ICSE
Living Science
Physics

Class 9

Chapter 2 Motion in One Dimension

As per the guidelines of NEP 2020

On Board! BOOKS

Revised and Updated

Living Science Physics

Based on the latest ICSE syllabus

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LEARNING OBJECTIVES

Rest and Motion

- ❖ Rest and motion are relative terms

One-Dimensional Motion

- ❖ Scalar and vector quantities
- ❖ Distance and displacement

Speed and Velocity

- ❖ Speed and kinds of speed
- ❖ Velocity and kinds of velocity

Concept of Acceleration

- ❖ Acceleration of a body in terms of its initial and final velocity
- ❖ Positive and negative acceleration
- ❖ Uniform and non-uniform acceleration
- ❖ Acceleration due to gravity

Graphical representation of linear motion

- ❖ Distance-time graph
- ❖ Velocity-time graph

Equations of Motion

Which is at rest and which is in motion?

A body is said to be at rest if it does not change its position with respect to a fixed point taken as a reference point in its surroundings.

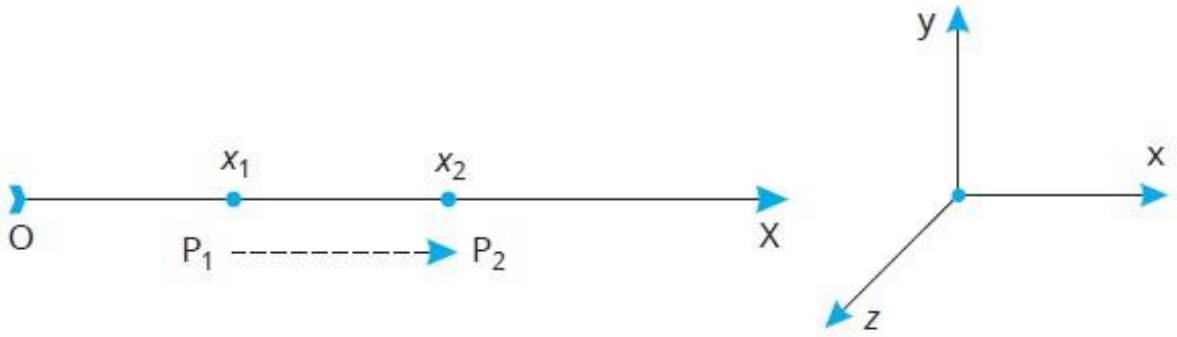
A body is said to be in motion if it changes its position with respect to a fixed point taken as a reference point in its surroundings.

Rest and Motion are Relative Terms

An object can be in motion in relation to one object while it can be at rest in relation to another object at the same instant of time. We can, therefore, say that **rest and motion are relative terms**.

One-Dimensional Motion

The motion of an object is said to be one dimensional motion if only one out of the three coordinates (i.e. *x*, *y* or *z*) specifying the position of the object changes with respect to time. In such a motion, the object moves along a straight line. For example, the motion of a train along a straight railway track, the motion of an object dropped from a certain height above the ground, etc. are one dimensional motion.



a. Only one coordinate *x* changes b. Three coordinates

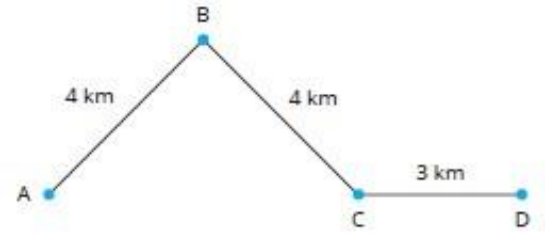
Scalar and vector quantities

A physical quantity which is described completely by its magnitude (or size) only is called a scalar quantity. Thus, a scalar quantity has only no direction. Some examples of scalar quantities are length, time, distance, area, speed, temperature, energy, power and mass.

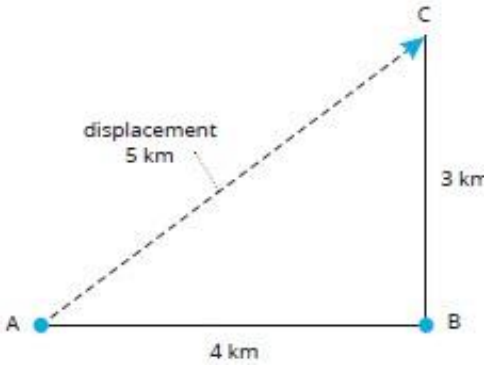
A physical quantity which requires both magnitude (or size) and direction for its complete description is called a vector quantity. Thus, a vector quantity has both magnitude and direction. Some examples of vector quantities are displacement, velocity, acceleration, force, weight and momentum.

