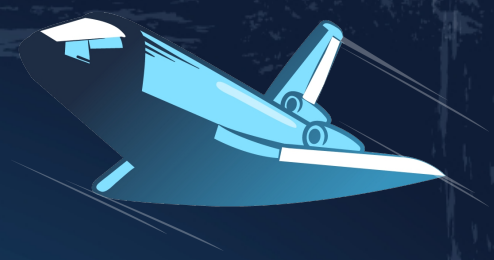
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Motion & Time

→ The study of motion is called 'Mechanics'.

- Mechanics
  - Kinematics
  - Dynamics

Types of Motion

01 Translational

02 Rotational

03 Circular

04 Periodic

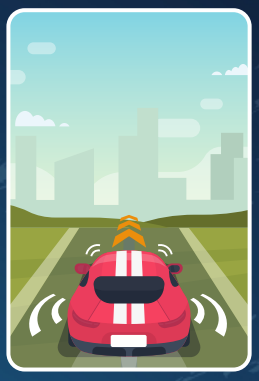
05 Oscillatory

- Translational Motion
  - Rectilinear Motion
  - Curvilinear Motion

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Translatory Motion



→ Motion of a body in which all the points in the body follow parallel paths is called translational motion.

→ It is a motion in which the orientation of an object remains the same throughout the journey.

(i) Rectilinear (ii) Curvilinear

Circular Motion



→ When an object moves along a circular path, this type of curvilinear motion is called circular motion.

Rotational Motion

→ Motion of a body turning about an axis is called rotational motion.

→ The path of an object in a rotational motion is always circular (or curved).





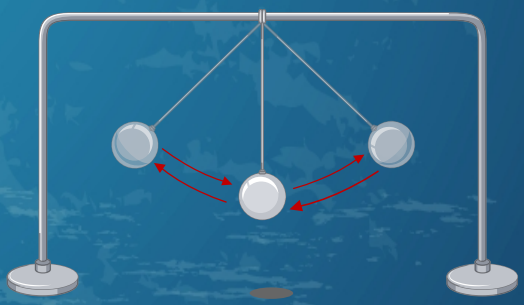
Rolling Motion

→ Motion of a wheels is a combination of translational and rotational motion.

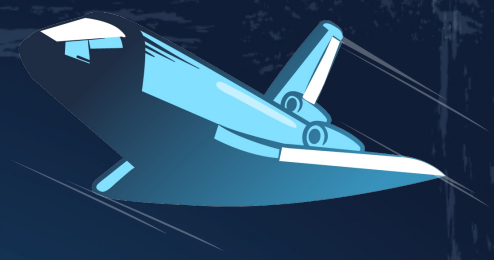
→ Motion of a wheel is also called rolling motion.

Oscillatory Motion

→ A motion that occurs when an object moves to and fro about its mean position over equal periods of time is called an oscillatory motion or vibratory motion.



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Distance and Displacement

Distance

→ The length of the actual path between initial and final positions of a moving object is called distance.

Unit of Distance

→ SI unit of distance is meter(m).

Other popular units are :

Millimeter (mm)

Centimeter (cm)

Kilometer (km)

→ Odometer is a device which is used to measure distance travelled by a vehicle.

Important point related to distance

→ Distance is a scalar quantity.

→ Distance depends on the path followed.

→ Distance is always taken positive.

Displacement

→ Shortest distance between the initial position and the final position of the particle is called displacement.

→ It is the change in the position of the particle.

Displacement = $x_f - x_i$

Where, x_f = final position, x_i = initial position

Unit of displacement

→ SI unit of displacement is meter(m).
C.G.S. Unit – Centimeter(cm)

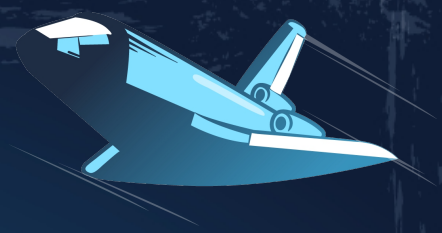
Important point related to displacement

→ It is vector quantity.

