Summary - Class 11 Physics Motion in a Straight Line Notes (Chapter 2)

1. Mechanics:

Mechanics refers to the branch of Physics, which involves the study of the movement of physical objects.

It may be broadly categorized into the following branches:

Statics:

It is the branch of mechanics, which involves the study of physical objects at rest.

Kinematics:

It is the branch of mechanics, which involves the study of the movement of physical objects without considering the factors that cause movement.

Dynamics:

It is the branch of mechanics, which involves the study of movement of physical objects considering the factors that cause movement.

2. Rest and Motion

Rest:

- An object is said to be at rest when it does not change its position with respect to its surroundings.
- For example, the white board in a classroom is at rest with respect to the classroom.

Motion:

- An object is said to be in motion when it changes its position with respect to its surroundings.
- For instance, when we walk, run or ride a bike, we are said to be in motion with respect to the ground.

Rest and Motion are Relative:

- Rest and motion are dependent on the observer. The object in one situation may be at rest while the same object in another situation may be in motion.
- For example, the driver of a moving car is in motion with respect to an observer standing on the ground whereas, the same driver is at rest with respect to the man(observer) in the passenger's seat.

3. While Studying This Chapter:

- We would consider the objects as point mass objects.
- An object can be taken as a point mass object if during the course of motion, it covers distances much greater than its own size.
- We may confine ourselves to the study of rectilinear motion, which is the study of motion of objects along a straight line.

4. Position, Distance, Displacement:

Position:

- Position of an object is always expressed with respect to some reference point which we generally account to as origin.
- To express the change in position, we consider two physical quantities.

Distance:

- It refers to the actual path traversed by the object during the course of motion.
- Its S.I. unit is $'m'$ and its dimensions are $[M^0L^1T^0]$.

Displacement:

- It refers to the difference between the final and initial positions of the object during the course of motion.
- Its S.I unit is 'm' and its dimensions are $M^0L^1T^0$.

Differences Between Distance and Displacement:

Distance	Displacement
It refers to the actual path traversed by the object during the course of motion.	It refers to the difference between the initial and the final positions $\Delta x = x_2 - x_1$, where, x_2 and x_1 are final and initial position respectively.
It is a scalar quantity.	It is a vector quantity.
The distance covered by an object during the course of motion can never be negative or zero. It is always positive.	The displacement of an object can be positive, negative or zero during the course of motion.
The distance travelled is either equal to or greater than displacement and is never less than magnitude of displacement.	The magnitude of displacement is less than or equal to the distance travelled during the course of motion.
The distance is dependent upon the path travelled by the object.	The magnitude of displacement is not dependent on the path taken by an object during the course of motion.

Difference Between Speed and Velocity:

Speed	Velocity
It refers to the total path length travelled divided by the total time interval during which the motion has taken place.	It refers to the change in position or displacement divided by the time intervals, in which this displacement occurs.
It is a scalar quantity.	It is a vector quantity.
It is always positive during the course of the motion.	It may be positive, negative or zero during the course of the motion.
It is greater than or equal to the magnitude of velocity.	It is less than or equal to the speed.

Note:

When the motion of an object is along a straight line and in the same direction, the magnitude of displacement is the same as the total path length.

In this case, the magnitude of average velocity is equal to the average speed. However, this is not always the case. The average velocity gives an idea on how fast an object has been moving over a given interval but does give an idea on how fast it moves at different instants of time during that interval.

5. Scalar and Vector Quantities:

Scalar quantities:

- The physical quantities that have only magnitude but no direction, are termed scalar quantities.
- Some examples of scalars are mass, length, time, distance, speed, work and temperature.

Vector quantities:

- The physical quantities that have magnitude as well as direction are termed vector quantities.
- Some examples of vectors are displacement, velocity, acceleration, force, momentum, torque.

6. Average Velocity and Average Speed:

Average velocity:

- It refers to the change in position or displacement divided by the time interval, in which the displacement occurs.
- The S.I. unit of velocity is m/s even though km/h is used in many daily life applications and its dimensions are $[M^0L^1T^{-1}]$.

Average speed:

- It refers to the total path length travelled divided by the total time interval during which the motion has taken place.
- Its S.I. unit is m/s and its dimensions are $[M^0L^1T^{-1}]$.

7. Instantaneous Velocity and Instantaneous Speed:

Instantaneous velocity:

- It refers to the velocity at an instant t. Instantaneous velocity can further be expressed as the limit of the average velocity during which the time interval Δt becomes infinitesimally small.
- Mathematically, instantaneous velocity $= Lt(\Delta x/\Delta t) = dx/dt$
- The quantity on the right-hand side of the above expression is the differential coefficient of x with respect to t and is represented by dx/dt.
- Clearly, it refers to the rate of change of position with respect to time at that particular instant.
- Its S.I. unit is m/s and its dimensions are $[M^0L^1T^{-1}]$.