Distance and displacement

The actual length of the path travelled (or covered) by a moving body, irrespective of its direction is called the ‘distance’ travelled by the body. The shortest distance (straight distance) between the initial and the final positions of a moving body in a particular direction is called its displacement.



Distance travelled by the person



Displacement of the person

Speed and Velocity

Speed

The speed of a body is the distance travelled by it per unit time.
That is, Speed = Distance travelled / Time taken

Units of speed

In CGS system, the unit of speed is **centimetre per second** written as cm s^{-1} or cm/s. In SI system, the unit of speed is **metre per second** written as m s^{-1} or m/s. The speed of fast moving bodies like cars, aeroplanes and scooters is expressed in **kilometre per hour** written as km h–1 or km/h. Speed has only magnitude (but no direction), therefore, **speed is a scalar quantity**.

Kinds of speed

1. Uniform speed: A body is said to be moving with uniform speed if it covers equal distances in equal intervals of time irrespective of the direction throughout its motion.

2. Non-uniform speed: A body is said to be moving with non-uniform speed if it covers unequal distances in equal intervals of time irrespective of the direction throughout its motion.

3. Instantaneous speed: If the speed of a body changes continuously with time, its speed at any instant is known as the instantaneous speed.

Instantaneous speed = Distance travelled in a very short time /Time interval

4. **Average speed:** When a body travels with a non-uniform speed, then the average speed of the body can be obtained by dividing the total distance travelled by the total time taken. Thus,

Average speed= Total distance travelled/ Total time taken

Velocity

The distance travelled by a body per unit time in a given direction is called its velocity. Velocity has both magnitude and direction. So, velocity is a vector quantity.
Velocity = Distance travelled in a specified direction (*S)* / Time taken *(t)*
Units of velocity are same as that of speed.

Kinds of Velocity

1. Uniform velocity: When a body travels in a straight line (in a particular direction) and covers equal distances in equal intervals of time, it is said to have uniform velocity.

2. Non-uniform velocity: A body is said to have non-uniform velocity when it covers unequal distances in equal intervals of time in a particular direction.

3. Instantaneous velocity: The velocity of a body at any particular instant during its motion is called instantaneous velocity.

4. Average velocity: If the velocity of a body in a particular direction changes continuously at a uniform rate, then the arithmetic mean of the initial and the final velocities over a given period of time is called the average velocity in that direction**.** So, average velocity = (Initial velocity + Final velocity)/2

If *u* is the initial velocity and *v* is the final velocity in a particular direction then,

Average velocity = $(u + v)/2$

Concept of Acceleration

The rate of change of velocity of a body with respect to time is called its acceleration.

So, Acceleration = (Final velocity - Initial velocity)/ Time interval

$$a = (v - u)/t$$

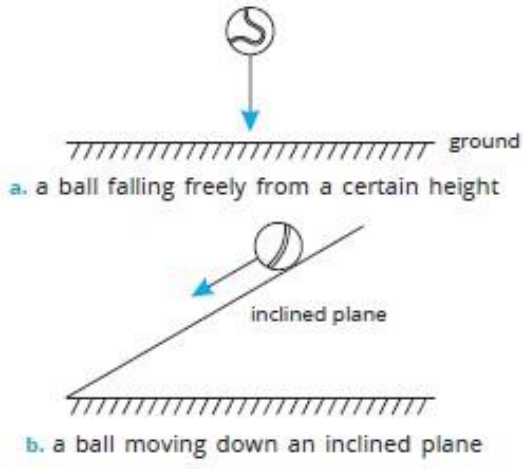
Units of acceleration: ms^{-2} or $km\ h^{-2}$

Positive and Negative Acceleration

When the velocity of a body increases with time, its acceleration is positive.
When the velocity of a body decreases with time, its acceleration is negative.
Negative acceleration is also called **retardation**.

Uniform and non-uniform Acceleration

When a body travels in a straight line and its velocity changes by equal amounts in equal intervals of time, then it is said to have uniform acceleration.
When the velocity of a body changes by unequal amounts in equal intervals of time, then it is said to have non-uniform acceleration.