→ Depends upon initial and final position only.

→ It can be positive, negative and zero.

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Speed and Velocity

→ The distance travelled by a particle per unit time is called speed.

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

→ SI unit of speed is meter/second (m/s). CGS unit- centimeter/second (cm/s).



Important points related to speed

→ Speed is a scalar quantity.

→ Speed depends on the path.

→ Speed gives no idea about the direction of motion of the object.

→ Speed can never be negative. In motion, it is taken positive ; at rest, it is zero.

Relation between km/h and m/s

→ Speed is a scalar quantity.

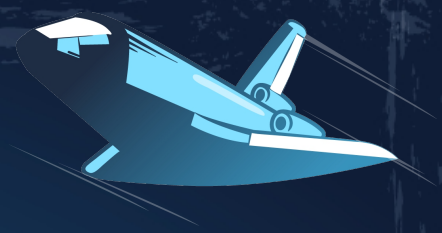
→ Speed depends on the path.

→ Speed gives no idea about the direction of motion of the object.

→ Speed can never be negative. In motion, it is taken positive ; at rest, it is zero.

$$\text{Now, } \frac{1\text{ km}}{\text{h}} = 1 \times \frac{1000\text{ m}}{60 \times 60\text{ s}} = 1 \times \frac{10\text{ m}}{36\text{ s}} = \frac{5}{18}\text{ m/s} \quad \text{or} \quad 1\text{ km/h} = \frac{5}{18}\text{ m/s}$$

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Uniform Speed

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

Non-Uniform Speed

→ An object is said to be moving with a variable speed, if it covers unequal distances in equal intervals of time. That is, magnitude of speed is variable.

Average Speed

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

$$\text{Average Speed} = \frac{\text{Total Distance Travelled}}{\text{Total Time Taken}}$$

Instantaneous Speed

→ The speed of the body at any instant of time. In uniform motion of a particle, the instantaneous speed is equal to its average speed.





Velocity

The rate of change of displacement is called velocity.

- S.I. unit of velocity is metre/second (m/s).
- C.G.S. unit is centimeter/second (cm/s).

Important points related to velocity

- It is a vector quantity.
- It can be negative, positive and zero.
- It does not depend on the path.
- It depends only on the initial and final position of the object.
- It gives the direction of motion of an object.

Uniform Velocity

- A particle is said to have uniform velocity, if the magnitude as well the direction of its velocity remains constant.
- It is possible only when the particle moves in straight line without changing its direction.

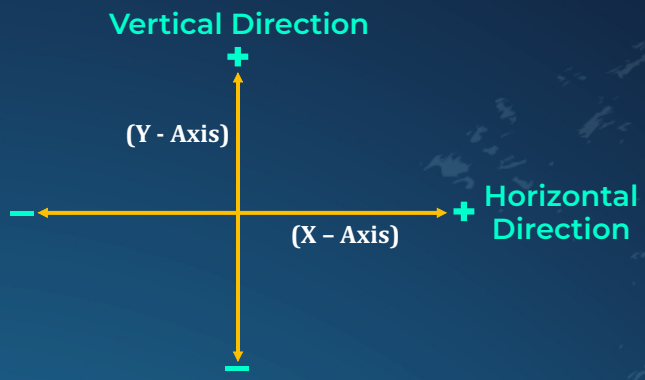
Non-Uniform Velocity

- A particle is said to have non-uniform velocity, if either the magnitude or direction of its velocity changes (or both changes).

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Sign Conventions for Velocity



Instantaneous Velocity

It is the velocity at some particular instant of time.It is the velocity at some particular instant of time.

