PHY

Chapters : 2
Total Marks : 35marks

Std 11 : Physics
Unit Test

Date : 06/10/20
Time : 1hr.

Section A

- **Answer the following Questions. [Each carries 1 mark]** [11]

1. Draw the $x \rightarrow t$ graphs which represent the positive, negative and zero velocity.
2. Write definition of instantaneous velocity.
3. What does $\dot{x}$ represent ?
4. What is displacement ?
5. What is path length ?
6. When path length and magnitude of displacement are same ?
7. Which among path length and displacement cannot be zero ?
8. Draw the $x \rightarrow t$ graphs for positive, negative and zero acceleration.
9. What is retardation ?
10. What is uniform motion ?
11. When the relative velocity of two cars $v_A = v_B$ becomes zero ?

Section B

- **Answer the following Questions. [Each carries 2 marks]** [16]

12. Give difference between path length and displacement.
13. Explain with an example that the magnitude of displacement may be zero but the corresponding path length is not zero.
14. Draw $v \rightarrow t$ graph for constant velocity and explain it.
15. Draw and explain the $v \rightarrow t$ graphs for uniformly accelerated motion.
16. What is stopping distance for vehicle ?
17. Give difference between average speed and average velocity.
18. Draw graphs $a \rightarrow t$, $v \rightarrow t$ and $x \rightarrow t$ for the object falling freely.
19. What is free fall ? Write equations of uniformly accelerated motion for object falling freely.

Section C

- **Answer the following Questions. [Each carries 3 marks]** [12]

20. Explain average velocity and average speed.
21. Explain the acceleration.
22. Derive the equations of uniformly accelerated motion by graphical method.
23. Obtain equations of motion for constant acceleration using method of calculus.

Section D

- **Answer the following Questions. [Each carries 4 marks]** [4]

24. For an object moving on a straight line, draw $x \rightarrow t$ graphs for :
    (i) When it is rest.
    (ii) When it is moving with constant velocity in positive direction.
    (iii) When it is moving with constant velocity in negative direction.
    (iv) When it performs non-uniform motion.

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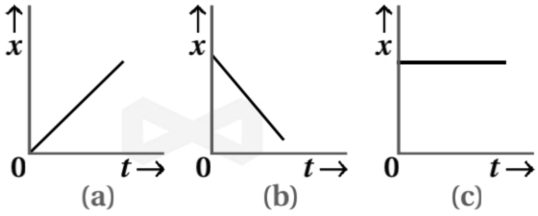
Section A

- **Answer the following Questions. [Each carries 1 mark]** **[11]**

1. **Draw the $x \rightarrow t$ graphs which represent the positive, negative and zero velocity.**

➠ 

➠ In graph (a), the position increases with respect to time, hence the average velocity is positive.
➠ In graph (b), the position decreases with respect to time, hence the average velocity is negative.
➠ In graph (c), the position doesn't change with respect to time, hence the average velocity is zero.

2. **Write definition of instantaneous velocity.**

➠ Try Yourself

3. **What does $\dot{x}$ represent ?**

➠ Try Yourself

4. **What is displacement ?**

➠ Try Yourself

5. **What is path length ?**

➠ Try Yourself

6. **When path length and magnitude of displacement are same ?**

➠ Try Yourself

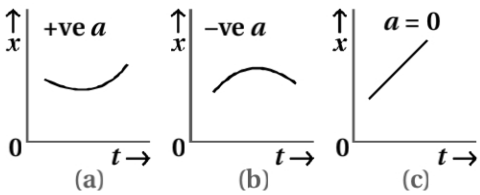
7. **Which among path length and displacement cannot be zero ?**

➠ Try Yourself

8. **Draw the $x \rightarrow t$ graphs for positive, negative and zero acceleration.**

➠ The average acceleration equals the constant value of acceleration during the interval.
➠ If the velocity of an object is v_0 at $t = 0$ and v at time t,

$$\bar{a} = \frac{v - v_0}{t}$$



9. **What is retardation ?**

➠ Try Yourself

10. **What is uniform motion ?**

➠ When an object moving on a straight line covers equal distance in equal intervals of time is called uniform motion.

11. **When the relative velocity of two cars $v_A = v_B$ becomes zero ?**

➠ When two cars move with same speed in same direction, then their relative velocity becomes zero.

