LearnoHub
learning simplified

Class 11
PHYSICS

www.learnohub.com

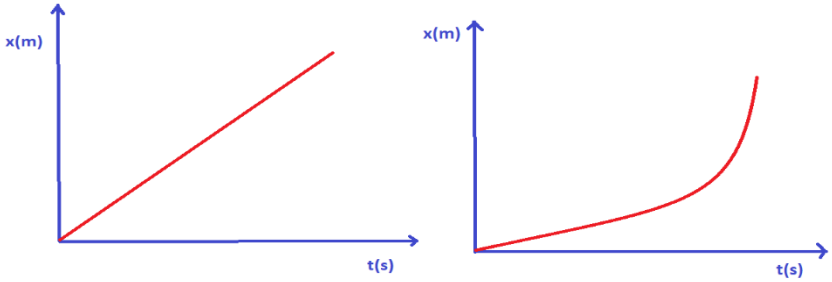
Motion in a Straight Line Daily Practice Problems Solutions

Question 1.

What do you understand by “uniform motion” and “non-uniform motion”?

Answer:

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



- If an object does not cover equal distances in equal intervals of time, it is said to be in non-uniform motion.
- In the above figures: 1st figure shows uniform motion and the 2nd figure shows non-uniform motion of an object.

Question 2.

What do you understand by the terms “average velocity” and “average speed”?

Answer:

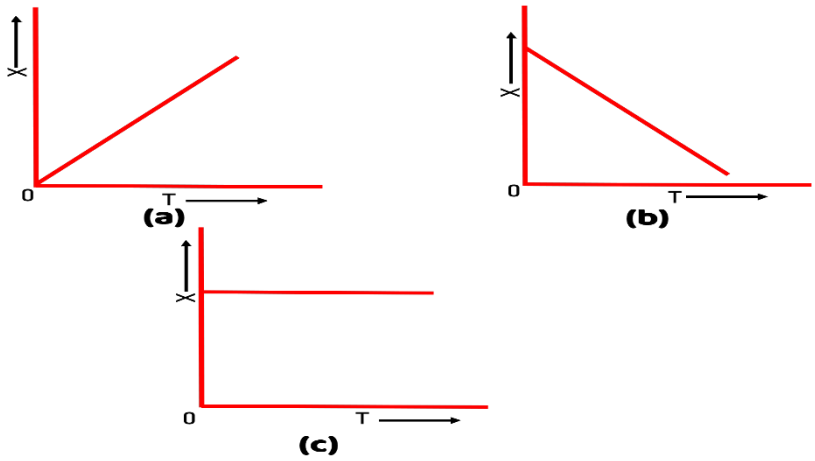
- Average velocity is defined as the change in position or displacement (Δx) divided by the time intervals (Δt), in which the displacement occurs:

$$\overline{v} = x_2\text{-}x_1/t_2\text{-}t_1 = \Delta x/\Delta t$$

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

- The average velocity can be positive or negative depending upon the sign of the displacement. It is zero if the displacement is zero.

- In the figure given below: (a) shows position-time graph for an object moving with positive velocity, (b) shows position-time graph for an



object moving with negative velocity, (c) shows position-time graph for an object at rest.

- Average speed is defined as the total path length travelled divided by the total time interval during which the motion has taken place:

  Average speed= Total path length/Total time interval
- Average speed has the same unit (ms^{-1}) as that of velocity.
- Average speed does not tell us in what direction an object is moving.
- Thus, average speed is always positive (in contrast to the average velocity which can be positive or negative).
- If the motion of an object is along a straight line and in the same direction, the magnitude of displacement is equal to the total path length. In that case, the magnitude of average velocity is equal to the average speed.

Question 3.

A bus is moving along a straight line. It moves from point A to point B in 15s and return from point B to point A in 5.0s. Calculate: the average velocity and average speed of the car in going from A to B? (Distance between point A and point B is 450m.)