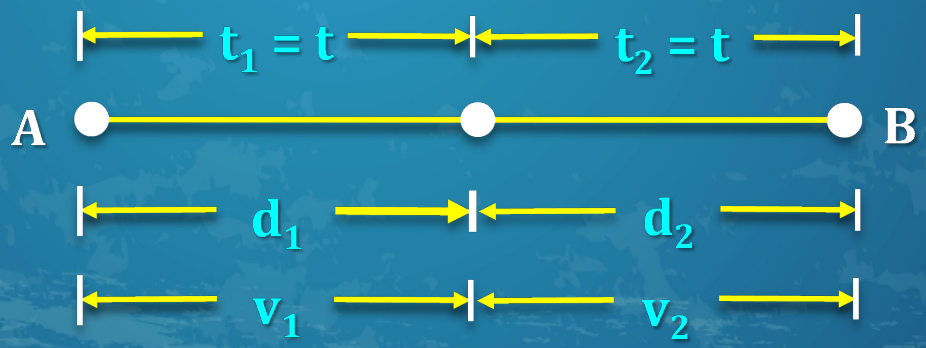
Average Velocity

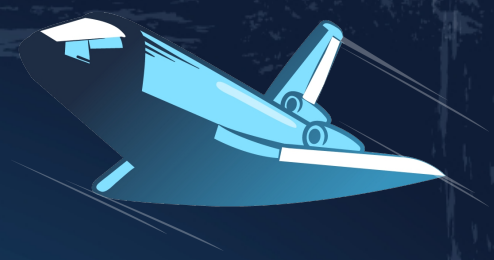
It is the ratio of total displacement to the total time taken.

$$\text{Average Velocity} = \frac{\text{Total Distance Travelled}}{\text{Total Time Taken}}$$

Case of half time

If the two given time interval are same i.e., $t_1 = t_2 = t$



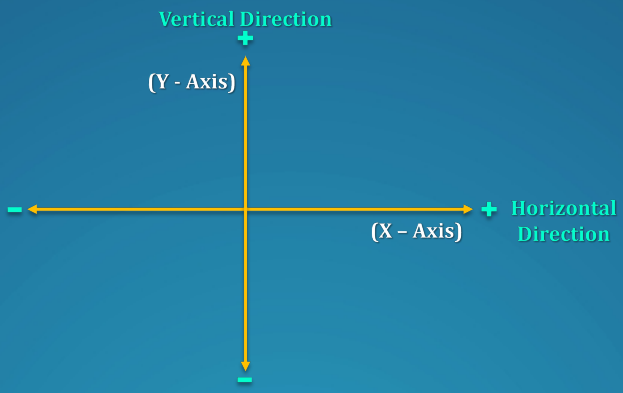


$$v_{avg} = \frac{d_1 d2}{t_1 t2} = \frac{v_1 t + v2t}{t + t}$$

$$= \frac{(v_1 + v2)t}{2t} = \frac{v_1 + v2}{2}$$

Sign Conventions for Velocity

→ It is the velocity at some particular instant of time.It is the velocity at some particular instant of time.



Uniform Motion

→ If a body covers equal distances in equal interval of time in a particular direction, its motion is called uniform motion.

→ A uniform motion always takes place in a straight line.

Non-uniform Motion

→ If a body covers unequal distances in equal intervals of time, its motion is called “non-uniform motion”.

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ACCELERATION

→ The rate of change of velocity is called acceleration.

→ It is a vector quantity.

A change in velocity occurs when

- Only its direction changes. Ex. Uniform circular motion.
- Only its magnitude changes. Ex. A ball dropped from certain height under gravity.
- Both magnitude as well as direction change. Ex. A projectile motion.

→ In all the cases, there must be some acceleration present in the motion.

