **displacement** with respect to time. Because it includes direction, it is a **vector quantity**.

$$Velocity = \frac{Displacement}{Time}$$

SI unit is meter per second (m/s)
Commercial unit : km/hr

Average velocity is defined as the **total displacement** of an object divided by the **total time taken**.

$$Average\ Velocity = \frac{Initial\ Velocity\ (u) + Final\ Velocity\ (v)}{2}$$

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Speed and Velocity

Speed	Velocity
It is the distance traveled by an object per unit of time. It is a **Scalar** quantity (it only has magnitude/value). Speed of a moving object can **never be zero**. $Speed = \frac{Distance}{Time}$	It is the displacement of an object per unit of time in a specific direction. It is a **Vector** quantity (it has both magnitude and direction). Velocity of a moving object **can be zero** if it returns to its starting point. $Velocity = \frac{Displacement}{Time}$

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Q. A car travels 100 meters towards the East in 10 seconds, then turns back and travels 40 meters towards the West in 4 seconds. Calculate:

Part 1: The **Average Speed** of the car for the entire journey.

Part 2: The **Average Velocity** of the car for the entire journey.

Acceleration

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Acceleration is seen in non-uniform motion and it can be defined as the rate of change of velocity with time.

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

It is a vector quantity.
SI Unit: m/s^2

If velocity changes from u to v in time t:

$$Acceleration = \frac{\text{Final Velocity} - \text{Initial Velocity}}{\text{Time Taken}}$$

- **Positive acceleration:** Direction of velocity.
- **Negative acceleration:** Opposite to direction of velocity.

Retardation

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Retardation is seen in non-uniform motion during decrease in velocity with time. It has same definition as acceleration. It is also called deacceleration.

Here v<u, **change in velocity or acceleration is negative.**

For Example: Plane Landing

Uniform and Non – Uniform Motion

Uniform Motion	Non Uniform Motion
An object covers **equal distances** in **equal intervals** of time.	An object covers **unequal distances** in **equal intervals** of time.
The velocity of the object remains **constant** throughout the motion	The velocity of the object **changes** (it is not constant).
The acceleration is always **zero** ($a = 0$).	The acceleration is **non-zero** (the object is accelerating or decelerating).
The Distance-Time graph is a **straight line** passing through the origin.	The Distance-Time graph is a **curved line**.

Q. A bus starting from rest moves with a uniform acceleration of $0.1 m/^2$ for 2 minutes. Find:

(a) The speed acquired

(b) The distance travelled

Uniform vs Non Uniform Acceleration

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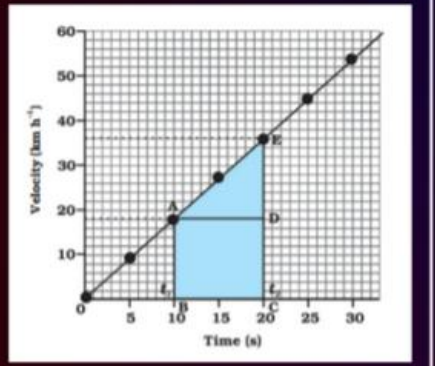
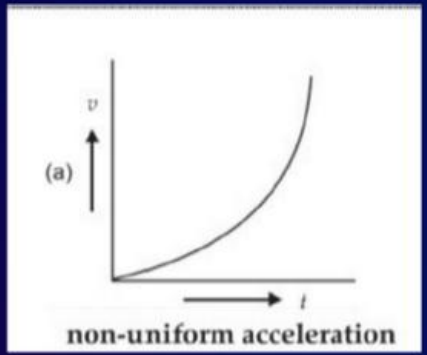
Parameters	Uniform Acceleration	Non-uniform Acceleration
Meaning	Equal amount of velocity increases in equal intervals of time.	Velocity changes by unequal amounts in equal intervals of time.
Velocity-time graph	Straight line 	Curved line  non-uniform acceleration
Example	A free-fall object	Circular motion types where speed is constant and direction changes at every point.