Instantaneous Speed:

- Instantaneous speed or simply speed refers to the magnitude of velocity.
- Its S.I. unit is m/s and its dimensions are $[M^0L^1T^{-1}]$.

8. Acceleration:

Average Acceleration:

- The average acceleration over a time interval refers to the change of velocity divided by the time interval.
- Mathematically, it is given by $a = (v_2 - v_1)/(t_2 - t_1)$, where v_2 and v_1 are velocities at time t_2 and t_1 respectively.
- Average acceleration can thus be defined as the average change of velocity per unit time.
- Its S.I. unit is m/s^2 and its dimensions are $[M^0L^1T^{-2}]$.

Instantaneous Acceleration:

- Mathematically, instantaneous acceleration can be expressed in the same way as the instantaneous velocity as follows:

  $$a = \lim_{\Delta t \to 0} (\Delta v/\Delta t) = dv/dt$$

- Its S.I. unit is m/s^2 and its dimensions are $[M^0L^1T^{-2}]$.
- When there is uniform acceleration, obviously, instantaneous acceleration is the same as the average acceleration over that period of time.
- As velocity is a quantity involving both magnitude and direction, a change in the velocity may also involve either or both of these factors.
- Thus, acceleration may result from a change in the speed(magnitude), a change in direction or changes in both.
- Similar to velocity, acceleration can also be positive, negative or zero.

Note:

- We would restrict ourselves to the study of constant acceleration in this chapter. In this case, average acceleration is the same as the constant value of acceleration during a particular time interval.

- When the velocity of an object is v_0 at $t = 0$ and v at time t, we have

$a = \frac{v - v_0}{t - 0} \Rightarrow v = v_0 + at$. This is nothing but the first equation of motion.

- Other equations of motion are:

$S = v_o t + \frac{1}{2} a t^2$

$v^2 - {v_0}^2 = 2aS$

$S = v_0 + \frac{a}{2}(2n - 1)$

In all these equations, acceleration is considered to be constant.

9. Graphs:

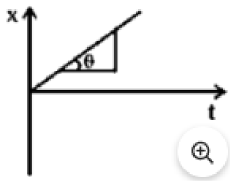
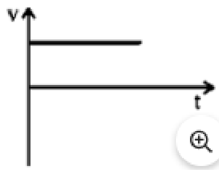
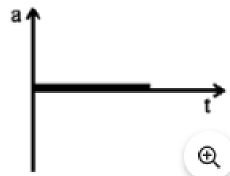
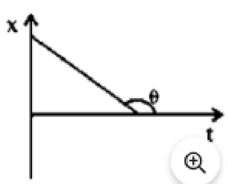
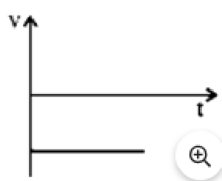
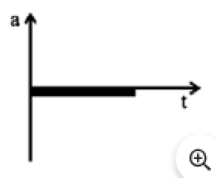
Uniform motion:

- If a body is said to be in uniform motion, the body completes equal distances in equal intervals of time.

- Here, velocity is constant during the course of motion.

- Also, acceleration is zero during the course of motion.

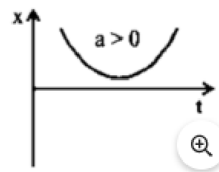
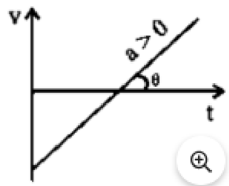
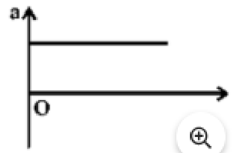
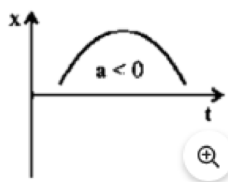
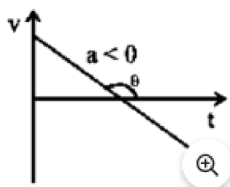
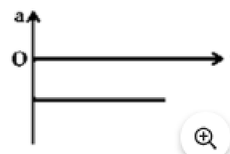
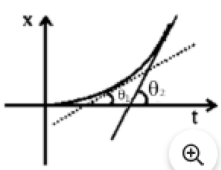
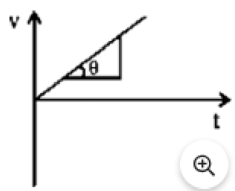
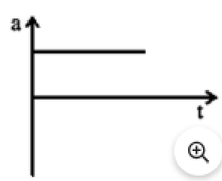
When we demonstrate this on the number line with x, v, a on the Y-axis and t on the X-axis, then we would have -