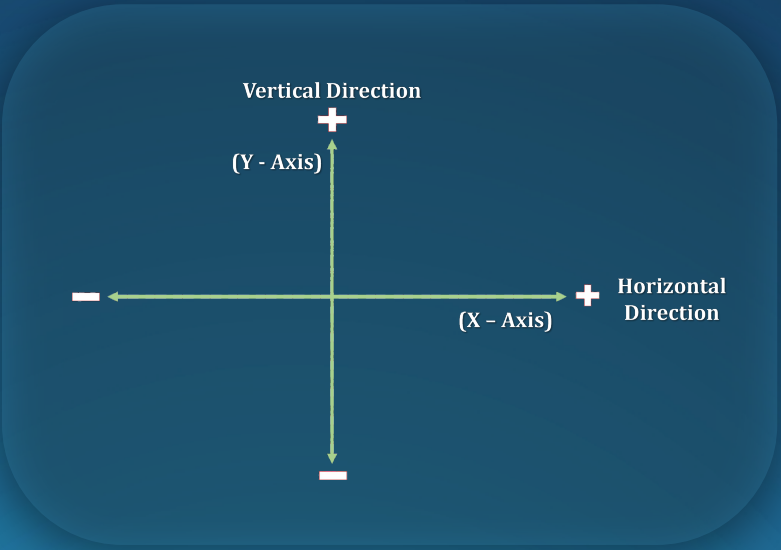
Accelerated motion

→ Whenever velocity and acceleration are in same direction, the velocity of particle increases.

Retarded motion

→ Whenever velocity and acceleration are in opposite direction, the velocity of a particle decreases.

Sign Conventions for Velocity



Formula for acceleration

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{time taken}} = \frac{v-u}{t}$$

Unit

S.I Unit : metre per second square (m/s2).

CGS Unit : centimetre per second square (cm/s2)

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Measurement of Time

- Our ancestors notice that many events in nature repeat themselves after definite intervals of time.
- For eg, they found that sun rises everyday in the morning. The time between one sunrise and the next was called a day.
- A month was measured from one new moon to the next.



- A year was fixed as the time taken by the earth to complete one revolution of the sun.



History of measuring time

- Starting in 1400 BC, ancient Egyptians and Greeks used water clocks to tell time during the day and the night.
- In 1582, Galileo Galilei found that a swinging weight always took the same time to go backward and forward.



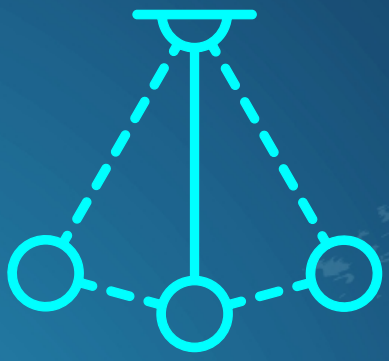


→ This swinging weight named as pendulum.

→ In 1657, Christian Huygens invented a clock that used the pendulum to keep time.

Simple Pendulum

Time Period : The time taken by the pendulumto complete one oscillation is called its time period.



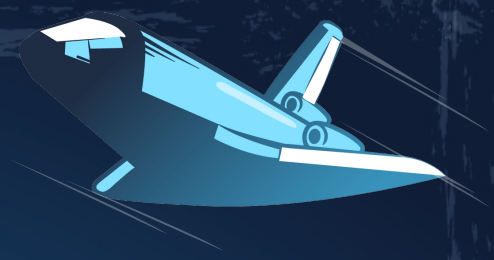
$$\text{Time period} = \frac{\text{Total time taken}}{\text{Number of oscillations}}$$

Unit of time

The SI unit of time is second (s).
Some commonly used unit of time are minute and hour.

1 minute = 60 s 1 hour = 60 minutes 1 hour = 3600 sec

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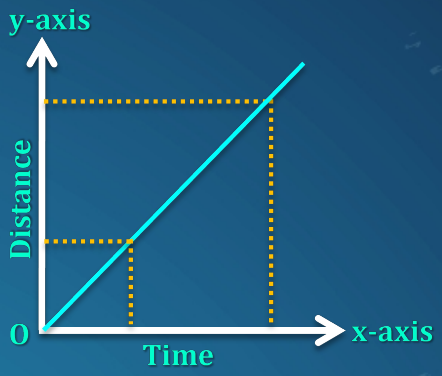


