Motion in a Straight Line

Short Answer Questions (2 Marks)

Q1. Write the characteristics of displacement.

Ans: Following are the characteristics of displacement:

(1) Displacement is a vector quantity having both magnitude and direction.

(2) Displacement of a given body can be positive, negative, or zero.

Q2. Sameer went on his bike from Delhi to Gurgaon at a speed of 60km/hr and came back at a speed of 40km/hr. What is his average speed for the entire journey?

Ans: In the above question it is given that:

Speed of the bike when Sameer traveled from Delhi to Gurgaon is v1=60km/hr.
Come back speed is v2=40km/hr.
Therefore, average speed will be:
Average speed=2v1v2/v1+v2=2(60)(40)/60+40=48km/hr.

Q3. What causes variation in the velocity of a particle?

Ans: Variation in velocity of a particle happens when:
(1) magnitude of velocity changes
(2) direction of motion changes.

4 Marks Answers and Questions

Q1. A stone is dropped from the top of a cliff and found to travel 44.1m before diving at the last second. What is the cliff's height? (g = 9.8m/s2)

A1. Consider the height of the cliff to be h.

u = 0m/s,

a = g = 9.8m/s2.

If n is the total time taken by the stone while falling,

Snth = u+a2(2n−1)

44.1 = 0+9.82(2n−1)

N = 102 = 5s

Now,

h = ut+12at2

h = 12(9.8)(5)2 = 122.5m, which is the required height.

Q2. A woman leaves her house at 9.00 a.m., walks at a speed of 5 km/hr on a straight road to her office, which is 2.5 km away, works there until 5.00 p.m., and then returns home by auto at a speed of 25 km/hr. Select appropriate scales and draw the x-t graph of her motion.

A2. It is given that:

Speed of the woman = 5 km/h

Distance between her office and home = 2.5 km

Time taken = Distance / Speed

= 2.5 / 5 = 0.5 h = 30 min

It is given that she covers the same distance in the evening by auto.

Now, the speed of the auto = 25 km/h

Time taken = Distance / Speed

= 2.5 / 25 = 1 / 10 = 0.1 h = 6 min

Q3. Regular bus service connects two towns, A and B, with a bus leaving in either direction every T minutes. A man cycling at 20 km/hr from A to B notices that a bus passes him every 18 minutes in the direction of his motion and every 6 minutes in the opposite direction. What is the bus service period T, and at what speed (assumed constant) do the buses travel on the road?

A1.

Consider V to be the speed of the bus running between towns A and B.

In the question, it is given that:

Speed of the cyclist is v=20 km/hr

The relative speed of the bus moving in the direction of the cyclist will be V−v = (V−20)m/s.

The bus went past the cyclist every 18 min, i.e., 18 / 60 h (when he moves in the direction of the bus).

Hence, distance covered by the bus = (V − 20) × 18 / 60 km …. (i)

As one bus leaves after every T minutes,

the distance travelled by the bus will be = V × T / 60 …. (ii)

As equations (i) and (ii) are equal,

(V − 20) × 18 / 60 = V × T / 60 ….. (iii)

The relative speed of the bus moving in the opposite direction of the cyclist will be (V + 20) km/h.

Thus, the time taken by the bus to go past the cyclist = 6 min = 6 / 60 hr.

⇒(V + 20)×6 / 60 = V × T / 60 …. (iv)

From (iii) and (iv), we get

(V + 20) × 6 / 60 = (V − 20) × 18 / 60

V + 20 = 3V 60

2V = 80

V = 40 km/h, which is the required speed.

Substituting the value of V in equation (iv),

(40 + 20) × 6 / 60 = 40 T / 60

T = 360 / 40 = 9 min, which is the required time period.

Q4. What is motion in a straight line and its types?

Ans: As we know, the change in position of a body with respect to time and its environment is called in motion. Therefore, as the name suggests, motion in a straight line is basically a linear motion in a certain straight line. Therefore, motion in a straight line uses one dimension only.

Types of Linear Motion

Uniform motion

Non-uniform motion

Q5. From the top of a multi-storey building, a ball is thrown vertically upwards with a velocity of 30m/s. In how much time the ball will hit the ground, if the height of the point from where the ball is thrown is 20 m from the ground? Take g=10ms−2.