Examples of uniform acceleration

Acceleration due to gravity

All objects when dropped from a certain height fall towards the earth. This happens due to the gravitational force exerted by the earth on these objects. The uniform acceleration produced in a freely falling body due to the gravitational pull of the earth is known as the acceleration due to gravity. It is denoted by the letter '*g* '.

Graphical Representation of Linear Motion

The linear motion of a body can be studied with the help of the following graphs:

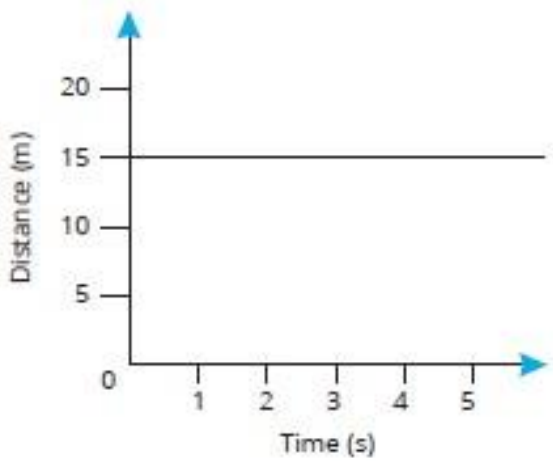
1. Distance–time graph **2.** Displacement–time graph **3.** Velocity–time graph

1. Distance–time graph

The geometrical relationship between the distance travelled by a body and the time taken is called the distance–time graph. Since, speed is the ratio of the distance travelled and the time taken, therefore, the slope of the distance– time graph gives the speed of a body.

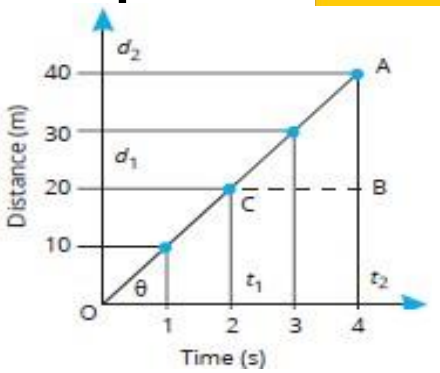
Distance–time graph for a body at rest

Distance–time graph for a body at rest is a straight line parallel to the time axis.
The slope of any line parallel to *x*-axis is zero. So, the slope of the distance–time graph for a body at rest is zero.



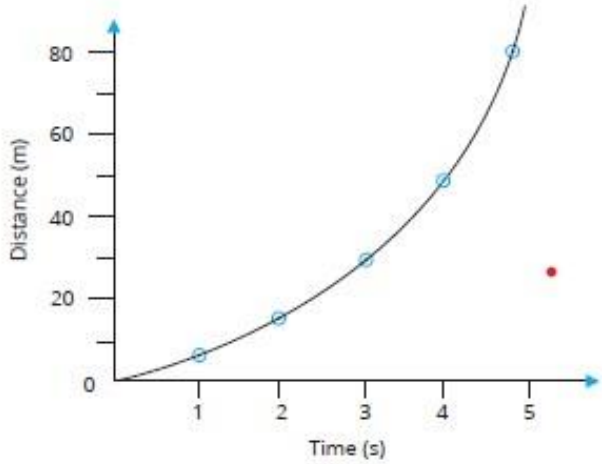
Distance–time graph for a body moving with a uniform speed

The distance–time graph for a body moving with uniform (constant) speed is a straight line. The distance–time graph for a body moving with a uniform speed is a straight line making an angle with the *x*-axis.

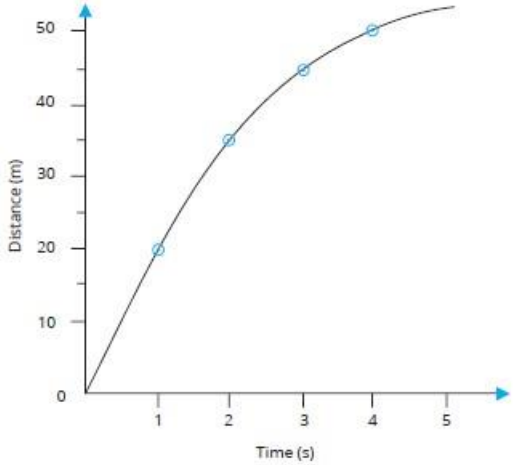


Distance–time graph for a body moving with a non- uniform speed

The distance–time graph for a body moving with a non-uniform speed is not a straight line. It is a curve.