Graphical Representation of Motion

When the body is in uniform motion

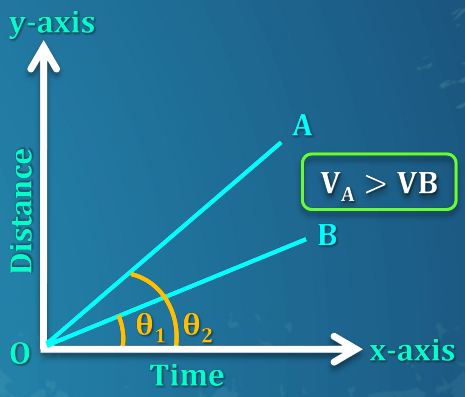
→ The distance-time graph of a body in uniform motion is a straight line, inclined to x-axis

$$\text{Slope} = \frac{\text{measure on y–axis}}{\text{measure on x–axis}}$$



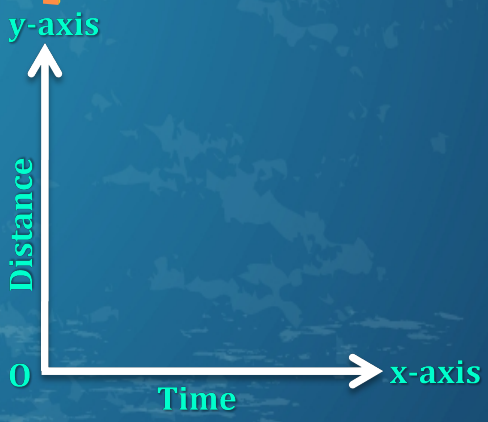
When the body is in uniform motion

→ In a distance-time graph, more the slope of the graph of an object in motion, more will be its speed and vice-versa.



Distance/displacement–time graph

→ This graph is plotted between the time taken and the distance covered, The time is taken along the x-axis and the distance covered is taken along the y-axis.

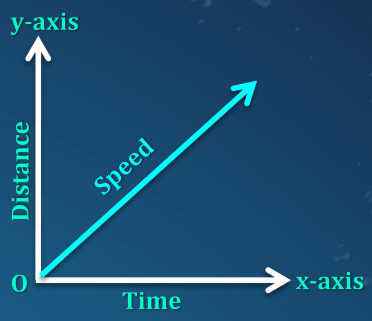


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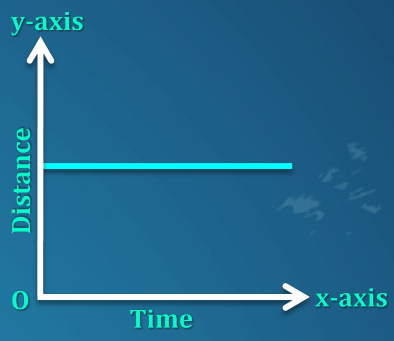
Distance/displacement–time graph

→ The slope of the distance-time graph gives the speed of the body.



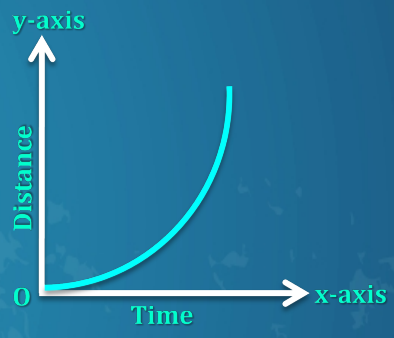
When the body is at rest

→ The distance-time graph of such a body is a straight line parallel to x-axis.



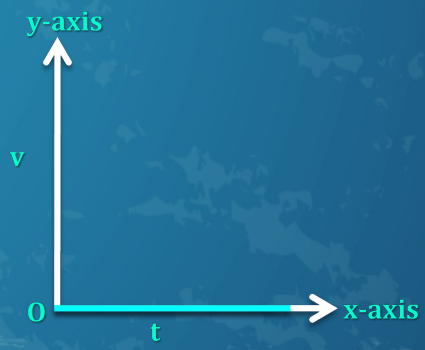
Distance-time graph

→ A body in uniformly accelerated motion.