Graphical Representation of Motions

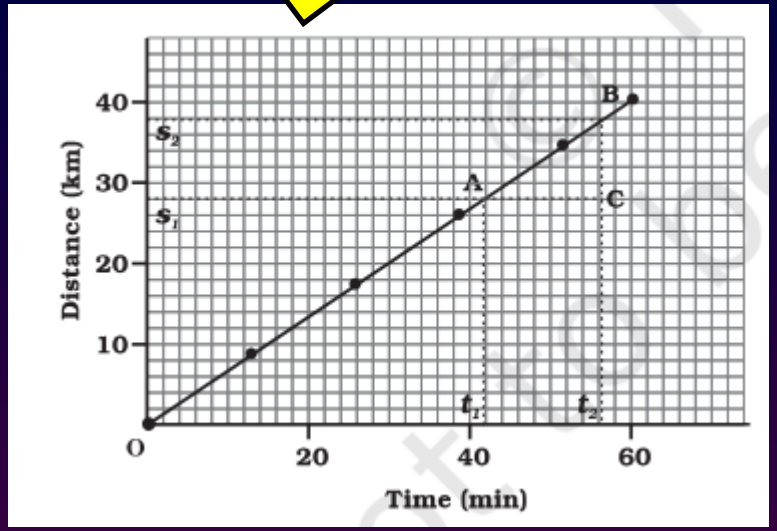
Distance-Time Graph

For a distance-time graph, **time** is taken on the **x-axis** and **distance** is taken on the **y-axis**.

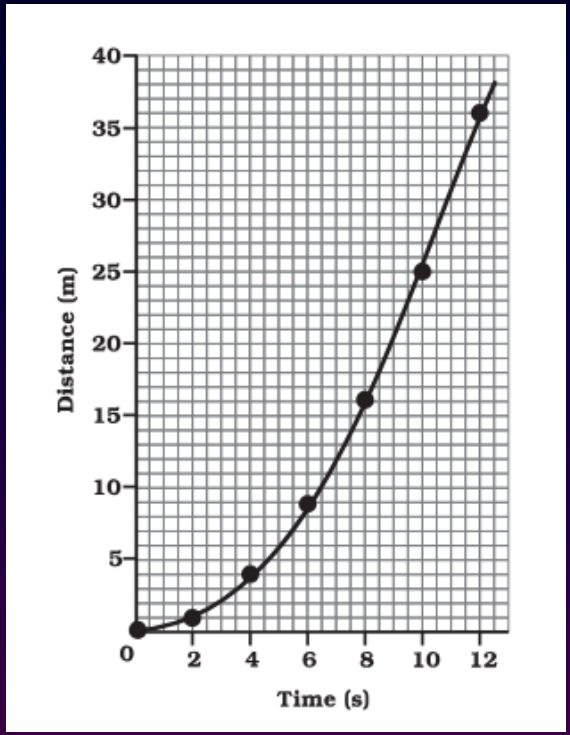
All **independent quantities** are taken along the **x-axis** and **dependent quantities** are taken along the **y-axis**.