Section B

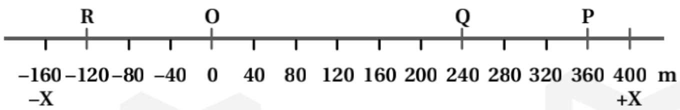
● **Answer the following Questions. [Each carries 2 marks]** **[16]**

12. Give difference between path length and displacement.

➠

Path length		Displacement	
(1)	The total distance covered by the moving object is called path length.	(1)	The shortest distance between final position and initial position is called displacement.
(2)	It is always positive.	(2)	It may be positive, negative or zero.
(3)	It is a scalar quantity.	(3)	It is a vector quantity.
(4)	It can never be zero for any moving object.	(4)	It can be zero for moving object.
(5)	If motion is not linear then path length > displacement.	(5)	If motion is not linear, then displacement < path length.
(6)	Final position cannot be determined from path length.	(6)	Final position can be determined from displacement.

13. Explain with an example that the magnitude of displacement may be zero but the corresponding path length is not zero.

➠ 

➠ For example, if the car starts from O, goes to P and then returns to O.

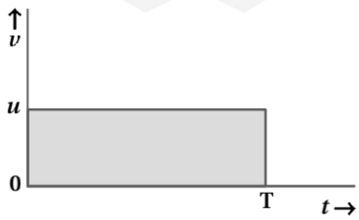
➠ The final position coincides with the initial position and the displacement is zero.

➠ However, the path length of this journey is OP + PO = 360 m + 360 m = 720 m.

➠ Thus, the magnitude of displacement for a course of motion may be zero but the corresponding path length is not zero.

14. Draw $v \to t$ graph for constant velocity and explain it.

➠ Suppose, there is an object moving with constant velocity u. Its velocity–time graph is as shown in figure.



➠ The $v \to t$ curve is a straight line parallel to the time axis.

➠ The area under it between $t = 0$ and $t = T$ is the area of the rectangle of height u and base T.

➠ Therefore, area = $u \times T = uT$ which is the displacement in this time interval.

➠ Note the dimensions of quantities on the two coordinate axes and it will give the proof.

➠ The area enclosed above t-axis is positive and the area enclosed below t-axis is negative.

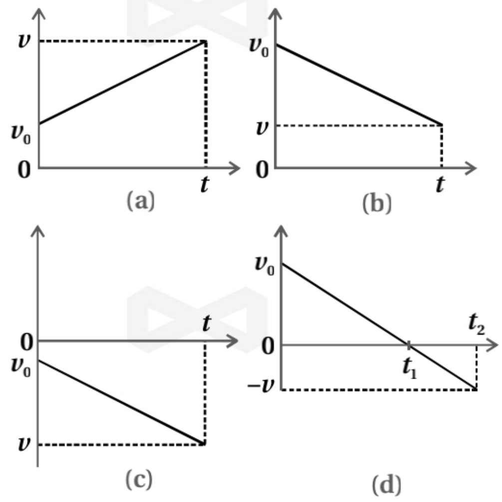
➠ Note that the x–t, v–t and a–t graphs shown in several figures in this chapter have sharp kinks at some points implying that the functions are not differentiable at these points.

➠ In any realistic situation, the functions will be differentiable at all points and the graphs will be smooth.

➠ What this means physically is that acceleration and velocity cannot change values abruptly at an instant. Changes are always continuous.

15. Draw and explain the $v \to t$ graphs for uniformly accelerated motion.

➠ Velocity–time graph for motion with constant acceleration are as following :



➠ An object is moving in a positive direction with a positive acceleration, then graph (a) is obtained.

➠ An object is moving in positive direction with a negative acceleration, then graph (b) is obtained.

➠ An object is moving in negative direction with a negative acceleration, then graph (c) is obtained.

➠ An object is moving in positive direction till time t_1 and then turning back and moving with the same negative acceleration. This is shown in graph (d).

➠ An interesting feature of a velocity–time graph for any moving object is that the area under the curve represents the displacement over a given time interval.

16. What is stopping distance for vehicle ?

➠ When brakes are applied to a moving vehicle, the distance it travels before stopping is called stopping distance.

➠ Suppose, the velocity of moving vehicle is v_0. After applying brakes retardation : $-a$

Distance covered : d_s (stopping distance)

Final velocity : $v = 0$

In equation $v^2 - v_0^2 = 2ax$

$\therefore\ 0 - v_0^2 = 2(-a)(d_s)$ $(\because\ v = 0,\ a = -a,\ s = d_s)$

$\therefore\ v_0^2 = 2ad_s$

$\therefore\ d_s = \dfrac{v_0^2}{2a}$

Here, a is value of retardation and it is constant.

Thus, stopping distance is proportional to square of the initial velocity.