Speed-time graph

→ A body at rest (v = 0)

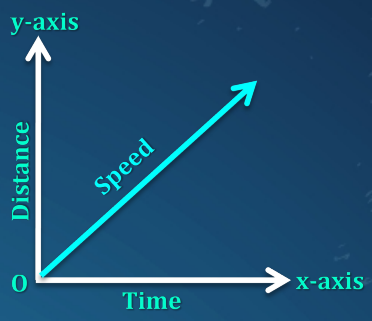


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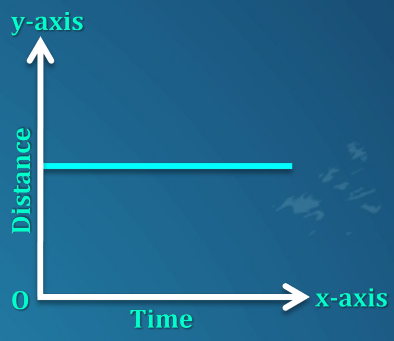
Distance/displacement–time graph

→ The slope of the distance-time graph gives the speed of the body.



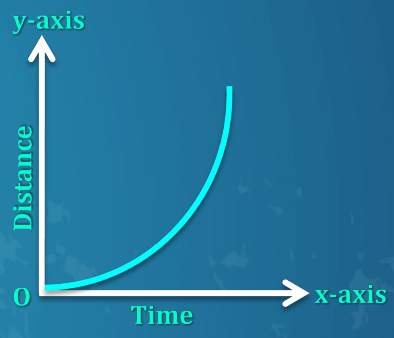
When the body is at rest

→ The distance-time graph of such a body is a straight line parallel to x-axis.



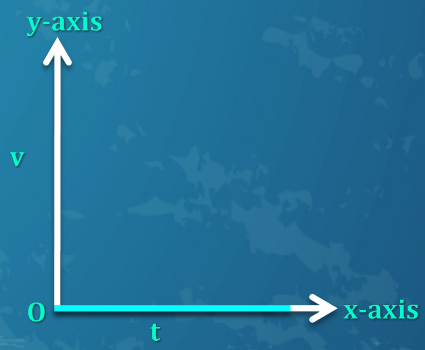
Distance-time graph

→ A body in uniformly accelerated motion.

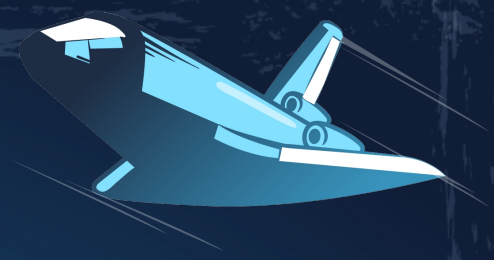


Speed-time graph

→ A body at rest (v = 0)

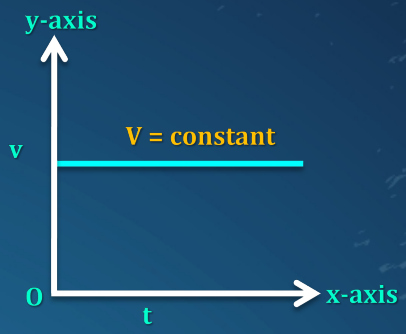


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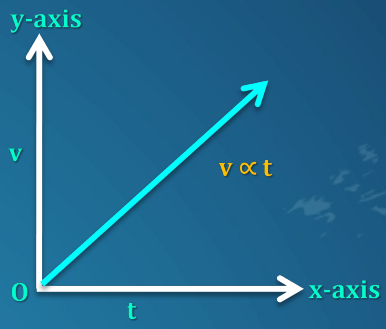
Speed-time graph

→ A body in uniform motion (v = constant)



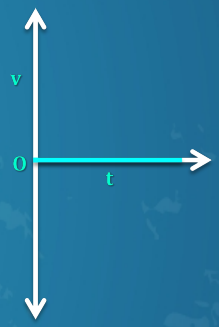
Speed-time graph

→ A body in uniformly accelerated motion (v = u + at)



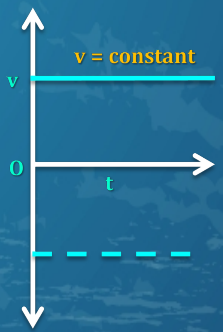
Velocity -time graph

→ A body at rest (v = 0)