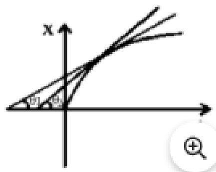
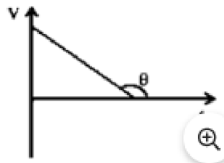
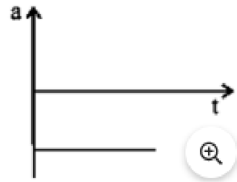
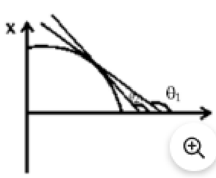
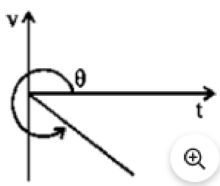
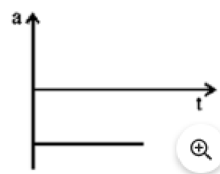
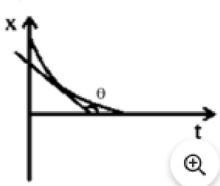
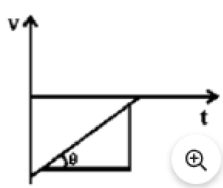
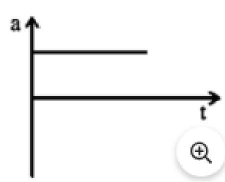
Displacement-time graph	Velocity-time graph Velocity = slope of $x - t$ graph	Acceleration-time graph $\text{acc}^{\text{n}} = \text{slope of } v -$
(i)  Nature of slope: positive Magnitude of slope: constant	 Nature of slope: zero Magnitude of slope: constant	 Nature of slope of $a - t$
(ii)  Nature of slope: negative Magnitude of slope: constant	 Nature of slope: zero Magnitude of slope: constant	 Nature of slope of $a - t$

Non-Uniform motion:

- If a body undergoes non-uniform motion, the body is said to be in uniformly accelerated motion.
- Here, the magnitude of velocity increases or decreases with the passage of time.
- Also, acceleration would not be zero as it undergoes accelerated motion.

When we demonstrate this on the number line with x, v, a on the Y-axis and t on the X-axis, then we would have -

Displacement-time graph	**Velocity-time graph** **Velocity = slope of $x - t$ graph**	**Acceleration-time graph** acc$^{\text{n}}$= slope of $v -$
(i) 		
(ii) 		
(iii)  Nature of slope: positive Magnitude of slope: Increasing	 Nature of slope: positive Magnitude of slope: constant	

(iv)  Nature of slope: positive Magnitude of slope: decreasing	 Nature of slope: negative Magnitude of slope: constant	
(v)  Nature of slope: negative Magnitude of slope: increasing	 Nature of slope: negative Magnitude of slope: constant	
(vi)  Nature of slope: negative Magnitude of slope: decreasing	 Nature of slope: positive Magnitude of slope: constant	

Section – A (1 Mark Questions)

1. Define the speed of the object.

Ans. The speed of an object is defined as the distance covered by it per unit of time.

2. Can there be motion in two dimensions with acceleration in only one dimension?

Ans. Yes, projectile motion.

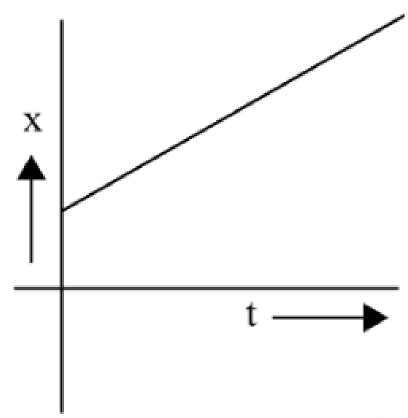
3. Is it true that a body is always at rest in a frame that is fixed to the body itself?

Ans. Yes, because the velocity of the body with respect to frame of reference is zero.

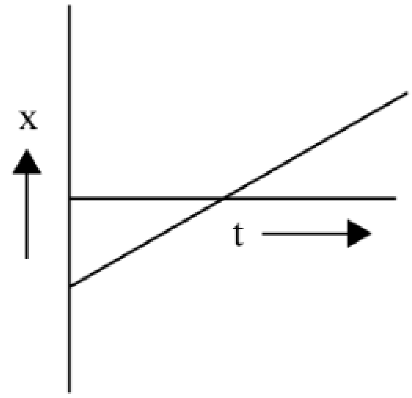
4. Tell under what condition a body moving with uniform velocity can be in equilibrium?