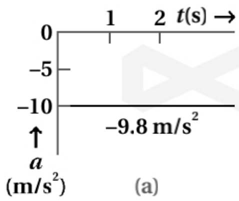
$\therefore\ d_s \propto v_0^2$

17. Give difference between average speed and average velocity.

➠

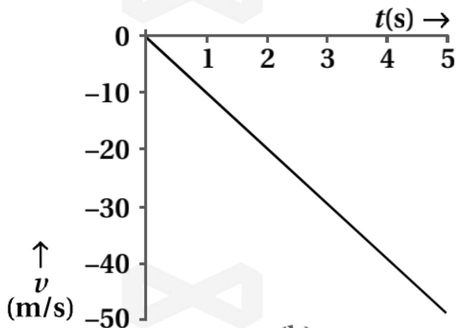
Average Speed		Average Velocity	
(1)	The ratio of path length covered to time taken is called average speed.	(1)	The ratio of displacement covered to time taken is called average velocity.
(2)	It is a scalar quantity.	(2)	It is a vector quantity.
(3)	It is always positive.	(3)	It may be positive, negative or zero.
(4)	Average speed ≥ Average velocity	(4)	Average velocity ≤ Average speed

18. Draw graphs $a \to t$, $v \to t$ and $x \to t$ for the object falling freely.

➠ 

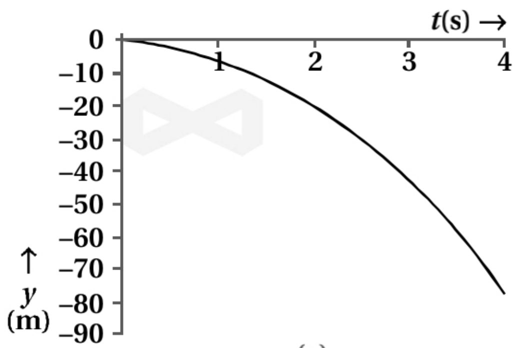
(a)

➠ For object falling freely, acceleration is constant and equal to negative g. Thus, graph (a) shows the change in acceleration with respect to time ($a \to t$).



(b)

➠ Velocity of object falling freely, $v = -gt$. Thus, graph (b) is obtained for $v \to t$.



(c)

➠ For object falling freely, $h = \frac{1}{2}gt^2$. Thus, graph (c) is obtained for $x \to t$.

19. What is free fall ? Write equations of uniformly accelerated motion for object falling freely.

➠ The acceleration produced in the object due to gravitational force is called gravitational acceleration.

➠ This acceleration is in downward direction.

➠ If the air resistance is neglected, then this type of falling of object is said to be free fall.

➠ Here, acceleration is considered as negative gravitational acceleration.

- This is also an uniformly accelerated motion.
- By putting $v_0 = 0$, $a = -g$, $d = -h$ in the kinematic equations; we can derive equations for free fall.

$$v = v_0 + at$$
$$\therefore\ v = -gt$$
$$d = v_0 t + \frac{1}{2}at^2$$
$$\therefore\ -h = -\frac{1}{2}gt^2$$
$$\therefore\ h = \frac{1}{2}gt^2$$
$$v^2 - v_0^2 = 2ad$$
$$\therefore\ v^2 = 2(-g)\ (-h)$$
$$\therefore\ v^2 = 2gh$$
$$\therefore\ v = \sqrt{2gh}$$

Section C

- **Answer the following Questions. [Each carries 3 marks]** **[12]**

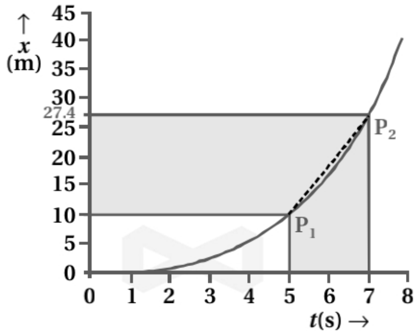
20. Explain average velocity and average speed.

- When an object is in motion, its position change with time and with what rate of time it will change its position that can be find in two ways.
- If we only find time rate then it is speed and if we find time rate with direction then it is velocity.
- **Speed :** The distance covered by object in unit time is called speed.
- **Average speed :** The ratio of total distance covered during travelling to total time taken is called average speed.
- Its unit is ms^{-1} and it is a scalar quantity. Hence its value is always positive.
- **Velocity :** The displacement covered in unit time is called velocity.
- It is a scalar quantity.
- Average velocity is defined as the change in position or displacement (Δx) divided by the time intervals (Δt), in which the displacement occurs :

$$\therefore\ \bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

where x_2 and x_1 are the positions of the object at time t_2 and t_1 respectively.