When the speed increases with time



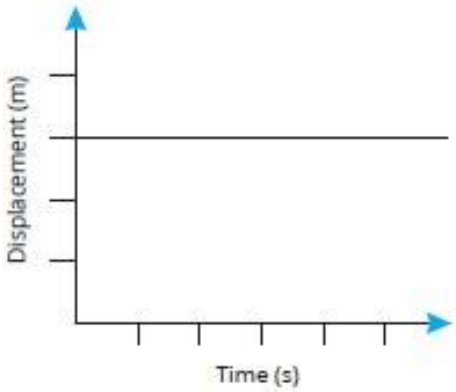
When the speed decreases with time

Displacement-time graph

The slope of a displacement–time graph gives the velocity of the body.

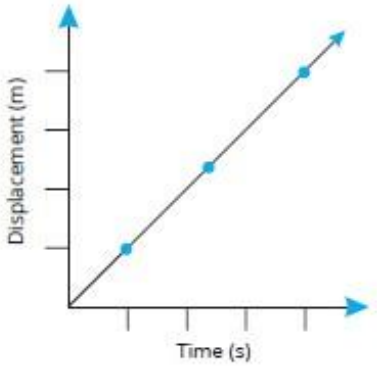
Body at rest

Displacement–time graph of a body at rest is a straight line.

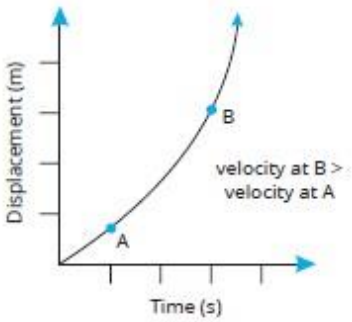


Body moving with uniform velocity

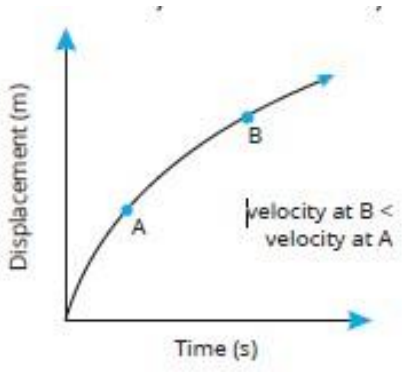
Displacement–time graph for a body moving with uniform velocity is a **straight line** at some angle with the time axis.



Body moving with non-uniform velocity



In displacement–time graph for a body moving with an increasing non-uniform velocity the slope increases with time.

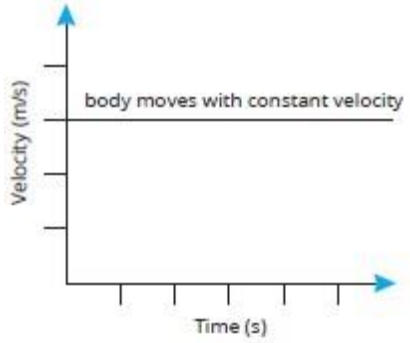


In displacement–time graph for a body moving with an increasing non-uniform velocity the slope decreases with time.

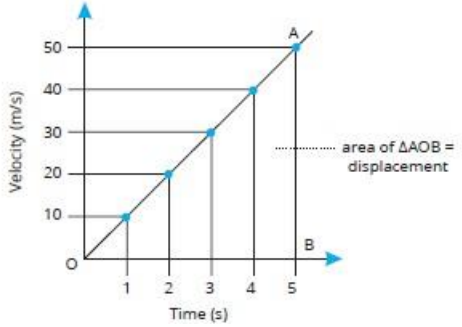
Velocity-Time Graph

The geometrical relationship between the velocity of a body and the time is called the velocity–time graph.

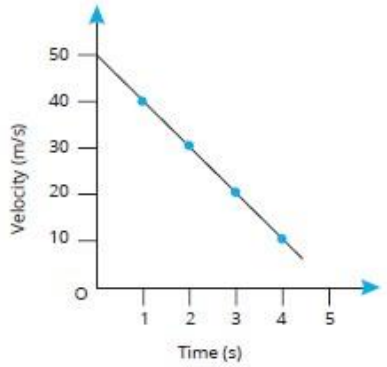
1. Velocity–time graph for a body in motion with uniform (constant) velocity