We can use v=u+at to calculate the time required by the ball to reach maximum height:

0=30+(−10) t

t=3sec

Since, s = ut+0.5at2

= 30(3) +0.5(−10) (3)2 = 45m

Therefore, for maximum height, the total distance is (45+20) m

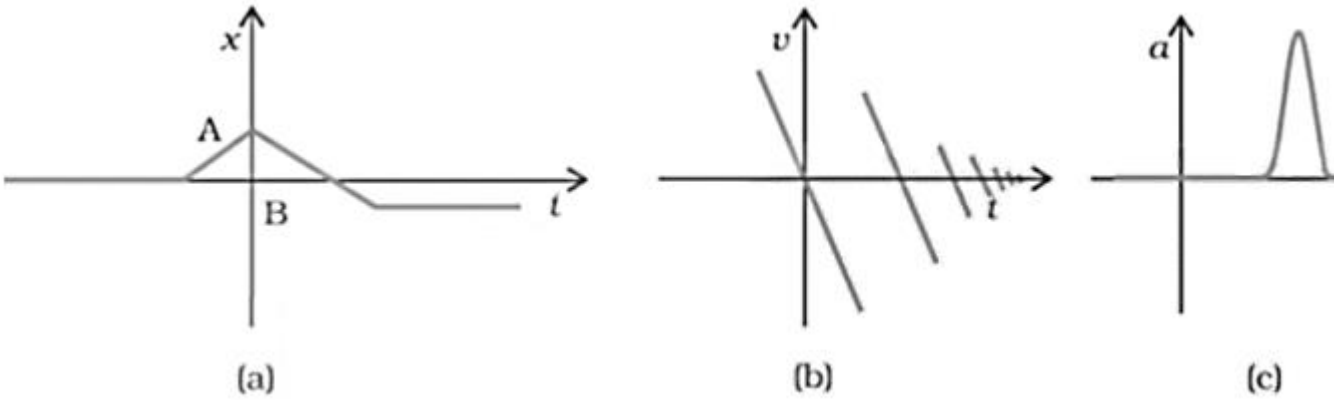
Now, s = ut+0.5at2

65=0+0.5(10) (t′)2

t′ =3.60sec

Total time= 3.60 + 3= 6.60sec

Q6. Suggest a suitable physical situation for each of the following graphs (figure):



Ans: Consider fig 3.22 given in the question:
a. From the x-t graph given it is clear that initially a body was at rest. Further, its velocity increases with time and attains an instantaneous constant value. The velocity then reduces to zero with an increase in time. Further, its velocity increases with time in the opposite direction and acquires a constant value. A similar physical situation arises when a football (initially kept at rest) is kicked and gets rebound from a rigid wall so that its speed gets reduced. Then, it passes from the player who has kicked it and ultimately stops after sometime.

b. From the given v-t graph it is clear that the sign of velocity changes and its magnitude decreases with a passage of time. This type of situation arises when a ball is dropped on the hard floor from a height. It strikes the floor with some velocity and upon rebound, its velocity decreases by a factor. This continues till the velocity of the ball eventually becomes zero.

c. From the given a-t graph it is clear that initially the body is moving with a certain uniform velocity. Its acceleration increases for a short interval of time, which again drops to zero. This shows that the body again starts moving with the same constant velocity. This type of physical situation arises when a hammer moving with a uniform velocity strikes a nail.

Q7. Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 km/h in the same direction, with A ahead of B. The driver of B decides to overtake A and accelerates by 1 m/□ . If after 50 s, the guard of B just 2 brushes past the driver of A, what was the original distance between them?

Ans: Since both the objects are in motion it will be easier for us to do this problem in the relative frame. We take train A as an observer.

Let the distance between the guard of B and the driver of A be s.

Since both the trains are travelling with the same velocity initially, the relative initial velocity of B with respect to A(u) is 0.

Since A is not accelerating the relative acceleration would be the same as the acceleration wrt the ground frame, a= 1m/□ 2

The time is taken to cover s distance by B wrt A = 50 s Using the second equation of motion

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

The distance between the guard of A and driver of B initially is 1250 meter

7 Marks Answers and Questions

Q1. A man walks from his house to a market 2.5 kilometres away at a speed of 5 kilometres per hour on a straight road. When he discovers that the market is closed, he immediately turns around and walks back home at a speed of 7.5 km/h. What exactly is the

(a) the average velocity magnitude, and

(b) the average speed of the man over the time intervals?