Ans. When the net force on the body is zero.

5. What is common between the two graphs shown in figs. (a) and (b)?



(a)



(b)

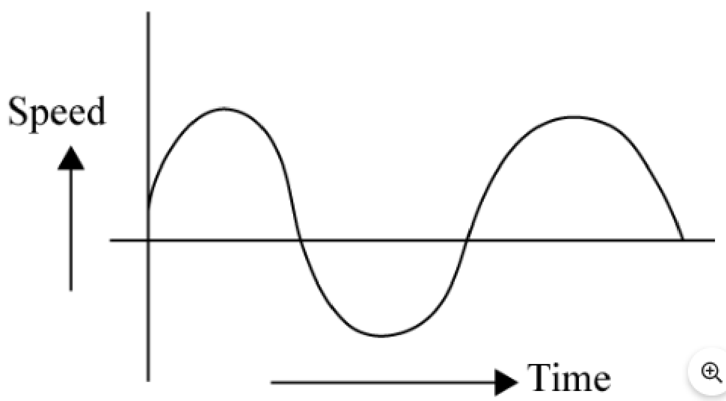
Ans. Both these graphs represent that velocity is positive.

Section – B (2 Marks Questions)

6. Can the speed of a body change if its velocity is constant? Why?

Ans. No, the speed of a body cannot change if its velocity is constant which means that both the magnitude and direction of velocity do not change. The magnitude of velocity is speed, so speed cannot change.

7. Is the following graph possible for the motion of a particle moving along a straight line? Explain.

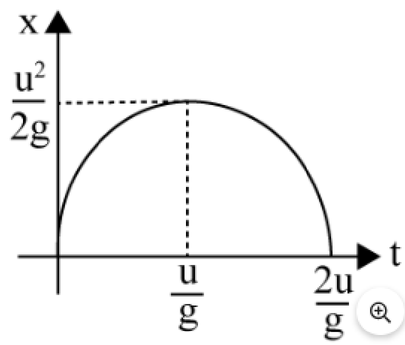


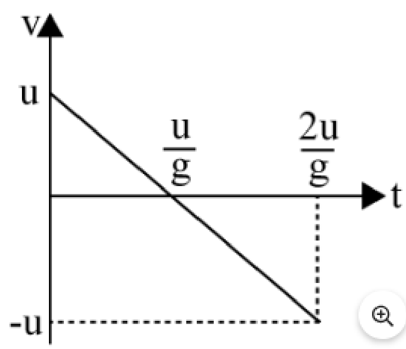
Ans. No.

This is because the speed for a given time is negative and speed is always positive.

8. Draw the position-time and velocity-time graph for a body projected vertically upwards with initial velocity u. Take the projection point to be origin and upward direction as positive.

Ans.





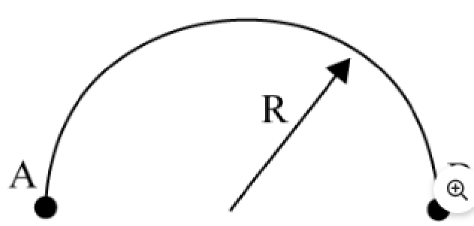
9.A particle moves along a semicircular path of radius R in time t with constant speed. For the particle calculate

(i) distance traveled,

(ii) displacement,

(iii) average speed,

(iv) average velocity,



Ans. (i) Distance = length of path of particle $= AB = \pi R$

(ii) Displacement = minimum distance between initial and final point $= AB = 2R$

(iii) Average speed, $V = \frac{total\ distance}{time} = \frac{\pi R}{t}$

(iv) Average velocity $= \frac{2R}{t}$

10. A car travels first half the distance between two places with a speed of 30km/h and the remaining half with a speed of 50km/h. Find the average speed of the car.

Ans. $V_{avg} = \frac{S}{t_1 + t_2} = \frac{S}{\frac{S}{2 \times 30} + \frac{S}{2 \times 50}} = \frac{S}{\frac{S}{20}\left(\frac{5+3}{15}\right)}$

$V_{avg} = \frac{20 \times 15}{8} = \frac{5 \times 15}{2} = \frac{75}{2} = 37 \cdot 5 km/h$

Tips for Learning the Class 11 Chapter 2 Physics Motion in a Straight Line

- Focus on understanding basic ideas like distance, displacement, speed, velocity, and acceleration.
- Practice reading and using motion graphs, like distance-time and velocity-time graphs.
- Work on different problems to get better at using the equations and concepts.
- Draw diagrams to help visualize how objects move.
- Regularly review your notes to remember important formulas and ideas.
- Relate the concepts to everyday examples, like how a car moves or how athletes run, to make them easier to grasp.