An object moving with unifrom speed

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

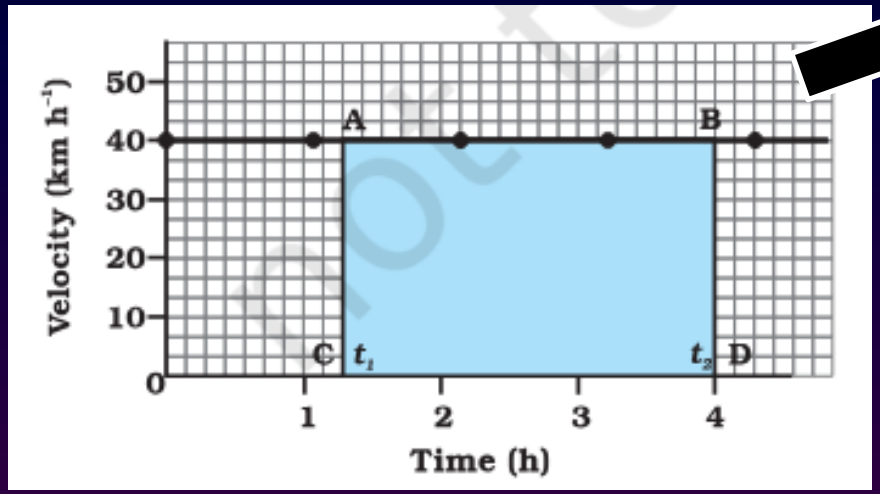


A car moving with non – uniform speed :



Graphical Representation of Motions

Velocity Time Graph For Uniform Motion Of Car



So, the distance s moved by the car in time (t2 – t1) can be expressed as

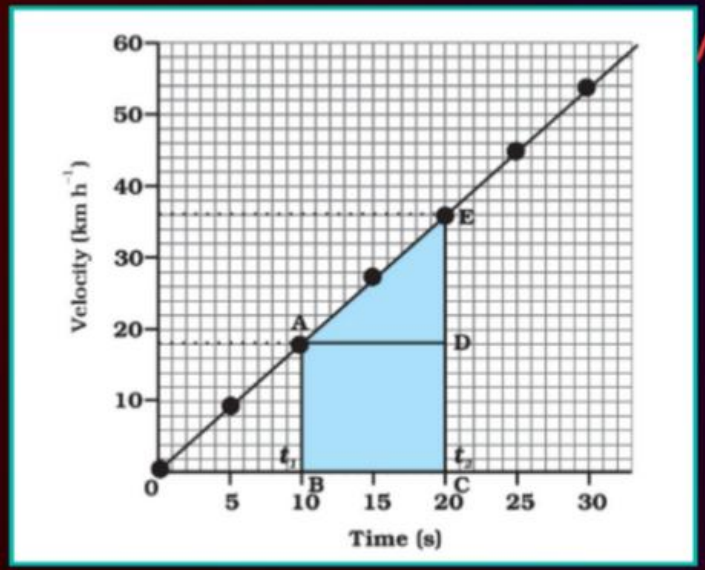
s = AC × CD

= [(40 km h–1) × (t2 – t1) h]

= 40 (t2– t1) km

= area of the rectangle ABDC (shaded in Fig.)

Velocity-Time Graph for a car moving with uniform accelerations



s = area ABCDE
= area of the rectangle ABCD + area of the triangle ADE
= AB × BC + 1/2 (AD × DE)

Graphical Representation of Motions

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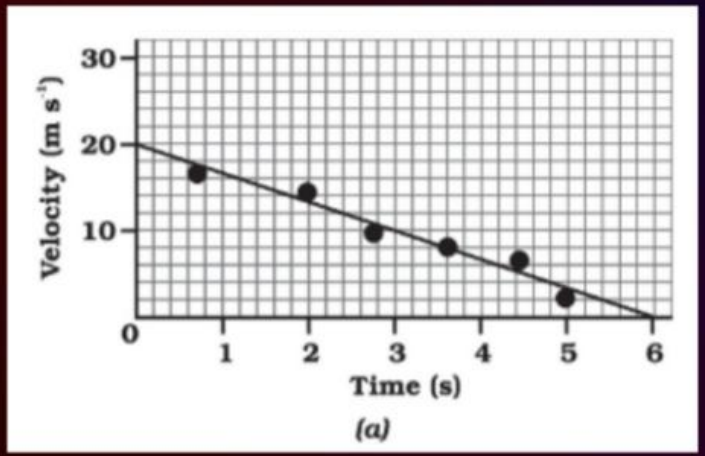
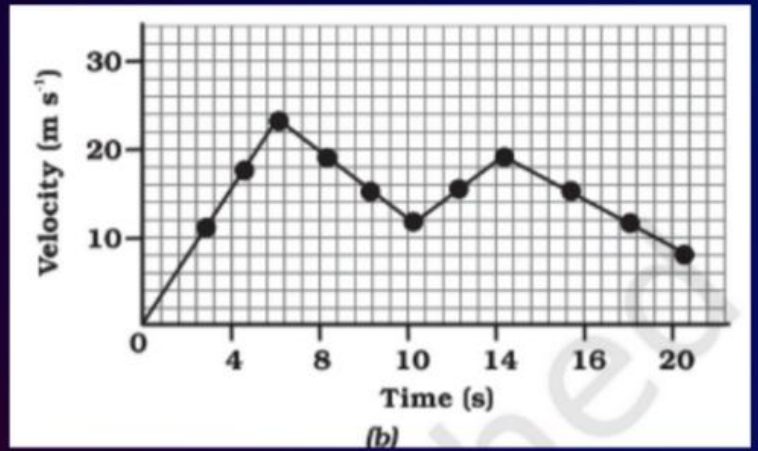
Velocity-Time Graphs of an object in non-uniformly accelerated motion:





Practice Question: Distance-Time Graph

Q. Study the distance-time graph of a car moving along a straight road and answer the following questions:

1. **Part A:** What type of motion is represented by the graph?
2. **Part B:** Find the **speed** of the car between $t_1 = 1\ h$ and $t_2 = 3\ h$ if the distances are $s_1 = 20\ km$ and $s_2 = 60\ km$ respectively.
3. **Part C:** What is the distance covered by the car in 4 hours?

Equations Of Motion

Equation for velocity – time relation

$$v = u + at$$

Second Equation of Motion

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

Third Equation of Motion

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

Terminology

u: Initial velocity

v: Final velocity

a: Acceleration

t: Time

s: Displacement

Free Fall (motion under gravity)

Free fall motion under gravity is when an object moves only under the influence of gravity, without any other external forces acting upon it. This motion is accelerated, and is known as acceleration due to gravity.

Question:

A car starts from **rest** ($u = 0$) and accelerates uniformly at a rate of $3\ m/s^2$ for **4 seconds**.

What will be the **final velocity (v)** of the car?

Uniform Circular Motion

- The motion of an object along a circular path covering equal distance along the circumference in the same interval of time is known as uniform circular motion.

Examples:

- Motion of Moon
- Motion of Earth
- A cyclist on circular track

Velocity v for a circular path with radius r and time t:

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

In any uniform circular motion, the speed remains constant, but the direction of the velocity changes.

Question:

A cyclist is moving on a circular track of radius $70\ m$. If he completes one full round in $44\ seconds$, what is his **speed (v)**?

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Top 5 Questions

Which of the following statements is correct?

a) Both speed and velocity are same

b) Speed is a scalar and velocity is a vector

c) Speed is a vector and velocity is scalar

d) None of these

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Top 5 Questions

An object travels from point A to point B and then comes back to point A. What is the total displacement of the object?

A) $2 \times AB$

B) AB

C) Zero

D) Half of AB

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Top 5 Questions

What does the 'area' under a Velocity-Time ($v - t$) graph represent?

A) Acceleration

B) Displacement

C) Average Speed

D) Final Velocity

Top 5 Questions

A car is moving at a speed of 54 km/h. What is its speed in meters per second (m/s)?

A) 10 m/s
B) 15 m/s
C) 20 m/s
D) 25 m/s

Top 5 Questions

Which of the following defines "Retardation" correctly?

A) Increase in velocity per unit time

B) Constant velocity over time

C) Decrease in velocity per unit time (Negative Acceleration)

D) Motion in a circular path

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"LIFE'S VELOCITY WILL ALWAYS CHANGE, JUST MAKE SURE YOU ARE IN THE RIGHT DIRECTION!"

- Motion