- The SI unit for velocity is ms^{-1}, although kmh^{-1} is used in many everyday applications.
- For motion in a straight line, the directional aspect of the vector can be taken care of by '+' and '–' signs and we do not have to use the vector notation for velocity.
- Magnitude of average velocity can be positive, negative or zero.
- Resultant effect of motion can be known from average velocity.
- Average speed can be greater than or equal to the magnitude of average velocity.
- For uniform motion at every moment, velocity is equal to average velocity.
- Consider the motion of the car, the portion of the $x - t$ graph between $t = 0$ s and $t = 8$ s is blown up and shown in figure.



- As seen from the plot, the average velocity of the car between time $t = 5$ s and $t = 7$ s is :

$$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{27.4 - 10.0}{7 - 5} = \frac{17.4}{2} = 8.7 \text{ ms}^{-1}$$

- Geometrically, this is the slope of the straight line P_1P_2 connecting the initial position P_1 to the final position P_2.

21. Explain the acceleration.

- The time rate of change of velocity is called acceleration.
- Let a particle be moving in a straight line and at time t_1 and t_2 its velocities are v_1 and v_2 respectively.
- Thus, the change in velocity of the particle in time interval $\Delta t = t_2 - t_1$ is $v_2 - v_1$.
- According to definition of average acceleration,

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

$$\therefore \ \langle a \rangle = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

- Average acceleration is a vector quantity and its direction is in the direction of change in velocity (Δv).
- The unit of acceleration is ms^{-2}.
- From average acceleration we cannot know how the velocity of particle changes with time.
- Taking $\lim\limits_{\Delta t \to 0}$ in equation then we get instantaneous acceleration a at time t.

$$\therefore \ a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

- Now, $v = \dfrac{dx}{dt}$

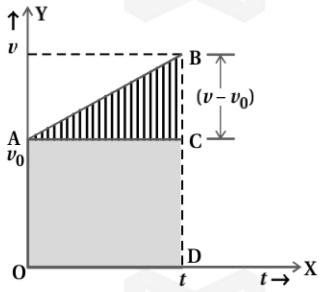
$$\therefore \ a = \frac{dv}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right)$$

$$\therefore \ a = \frac{d^2x}{dt^2} = \ddot{x}$$

- In other words second derivative of position with respect to time is acceleration of a particle.
- If $\dfrac{dv}{dt}$ is positive, acceleration is along the positive X-axis and if $\dfrac{dv}{dt}$ is negative the acceleration is along the negative X-axis.

22. Derive the equations of uniformly accelerated motion by graphical method.

- Now at $t = 0$ the velocity of the particle be v_0 and at $t = t$ the velocity of the particle be v.



$\therefore$ Acceleration a = slope of line AB

$$= \frac{v - v_0}{t - 0}$$

$$\therefore \quad a = \frac{v - v_0}{t}$$

$$\therefore \quad v = v_0 + at \qquad \dots (1)$$

➠ Now displacement of a particle during time t is equal to the area of region OABCD in $v \rightarrow t$ graph.

$\therefore$ x = Area of rectangle OACD + Area of ΔACB

$$= v_0 t + \frac{1}{2}(v - v_0)t$$

$$\therefore \quad x = v_0 t + \frac{1}{2}at^2 \qquad \dots (2)$$

but average velocity,

$$x = \left(\frac{v + v_0}{2}\right)t \qquad \dots (3)$$

For, equation (3) and equation (1),

$$t = \frac{v - v_0}{a}$$

$$\therefore \quad x = \left(\frac{v + v_0}{z}\right)\left(\frac{v - v_0}{a}\right)$$

$$\therefore \quad v^2 - v_0^2 = 2ax \qquad \dots (4)$$

➠ Above equation can be written as follows :

$v = v_0 + at$

$x = x_0 + v_o t + \frac{1}{2} at^2$

$2a(x - x_0) = v^2 - {v_0}^2$

23. Obtain equations of motion for constant acceleration using method of calculus.

➠ Acceleration $a = \frac{dv}{dt}$

$\therefore$ $dv = a\,dt$

By integrating both sides,

$$\int_{v_0}^{v} dv = \int_{0}^{t} a\,dt$$

$$[v]_{v_0}^{v} = a[t]_0^t$$

$$\therefore \quad v - v_0 = at$$

$\therefore\ v = v_0 + at$ ... (1)