(i) 0 to 30 minutes

(ii) 0 to 50 minutes

(iii) 0 to 40 minutes

(Note: This exercise will show you why it is better to define average speed as total path length divided by time rather than average velocity magnitude. You don't want to tell the tired man on his way home that his average speed was 0.)

A1. In the question, it is given that,

Time taken by the man to reach the market from home is t1 = 2.5/5 = 1/2hr = 30min.

Time taken by the man to reach home from the market is t2 = 2.5/7.5 = 1/3hr = 20min.

Total time taken in the whole journey = 30 + 20 = 50 min

1. i) 0 to 30 min

Average velocity = Displacement/Time

Average speed = Distance/Time

1. ii) 0 to 50 min

Time = 50 min = 50/60 = 5/6 h

Net displacement = 0

Total distance = 2.5 + 2.5 = 5 km

Average velocity = Displacement / Time = 0

Average speed = Distance / Time = 5/(5/6) = 6 km/h

iii) 0 to 40 min

Speed of the man = 7.5 km/h

Distance travelled in first 30 min = 2.5 km

Distance travelled by the man (from the market to home) in the next 10 min

= 7.5 × 10/60 = 1.25 km

Net displacement = 2.5 1.25 = 1.25 km

Total distance travelled = 2.5 + 1.25 = 3.75 km

Average velocity = Displacement / Time = 1.25 / (40/60) = 1.875 km/h

Average speed = Distance / Time = 3.75 / (40/60) = 5.625 km/h

Q2. Figure gives a speed-time graph of a particle in motion along a constant direction. Three equal intervals of time are shown. In which interval is the average acceleration greatest in magnitude? In which interval is the average speed greatest? Choosing the positive direction as the constant direction of motion, give the signs of v and a in the three intervals. What are the accelerations at the points A, B, C and D?

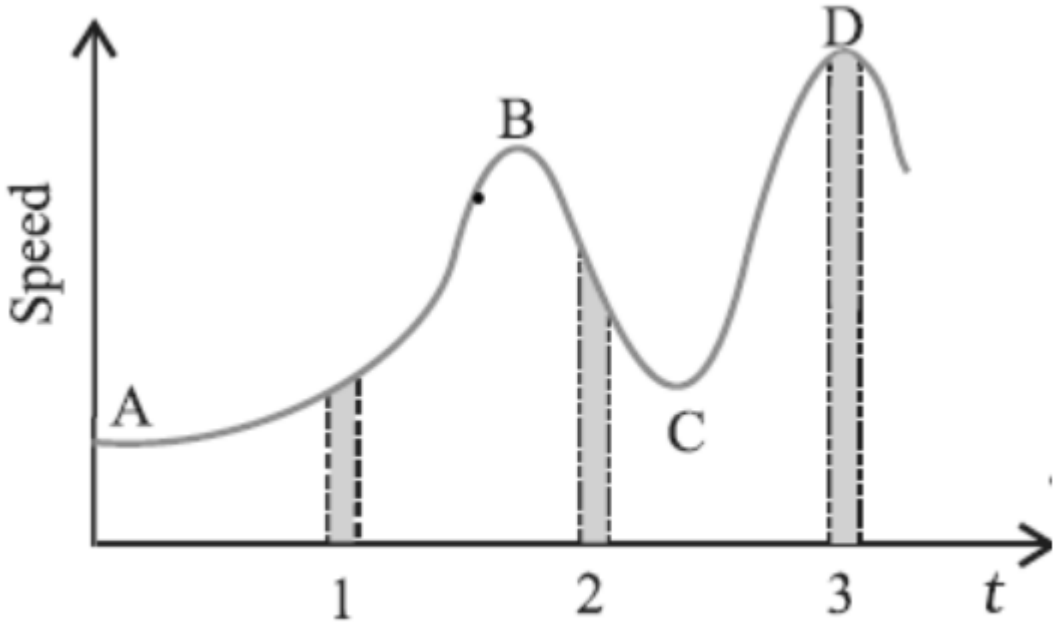


Fig. 3.25

Ans: From the graph given in the question,

Average acceleration is greatest in interval 2
.
Average speed is greatest in intervals of 3.
v is positive for intervals 1, 2, and 3.
a is positive for intervals 1 and 3 and negative in interval 2