Answer:

Average velocity = Displacement/Time interval
$\bar{v}$= 450/15 ms^{-1}= 30ms^{-1}.
Average speed = Path length/ Time interval
Average speed = 450/15 ms^{-1}= 30ms^{-1}.

Thus, in this case, the average speed is equal to the magnitude of the average velocity.

Question 4.

Define: Instantaneous velocity.

Answer:

The velocity at an instant or instantaneous velocity is defined as the limit of the average velocity as the time interval Δt becomes infinitesimally small. In other words,

$$v = \lim_{\Delta t \to 0} \Delta x/\Delta t = dx/dt$$

Where, dx/dt is the rate of change of position with respect to time, at an instant.

Question 5.

The position of an object moving along x-axis is given by: $x=b+ct^2$; where a=9.0m., $b=4.5ms^{-2}$and t is measured in seconds. What is its velocity at t=0s and t=3.0s? What is the average velocity between t=3.0s and t=6.0s?

Answer:

In notation of differential calculus, the velocity is

$$v = dx/dt = d/dt(b+ct^2)$$

$$v = 2c.t = (2\times4.5)\ ms^{-1}.$$

At t=0s, $v=0ms^{-1}$.
At t=3.0s, $v=27ms^{-1}$.
Average velocity= x (6.0)-x (3.0)/ (6.0-3.0) ms^{-1}.
Average velocity= b+36c-b-9c/3.0 = 27c/3.0 = 9 x c = (9 x 4.5) ms^{-1}.
Average velocity= 40.5 ms^{-1}.

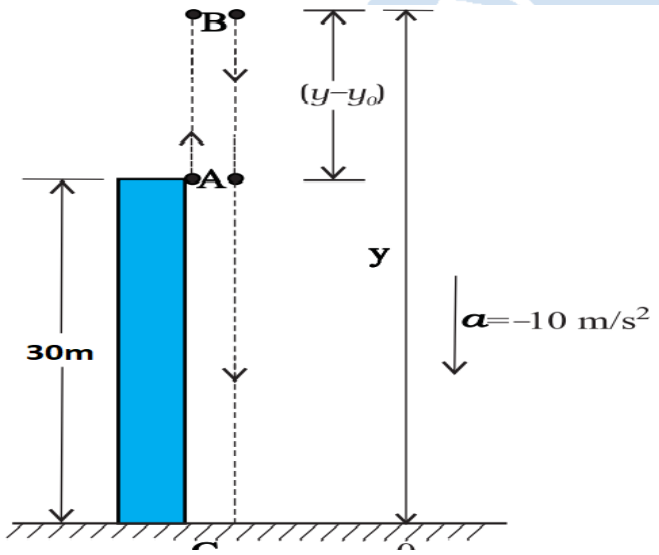
Question 6.

A ball thrown vertically upwards with a velocity of $15ms^{-1}$ from the top of a complex. The height of the point from where the ball is thrown is 30.0m from the ground. How high will the ball rise?

Answer:

According to the figure below,
Let us take the y-axis in the vertically upward direction with zero at the ground.
Now,
$v_0 = +15ms^{-1}$
$a = -g = -10ms^{-2}$
$v = 0ms^{-1}$
If the ball rises to height y from the point of launch, then using the equation;

$$v^2=v_0^2+2a(y-y_0)$$
$$0= (15)^2+2(-10)\ (y-y_0)$$
$$(y-y_0) = 225/20= 45/4 = 11.25m.$$
$$y= (30+11.25)\ m.=41.25m.$$



Question 7.

Two parallel rail tracks run north-south. Train P moves north with a speed of $63kmh^{-1}$, Q moves south with a speed of $81kmh^{-1}$. What is the

(a) Velocity of Q with respect to P?
(b) Velocity of ground with respect to Q?