Now,

$$\frac{dx}{dt} = v$$

$\therefore\ dx = v\,dt$

By integrating both sides,

$$\int_{x_0}^{x} dx = \int_0^t v\,dt$$

$$[x]_{x_0}^{x} = \int_0^t (v_0 + at)dt \quad \text{[From equation (1)]}$$

$$x - x_0 = \left[v_0 t + \frac{at^2}{2}\right]_0^t$$

$$= v_0 t + \frac{1}{2}at^2$$

$$\therefore\ x = x_0 + v_0 t + \frac{1}{2}at^2 \quad ...\ (2)$$

$$\text{Now } a = \frac{dv}{dt} = \frac{dv}{dx} \times \frac{dx}{dt}$$

$$\therefore\ a = v\frac{dv}{dx} \qquad \left[\because \frac{dx}{dt} = v\right]$$

$\therefore\ v\,dv = a\,dx$

By integrating both sides,

➠ $$\int_{v_0}^{v} v\,dv = \int_{x_0}^{x} a\,dx$$

$$\left[\frac{v^2}{2}\right]_{v_0}^{v} = a[x]_{x_0}^{x}$$

$$\therefore\ \frac{v^2 - v_0^2}{2} = a(x - x_0)$$

$\therefore\ v^2 - {v_0}^2 = 2a(x - x_0)$

$\therefore\ v^2 = v_0^2 + 2a(x - x_0)$ ... (3)

Equation (1), (2) and (3) are equation of uniformly accelerated motion.

Section D

- **Answer the following Questions. [Each carries 4 marks]** **[4]**

24. **For an object moving on a straight line, draw $x \rightarrow t$ graphs for :**
   (i) When it is rest.
   (ii) When it is moving with constant velocity in positive direction.
   (iii) When it is moving with constant velocity in negative direction.
   (iv) When it performs non-uniform motion.

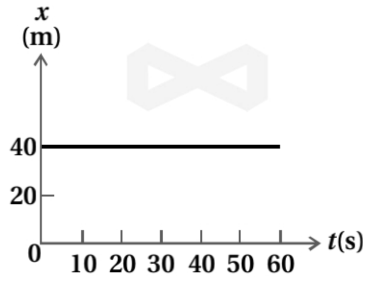
➠ Motion of an object can be represented by a position–time graph.

➠ Such a graph is a powerful tool to represent and analyse different aspects of motion of an object.

➠ For motion along a straight line, say X-axis, only x-coordinate varies with time and we have an x-t graph.

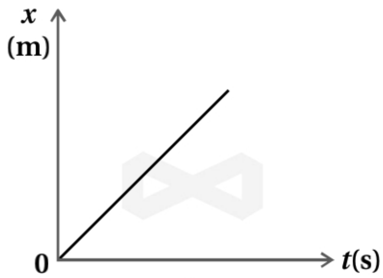
(1) Let us first consider the simple case in which an object is stationary. e.g. : a object standing

still at $x = 40$ m. The position–time graph is a straight line parallel to the time axis.



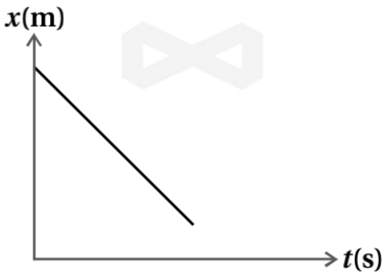
(a)

(2) If an object moving along the straight line covers equal distances in equal intervals of time, it is said to be in uniform motion.

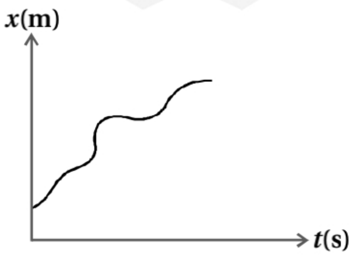


(b)

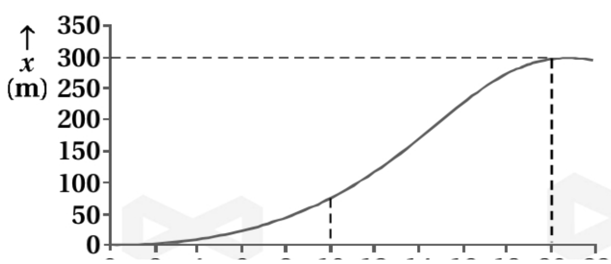
(3) The $x \rightarrow t$ graph for any object moving with constant negative velocity is as below.



(4) (a) If object covers different distances in different intervals of time, it is said to be nonuniform motion. The $x \rightarrow t$ graph for it is as below :



(b) Let us consider the motion of a car that starts from rest at time $t = 0$ s from the origin O.



0 2 4 6 8 10 12 14 16 18 20 22

t(s)→

- Picks up speed till t = 10 s and thereafter moves with uniform speed till t = 18 s. Then the brakes are applied and the car stops at t = 20 s and x = 296 m. The position–time graph for this case is as above.