a = 0 at A, B, C, D

Acceleration is calculated as the slope of the speed-time graph. In the given case, it is given by the slope of the speed-time graph within the given interval of time.
As the slope of the given speed-time graph is maximum in interval 2
, average acceleration will be the greatest in this interval.
From the time-axis, height of the curve gives the average speed of the particle. It is clear that the height is the greatest in interval 3. Thus, average speed of the particle is the greatest in the interval 3.
For interval 1:
The slope of the speed-time graph is positive. Hence, acceleration is positive. Similarly, the speed of the particle is positive in this interval.
In interval 2:
As slope of the speed-time graph is negative, acceleration is negative in this interval. However, speed is positive because it is a scalar quantity.
In interval 3:
As the slope of the speed-time graph is zero, acceleration is zero in this interval.
However, here the particle acquires some uniform speed. It is positive in this interval.
Points A, B, C, and D are all parallel to the time-axis. Thus, the slope is zero at these points.
Therefore, at points A, B, C, and D, acceleration of the particle is zero.

Multiple Choice Questions

1) If the total displacement is divided by the total time taken, which of the following will be obtained?

a) Speed

b) Acceleration

c) Uniform velocity

d) Average Velocity

Answer: (d)

Explanation: Since velocity is said to be uniform when at every instant of time the velocity is equal to the average velocity, speed is the total distance divided by time, acceleration

is obtained by velocity divided by time, and the average velocity is attained when total displacement is divided by the total time taken.

2) What kind of energy does a body possess when it is in the state of complete rest?

a) Kinetic energy

b) Potential energy

c) Thermal energy

d) Electrical energy

Answer: (b)

Explanation: There is no motion when a body is in a state of rest. Therefore, there will be no kinetic energy, and as we know, the sum of kinetic and potential energies is the total energy. Hence the total energy stored in the body will be potential energy.

3) Rectilinear motion is said to be what kind of motion?

a) Four dimensional

b) Three dimensional

c) One dimensional

d) Zero dimensional

Answer: (c)

Explanation: Since the linear motion, also entitled the rectilinear motion, happens in a straight line, it uses one dimension only. Therefore, rectilinear motion is one dimensional.

4) Which among the following forces can probably act on a body whose motion is in a straight line?

a) Force of friction

b) Tangential force

c) Magnetic force

d) Centrifugal force

Answer: (a)

Explanation: Since no surface in the world of physics is frictionless, whenever a body is in motion, the force of friction acts on it. And rest, all the given forces act on the body under some special conditions, like when it moves along a curve, and the magnetic force acts on a body when placed in a magnetic field.

5) Which among the following types of motion does not define the motion of the hand of a clock?

a) Rectilinear or linear

b) Periodic

c) Harmonic

d) Circular

Answer: (a)

Explanation: The motion of a hand of a clock is not a rectilinear motion, as it exhibits circular motion, because it moves in a circular manner. Furthermore, this motion also occurs periodically, so it is also a periodic motion too.

6. Which is the formula for motion in a straight line

a. v =u + at
b. v =u – at
c. U = 2at+v
d. v = 2at+u

Answer: (a) v =u + at

Explanation: The formula for motion in a straight line is v =u + at.

7. The ratio of the average velocity and average speed of a body is

a. 1
b. More than 1
c. 1 or Less than 1
d. None of these options

Answer: (c) 1 or Less than 1

Explanation: The ratio of the average velocity and average speed of a body is always 1 or less than 1.

8. Which among the following can be zero when a particle is in motion for some time.

a. Speed
b. Force
c. Time
d. Displacement

Answer: (d) Displacement

Explanation: Displacement can be zero when a particle is in motion for some time.

9. A particle is moving with a constant speed along a straight-line path. A force is not required to

a. change its direction
b. decrease its speed
c. keep it moving with uniform velocity
d. Increase its momentum

Answer: (c) keep it moving with uniform velocity

Explanation: Force is not required for a particle to move with a constant speed along a straight-line path.

10. Consider a body moving with an acceleration of 2 m/s^2. After t seconds its velocity is 10 m/s. Find ‘t’.

a. 4 s
b. 20 s
c. 5 s
d. 8 s

Answer: (c) 5 s

Explanation: V=U+at

t=v-u/a = 10/2= 5 s