Answer:

v_p = +63km/h = 63×5/18ms^{-1}= 17.5 ms^{-1}.
v_Q= -81km/h = -81×5/18ms^{-1}= -22.5 ms^{-1}.
(a) Relative velocity of Q with respect to P = v_Q- v_p= (-22.5-17.5) ms^{-1}
Relative velocity of Q with respect to P = -40.0ms^{-1}.
i.e., the train Q appears to P to move with a speed of 40ms^{-1} from north to south.
(b) Relative velocity of ground with respect to Q = 0- v_Q= 0-(-22.5ms^{-1})
Relative velocity of ground with respect to Q = 22.5ms^{-1}.

Question 8.

How do you define "average acceleration"?

Answer:

The average acceleration an over a time interval is defined as the change of velocity divided by the time interval:

$$\bar{a} = v_2\text{-}v_1/t_2\text{-}t_1 = \Delta v/\Delta t$$

where v_2 and v_1 are the instantaneous velocities or simply velocities at time t_2 and t_1. It is the average change of velocity per unit time. The SI unit of acceleration is ms^{-2}.

Question 9.

A car moving along a straight highway with speed of 159kmh^{-1} is brought to a stop within a distance of 300m. What is the retardation of the car (assumed uniform), and how long does it take for the car to stop?

Answer:

Given:
Initial velocity (u) of the car = 159km/h. = 159×5/18ms^{-1}= 44.166m/sec.
u = 44.2 ms^{-1}.
Final velocity (v) = 0ms^{-1}.
Distance covered (S) = 300m.
Using equation:

$v^2-u^2=2aS$
$a = v^2-u^2/2S = (0-(44.2)^2)/2\times300\ ms^{-2}$.
$a = -(1953.64/600)\ ms^{-2}. = -3.25\ ms^{-2}$.
(Negative sign indicates that it is retardation).
Using equation,
$v = u+at$
$t = (v-u)/a = (0-44.2)/ (-3.25)$ seconds = 13.6 seconds.
It will take 13.6 seconds for the car to stop.

Question 10.

Megha starts from her home at 11:00 AM, walks with a speed of $4kmh^{-1}$ on a straight road up to the market 2.0km away, visited market up to 3:00PM, and returns home by a cab with a speed of $30kmh^{-1}$. Choose the suitable scales and plot x-t graph of her motion.

Answer:

Speed of Megha = $4kmh^{-1}$.
Distance between the market and her home = 2.0km.
Time taken = (Distance)/(Speed) = (2.0)/ (4) hours
Time taken = 0.5 h. = 30 min.
It is also given that she covers the same distance in the evening by a cab.
Now, speed of the cab = $30kmh^{-1}$.
Time taken = (Distance)/(Speed) = (2.5)/ (30) hours = 0.0833 h.
Time taken = (0.083 × 60) min. = 4.98 min.

Question 11.

What are the dimensions and units for “path length” and “displacement”?

Answer:

Path length:

- Unit: metre.
- Dimension: $[M^0L^1T^0]$.

Displacement:

- Unit: metre.

- Dimension: $[M^0L^1T^0]$.

Question 12.

Write down the three kinematic equations of motion.

Answer:

For objects in uniformly accelerated rectilinear motion, the five quantities, displacement x, time taken t, initial velocity v_0, final velocity v and acceleration a are related by a set of simple equations called kinematic equations of motion:

- $v = v_0 + at$.
- $x = v_0t + 1/2at^2$.
- $v^2 = v_0^2 + 2ax$.

Where, v_0 is the initial velocity, v is the final velocity, a is the acceleration and t is the time taken by an object.

Question 13.

Differentiate between "path length" and "displacement".

Answer:

Path Length	Displacement
• Path length is defined as the total length of the path traversed by an object. • The path length traversed by an object between two points is, in general, not the same as the magnitude of displacement. • The path length (as the name implies) depends on the actual path.	• Displacement is defined as the change in position: $\Delta x = x_2 - x_1$. • The displacement depends only on the end points. • In all other cases (except one-dimensional motion), the path length is greater than the magnitude of displacement.

