MOTION AND TIME

CONTENTS

UNIT

Measurement of any physical quantity is expressed in terms of an internationally accepted certain basic standard called unit.

Length, time & mass are measured in metre, sec, and kilogram

PHYSICAL QUANTITIES

The quantities which can be measured by an instrument and by means of which we can describe the laws of physics are called physical quantities.

Eg. length, velocity, acceleration, force, time, pressure, mass, density etc.

REST & MOTION

An object is said to be at **rest** if it does not change its position with respect to its surrounding with the passage of time.

A body is said to be in **motion** if its position changes continuously with respect to the surroundings (or with respect to an observer) with the passage of time.

TYPES OF MOTION

(a) Linear motion : The motion of a moving car, a person running, a stone being dropped.

(b) Rotational motion : The motion of an electric fan, motion of earth about its own axis.

(c) Oscillatory motion (to and fro motion) : The motion of a simple pendulum, a body suspended from a spring etc are the examples of oscillatory motion.

UNIFORM & NON UNIFORM MOTION

(a) Uniform Motion :

A body has a uniform motion if it travels equal distances in equal intervals of time, no matter how small these time intervals may be.

For example, a car running at a constant speed of say, 10 m/s, will cover equal distances of 10 metres, in every second, so its motion will be uniform.

(b) Non-Uniform motion :

A body has a non-uniform motion if it travels unequal distance in equal intervals of time.

For example, if we drop a ball from the roof of a building, we will find that it covers unequal distances in equal intervals of time.

It covers :

4.9 meters in the 1^{st} second

14.7 metres in the 2^{nd} second

24.5 metres in the 3^{rd} second and so on.

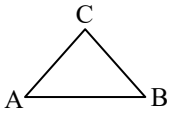
TERMS USED TO DEFINE MOTION

(a) DISTANCE & DISPLACEMENT :

(i) Distance : Distance is the actual path travelled by a body in a given time.

Consider a body travelling from A to B along any path between A and B. The actual length of the path that a body travels between A and B is known as the distance. Here if the body goes from A to B via C, the distance travel will be ACB.

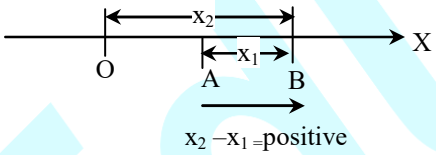
The distance travelled will be different for different paths between A and B. It is a scalar quantity.



(ii) Displacement : The distance travelled in a given direction is the displacement. Thus displacement is the shortest distance between the given points.

S.I. unit of distance and displacement is metre.

Ex. When an object moves from O to B and then from B to A. Then displacement = $x_2 - x_1$.



Ex. Suresh walks from point A to B and then again from B to C.

Distance he has travelled is A to B + B to C.

Displacement he has travelled is line A to C

Note : If a body travels in such a way that it comes back to its starting position, then the displacement is zero. However distance travelled never zero.

(b) SPEED :

(i) Speed : Speed of a body is the distance travelled by the body in one second

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

Distance travelled is measured in metre and time in second.

Therefore, the unit of speed is metre/second.[(m/s)].

It can also be expressed in kilometer/hour [km/h]

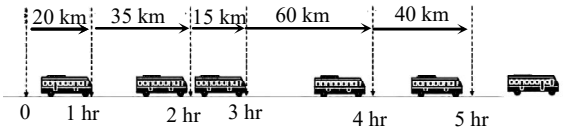
If we know the speed of an object we can find out the distance covered by it in a given time.

Distance covered= speed × time.

(ii) Average speed :

The speed of a bus during a journey may vary. When the bus is nearing a bus stop, its speed decreases. On the highways the bus travels with greater speed but in a city or town it travels with less speed due to heavy traffic.

The bus has different speeds at different times. So we say that it has **variable speed.**

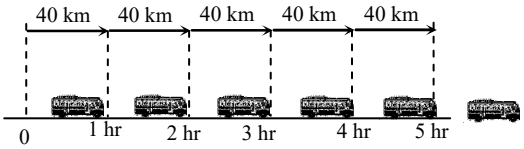


Variable speed

for such bodies, we can calculate the average speed.

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

If a body moves with the same speed at all times we say that it has **uniform speed.**



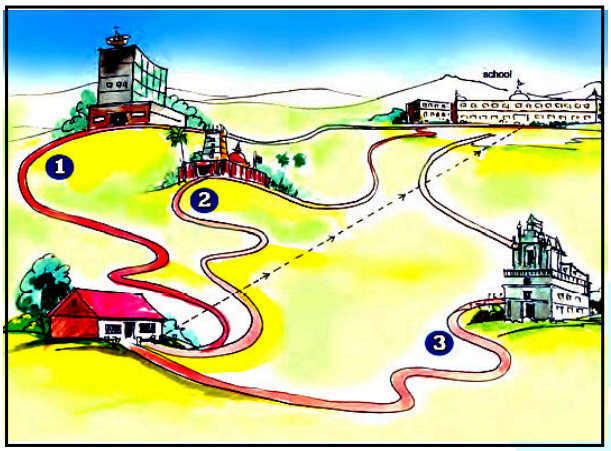
Uniform speed

(c) VELOCITY :

Every day when you go to school from your house, you could take path 1 or path 2 or path 3. Do these paths have the same distance? No, the

distance is not the same; it varies with the path taken. Imagine that you travel from your house to school in a straight line. This will be the shortest distance between them, called **displacement**. In the picture, it is represented by a dotted line. **Displacement is the shortest distance between two points.**

Velocity is the displacement of a body in one second.



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

its unit is **m/s**

Velocity is nothing but speed in a definite direction.

(d) ACCELERATION :

Do you ride a bicycle to school? If you are late, what would you do? you would increase your velocity or accelerate.