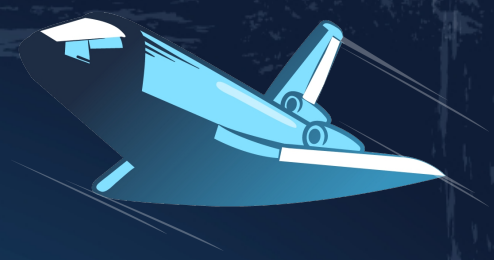


Velocity -time graph

→ A body in uniform motion (v = constant)

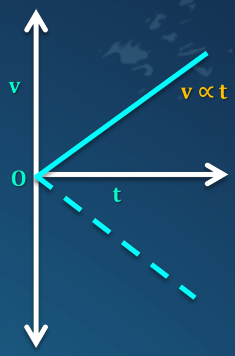


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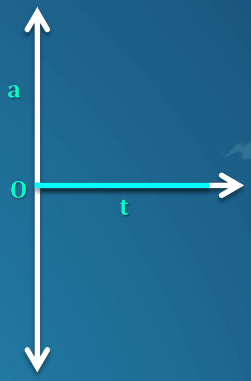
Velocity -time graph

→ A body in uniformly accelerated motion (v = u + at)



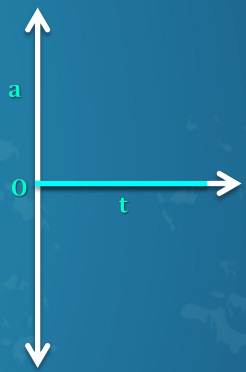
Acceleration -time graph

→ A body at rest (a = 0)



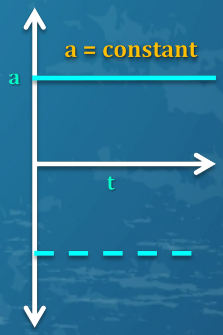
Acceleration -time graph

→ A body in uniform motion (a = 0)



Acceleration -time graph

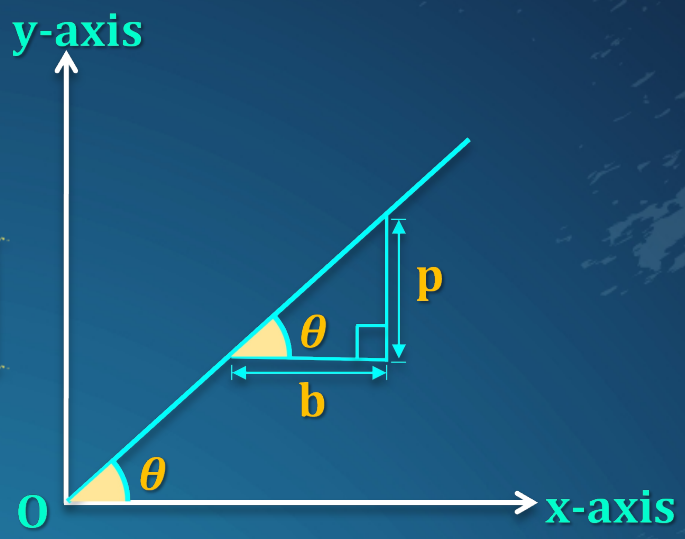
→ A body in uniformly accelerated motion (a = constant)