Question 14.

In which case, the average velocity and the average speed of an object would be the same?

Answer:

- Average velocity is the displacement divided by the time interval in which the displacement occurs: $\bar{v}$ = dx/dt.
- Average Speed is the ratio of total path length traversed and the corresponding time interval.
- In one-dimensional motion of an object; the total path length equals to the displacement.
- So, in one-dimensional motion of an object; the average velocity will be equal to the average speed of an object.

Question 15.

Does the zero velocity of a particle at any instant necessarily imply zero acceleration?

Answer:

- The zero velocity of a particle at any instant does not necessarily imply zero acceleration at that instant.
- A particle may be momentarily at rest and yet have non-zero acceleration.
- For example, a particle thrown up has zero velocity at its uppermost point but the acceleration at that instant continues to be the acceleration due to gravity.

Question 16.

A jet airplane travelling at the speed of 600kmh^{-1} ejects its products of combustion at the speed of 1800kmh^{-1} relative to the jet plane. What is the speed of the latter with respect to an observer on the ground?

Answer:

Let the velocity of jet (v_j) = 600kmh^{-1}.
Let the velocity of observer on the ground (v_0) = 0kmh^{-1}.
Let the velocity of ejected gas = v_e.
So, the relative velocity of jet with respect to ground = (v_j-v_0) = 600kmh^{-1}.
The relative velocity of ejected gas with respect to jet = (v_e-v_j) = -1800kmh^{-1}.
Therefore, the relative velocity of ejected gas with respect to ground = (v_e-v_0)
(v_e-v_0) = (v_e-v_j) + (v_j-v_0) = (-1800 + 600) kmh^{-1}. = -1200 kmh^{-1}.
(Negative sign indicates the relative speed of ejected products is opposite to the direction of jet.)

Question 17.

A ball is dropped from a height of 80m. on a floor. At each collision with the floor, the ball loses one-eighth of its speed. Plot the speed-time graph of its motion between t=0 to 11s.

Answer:

Given:
Ball is dropped from a height, S = 80m.
Initial velocity of the ball, u = 0m/s.
Acceleration, a = g = 9.8 ms^{-2}.
From second eq. of motion,
$S = ut + (1/2)\, at^2$
$80 = 0 + (1/2) \times 9.8 \times (t_1)^2$.
t_1 = 4.03 s.
From first equation of motion, final velocity is given:
$v_1 = u+at = 0 + (9.8 \times 4.03) = 39.5$ ms^{-1}.
The ball loses one-eighth of the velocity at collision. So, the rebound velocity of the ball is, $u_r = v_1 – (1/8)\, v_1 = (7/8)\, v_1 = (7/8 \times 39.5)$ ms^{-1}.
u_r = 34.56 ms^{-1}.
Time (t) taken by the ball to reach maximum height can be obtained by using first equation of motion as:
$v = u_r + at'$
$0 = 34.56 + (-9.8)\, t'$.
t' = (-34.56)/ (-9.8) = 3.52s.
Total time taken by the ball = (t_1+t') = (4.03 +3.52) s = 7.55s.

As, the time of ascent is equal to the time of descent, the ball takes 3.52s to strike back on the floor for the second time.
The velocity with which the ball rebounds from the floor = (7/8 × 34.56) ms^{-1}.
The velocity with which the ball rebounds from the floor = 30.24 ms^{-1}.
Total time taken by the ball for second rebound = (7.55 + 3.52) s. = 11.07 s.