Acceleration is the change of velocity in one second

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

Its unit is **m/s^2 .**

If car has an acceleration of 5 m/s^2 every second its velocity increases by 5 m/s. If the velocity of a moving body decreases, we say that it has negative acceleration or retarding or deceleration.

ACCELERATION DUE TO GRAVITY :

Let us see what happens when a ball is thrown up vertically? As it rises, its velocity gradually decreases till it becomes zero i.e., the ball is retarded. As the ball falls down its velocity gradually increases i.e., it is accelerated. The retardation or acceleration is due to the earth's gravitational force. *It is known as acceleration due to gravity.* This means that the velocity of a body decreases by 9.8 m/s every second when it is thrown up and the velocity increases by 9.8 m/s every second when it falls down.

MEASUREMENTS

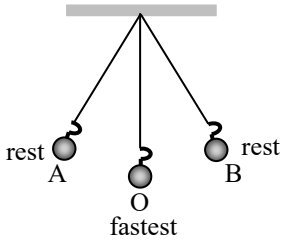
(a) Measurement of time :

Many events in nature repeat themselves after definite intervals of time. For example, we can find that the sun rises everyday in the morning. The time between one sunrise and the next was called a day. Similarly, 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 clocks or watches are perhaps the most common time measuring devices.

All of them make use of some periodic motion. One of the most well-known periodic motions is that of a **simple pendulum** .

A simple pendulum consists of a small metallic ball or a piece of stone suspended from a rigid stand by a thread. The metallic ball is called the **bob** of the pendulum.

Initially the pendulum at rest in its mean position. When the bob of the pendulum is released after taking it slightly to one side, it begins to move to and fro. The to and fro motion of a simple pendulum is an example of a periodic or an oscillatory motion.



The pendulum is said to have completed one **oscillation** when its bob, starting from its mean position O, moves to A, to B and back to O. *The time taken by the pendulum to complete one oscillation is called its time period.*

To set the pendulum in motion, gently hold the bob and move it slightly to one side. Now release the bob from its displaced position. Measure the time the pendulum takes to complete 20 oscillations. Repeat this activity a few times and record your observations. You will note that a slightly change in the initial displacement not affect the time period of your pendulum.

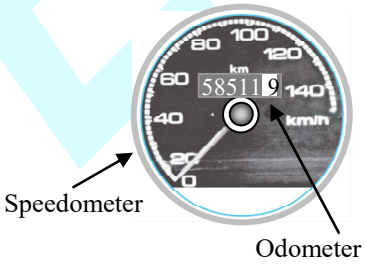
◆ **Unit of time :**

The basic unit of time is a **second**. Its symbol is **s**. Larger units of time are minutes (min) and hours (h).

Many time measuring devices were used in different parts of the world before the pendulum clocks became popular. Sundials, water clocks and sand clocks are some examples of such devices.

(b) Measurement of speed : By calculating the distance travelled in the given time, we can calculate speed. Speed generally measured in **m/s**. In vehicles speed is measured in km/h by the instrument *speedometer*.

(c) Odometer : It measure the distance moved by vehicles directly.



DISTANCE- TIME GRAPH

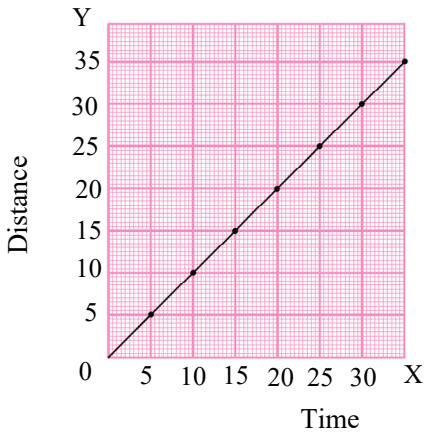
Consider the example : Rajesh was travelling with his father in their car from Kota to Bundi. He kept himself busy by noting the distance travelled by the car every 5 minutes. This is what he noted in the first 30 minutes.

S. NO.	Time in minutes	Distance in km
1	0	0
2	5	5
3	10	10
4	15	15
5	20	20
6	25	25
7	30	30

You can make a graphical representation of his observations follow these simple steps.

Taking axes and scale : Take a graph sheet an draw two lines perpendicular to each other.

Mark the horizontal line as OX (x-axis) and the vertical line as OY(y-axis). Time is taken on the X-axis and distance on the Y-axis.



Choose scales to represent distance and time.

For example, the scales could be

X-axis : 1 cm = 5 minutes

Y-axis : 1 cm = 5 km

Plotting the graph: Mark the value on the axes for time and distance according to the scales you have chosen. According to the values noted, mark the points on the graph sheet. Join the points

For uniform speed, the distance time graph is always a straight line.

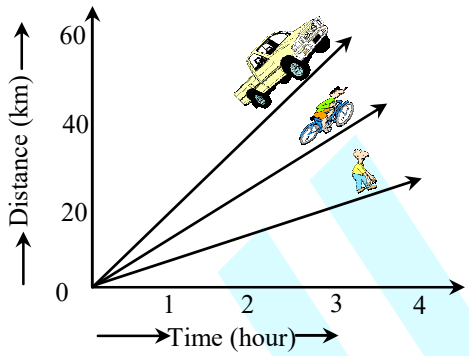
For variable speed, it could be of any shape.

Ex. Three cars A, B and C travel from Delhi to Agra. The time taken and the distance covered are given in the table below.

S. NO.	Time taken in hours	Distance travelled in km		
		Car A	Car B	Car C
1	1	20	50	40
2	2	40	100	80
3	3	60	150	120
4	4	80	200	160
5	5	100	250	200

Plot the distance time graph of the three cars in the same graph sheet.

Sol.



Greater the speed, steeper will be the graph