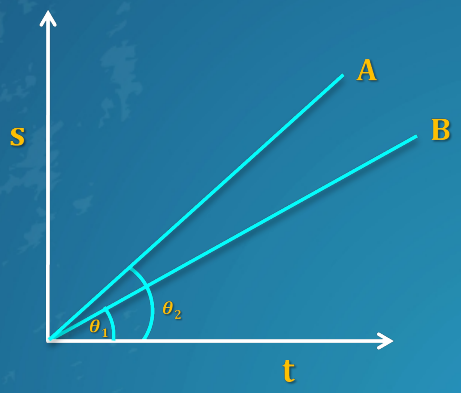


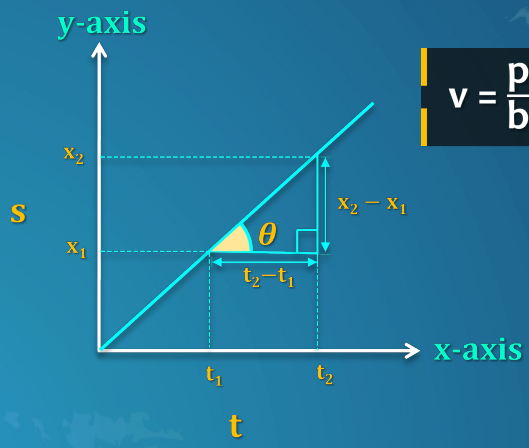
Significance of graph in motion

→ More the value of , more will be the value of slope.

$$\text{Slope} = \frac{\text{measure on y-axis}}{\text{measure on x-axis}}$$

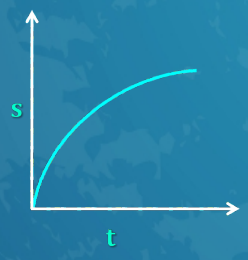




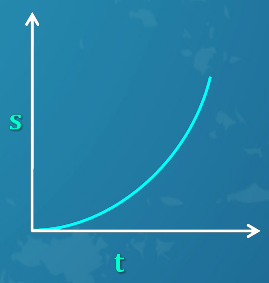


$$v = \frac{p}{b} = \frac{x_2 - x_1}{t_2 - t_1}$$

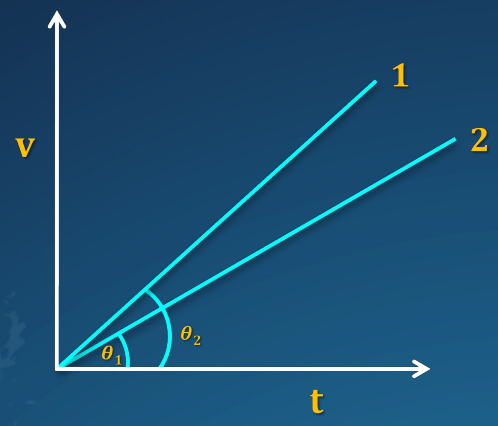
Slope of speed – time graph or velocity graph gives acceleration .

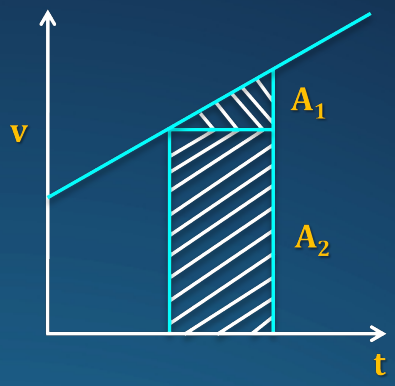


Graph –2
(v decreasing with time)
retarded motion

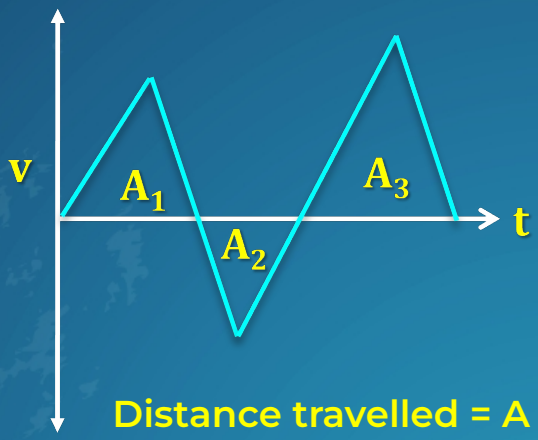


Graph –1
(v increasing with time)
accelerated motion





Distance travelled = $A_1 + A_2$



Distance travelled = A 1 + A 2 + A3

Displacement = A 1 - A 2 + A3