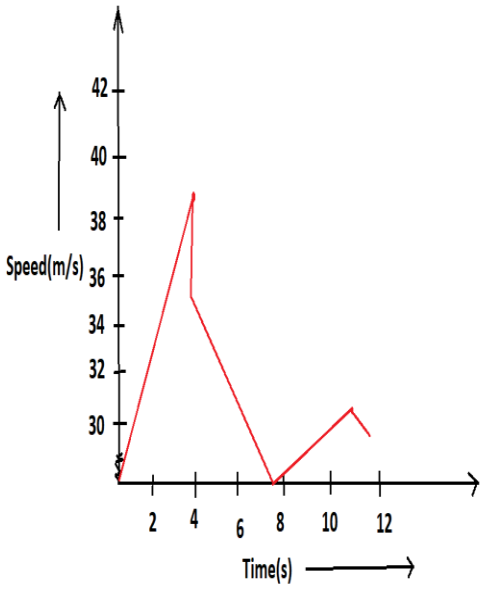


Fig.: Speed-time graph for the given condition.

Question 18.

Explain with example that how the magnitude of displacement may or may not be equal to the path length traversed by an object.

Answer:

The magnitude of displacement may or may not be equal to the path length traversed by an object.
For example:

- For motion of the car from first point to the end point, the path length is +400 m and the displacement is +400 m. In this case, the magnitude of displacement (400 m) is equal to the path length (400 m).
- But if we consider the motion of the car from first point to end point and back to the centre of these two points. In this case, the path length = (+400m) + (+200 m) = + 600 m. However, the displacement = (+200 m) –

(0 m) = + 200 m. Thus, the magnitude of displacement (200 m) is not equal to the path length (600 m).

- The magnitude of the displacement for a course of motion may be zero but the corresponding path length is not zero. For example, if the car starts from first point, goes to end point and then returns to final point, the final position coincides with the initial position and the displacement is zero. However, the path length of this journey is = (400 + 400) m. = 800m.

Question 19.

Anil standing on a stationary lift (open from above) throws a ball upwards with the maximum initial speed he can, equal to $55ms^{-1}$. How much time the ball takes to return to his hands?

Answer:

Initial velocity of the ball, $u = 55ms^{-1}$.
Anil throws the ball upwards, when the lift is stationary and the vertically upward direction is taken as the positive direction.
Therefore, the displacement of the ball = zero.
From the second equation of motion;
$S = ut + (½)at^2$
$0 = (55)t + (½)(-9.8)t^2$.
$t = (55 \times 2)/9.8 = 11.22s$.

Question 20.

A person walking in a narrow lane takes 3 steps forward and 2 steps backward, followed again by 3 steps forward and 2 steps backward, and so on. Each step is 1m. long and requires 1 s. Plot x-t graph of his motion. Determine graphically and otherwise how long the man takes to reach a wall 5m. away from the start.

Answer:

Distance covered with 1 step = 1m.
Time taken = 1 s.

Time taken to move first 3m. forward = 3s.
Time taken to move 2 steps backward = 2s.
Net distance covered = (3 – 2) m. = 1m.
Net time taken to cover 1m. = (3+2) s. = 5s.
So, the person covers 1m. in 5s.
Person covered 2m. in 10s.
Person covered 3m. in 15s.
Person covered 4m. in 20s.
Person covered 5m. in 25s.
So, the net time taken by the person to cover 5m. = 25s.

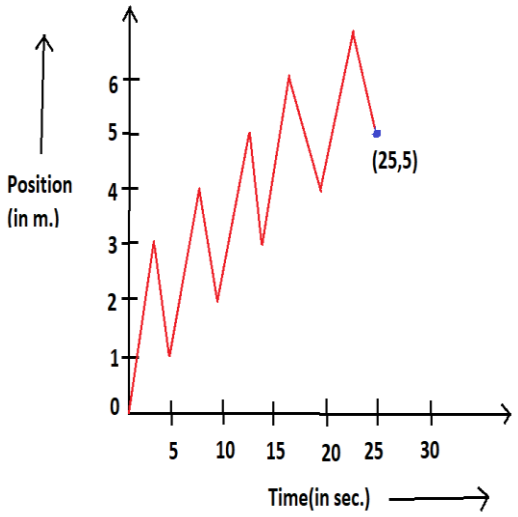


Fig.: x-t graph for given condition.

****