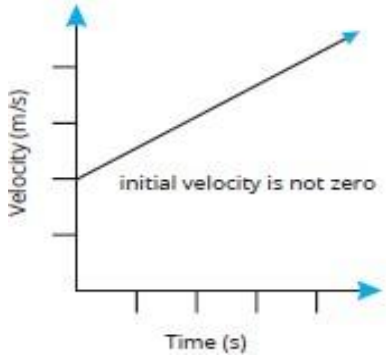
2. Velocity–time graph for a body in motion with uniform acceleration (when the initial velocity is zero)



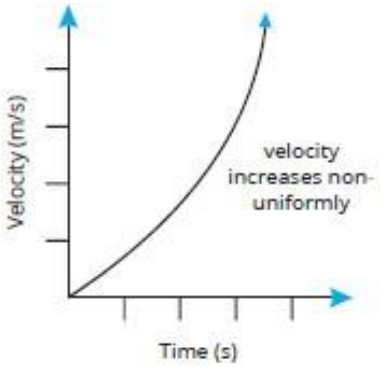
3. Velocity–time graph for a body in motion with uniform retardation



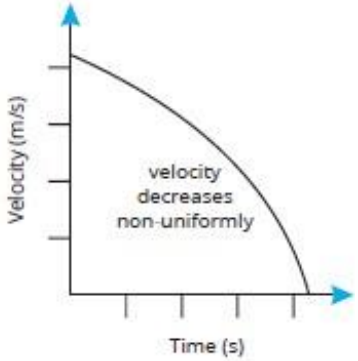
4. Velocity–time graph for a body when its initial velocity is not zero and the velocity increases uniformly with time



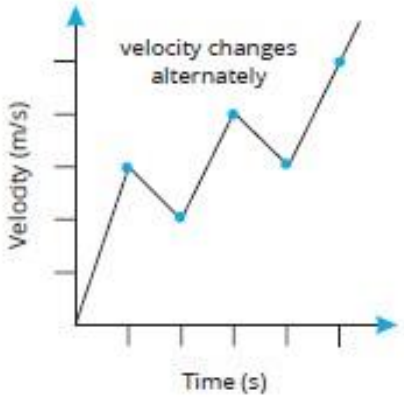
5. Velocity–time graph for a body when its velocity increases non-uniformly with time



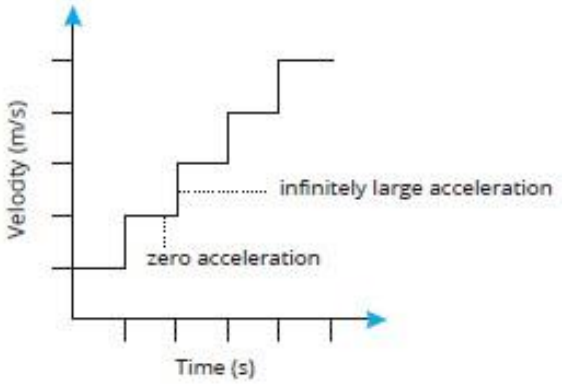
6. Velocity–time graph for a body when its velocity decreases non-uniformly with time



7. Velocity–time graph for a body when its velocity increases and decreases alternately



8. Velocity–time graph for a body when its velocity increases in a stepwise manner



Equations of Motion

When a body travels in a straight line having uniformly accelerated motion, then **the relationships between the initial velocity (*u*), final velocity (*v*), distance travelled (*S*), acceleration (*a*) and the time taken (*t*) are called the equations of motion**.

There are three equations for the motion of a body moving with a uniform acceleration.

These three equations are

$v = u + at$;

$S = ut + 1/2\ at^2$ and

$v^2 = u^2 + 2aS$

SUMMARY

1. Rest: A body is said to be at rest if it does not change its position with respect to a fixed point taken as a reference point in its surroundings.

2. Motion: A body is said to be in motion if it changes its position with respect to a fixed point taken as a reference point in its surroundings.

3. One-dimensional motion: The motion of an object is said to be one-dimensional if only one of the three coordinates (i.e. *x*, *y* or *z*) specifying the position of the object changes with respect to time.

4. Distance: The actual length of the path travelled (or covered) by a moving body, irrespective of its direction is called the distance travelled by the body.

5. Displacement: The shortest distance between the initial and the final positions of a moving body in a particular direction is called its displacement.

6. Speed: The speed of a body is the distance travelled by it per unit time.

7. Velocity: The distance travelled by a body per unit time in a given direction is called its velocity.

8. Acceleration: The change of velocity of a body with respect to time is called its acceleration.