CHAPTER

7

Motion

UNIT – III
Motion, Force and Work

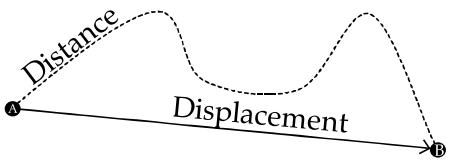
Syllabus

Distance and displacement, velocity; uniform and non-uniform motion along a straight line; acceleration, distance-time and velocity-time graphs for uniform motion and uniformly accelerated motion, derivation of equations of motion by graphical method; elementary idea of uniform circular motion.

TOPIC-1
Physical Quantities Describing Motion

Revision Notes

- While describing motion, it is necessary to understand the concepts such as distance, displacement, speed, velocity and acceleration.
- **Distance :** The distance covered by a moving object is the actual length of the path followed by the object. Distance is a scalar quantity. SI unit of distance is metre.
- **Displacement :** It is the shortest distance covered by a moving object from the point of reference (initial position of the body), in a specified direction. SI unit of displacement is metre.
- **Speed :** It is the ratio of distance travelled to the time taken to cover that distance. The S.I. unit of speed is metre per second. Speed is a scalar quantity which means it has only magnitude *i.e.* only a numerical value. The average speed of a body is the total distance travelled divided by the total time taken.



- We can find out the speed with which an object is moving by the following formula :

  Speed = Distance/Time
- For example, if a boy riding a bicycle covers a distance of 150 m in 30 seconds, the speed will be 150/30 = 5 m/s
- **Uniform speed :** An object is said to be moving with uniform speed if it covers equal distances in equal intervals of time.
- **Non-uniform speed :** An object is said to be moving with variable speed or non-uniform speed if it covers equal distances in unequal intervals of time or vice-versa.
- **Velocity :** It is defined as the distance covered by a moving object in a particular direction in unit time or speed in a particular direction. Velocity is displacement per unit time.
- Velocity is a vector quantity, which means it has both magnitude and direction. The S.I. unit of velocity is metre per second. The average velocity is displacement divided by the time taken.
- We can find out the velocity with which an object is moving by the following formula:

  Velocity = Displacement /Time
- For example, if a body gets displaced by 300 m in a particular direction in 30 seconds, its velocity will be, 300/30 = 10 m/s in that direction.

- **Uniform velocity :** A body is said to be moving with uniform velocity if it covers equal distances in equal intervals of time in a specified direction.
- **Variable velocity :** A body is said to be moving with variable velocity if it covers unequal distances in equal intervals of time and vice-versa in a specified direction or if it changes the direction of motion.
- **Acceleration :** It is the rate of change of the velocity of an object with respect to time. Acceleration is a vector quantity. It can be negative. Its S.I. unit is metre per second square.
- Acceleration = Change in velocity / Time taken
- For example, if a body is moving with a velocity of 30 m/s initially, changes its velocity to 50 m/s, in 10 seconds. Then the acceleration shown by the body will be, acceleration = change in velocity / time taken = 50 -30/ 10 = 20/10 = 2 metre per second square.

Activity 7.1

- Identify one example each for the below type of motion from your everyday life.
  - **(a)** acceleration is in the direction of motion,
  - **(b)** acceleration is against the direction of motion,
  - **(c)** acceleration is uniform,
  - **(d)** acceleration is non-uniform.
- **Observations :**
  - **(a)** Acceleration of a moving car.
  - **(b)** When brakes are applied to the car in motion.
  - **(c)** Acceleration of a freely falling body.
  - **(d)** Motion of bus leaving a bus stop.

- **Uniform Acceleration :** If the change in velocity in equal intervals of time is always the same, then the object is said to be moving with uniform acceleration.
- **Non-uniform or Variable Acceleration :** If the change in velocity in equal intervals of time is not the same, then the object is said to be moving with variable acceleration.
- **Motion :** If the position of an object does not change with time, it is said to be at rest. On the other hand, if the position of an object changes as time passes, it is said to be in motion.
- An object may appear to be moving for one person and stationary for some other. Thus, rest and motion are relative terms.

SELF ASSESSMENT – 1

I. OBJECTIVE TYPE QUESTIONS [1 mark each]

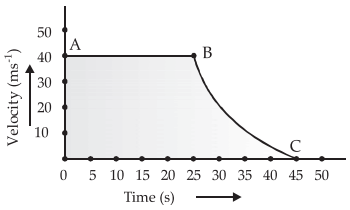
A. Multiple Choice Questions

Q. 1. The numerical ratio of displacement and distance for a moving object is
- **(a)** Always less than 1
- **(b)** Always equal to 1
- **(c)** Always more than 1
- **(d)** Equal or less than 1

Q. 2. **In which of the following cases of motions, the distance moved and the magnitude of displacement are equal?**
- **(a)** If the car is moving on straight road
- **(b)** If the car is moving in circular path
- **(c)** The pendulum is moving to and fro
- **(d)** The earth is revolving around the sun

B. Diagram Based Questions

Q. 1. **The velocity-time graph of an object is shown in the following figure :**



- **(a)** State the kind of motion that objects has, from A to B and from B to C.
- **(b)** Identify the part of graph where the object has zero acceleration. Give reasons for your answer.
- **(c)** Identify the part of graph where the object has negative acceleration. Give reasons for your answer.
- **(d)** State the reason, why velocity-time graph can never be a straight line parallel to velocity axis ?

C. Assertion and Reason type questions

Directions : In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as :

(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A)

(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

(c) Assertion (A) is true but reason (R) is false.

(d) Assertion (A) is false but reason (R) is true.

Ⓚ **Q. 1. Assertion :** Displacement for a course of motion may be zero but the corresponding distance covered is not zero.

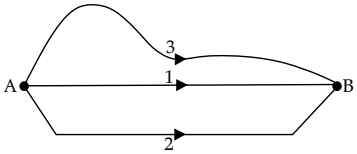
Reason : Displacement and distance covered may not always equal.

Ⓚ **Q. 2. Assertion :** Motion of satellites around their planets is considered an accelerated motion.

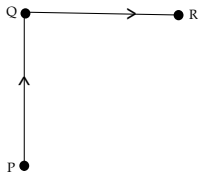
Reason : During their motion, the speed remains constant, while the direction of motion changes continuously.

D. Very short answer type questions

Q. 1. A person standing at A goes to B by following any of the paths 1, 2, or 3. Which path can we measure to find the average velocity? Ⓐ



Q. 2. An ant travels from P to Q and then moves from Q to R (as shown in the diagram). Show its resultant displacement in the diagram. Ⓐ



Q. 3. What is motion? Ⓡ

Q. 4. What is the rate of change of velocity called? Ⓡ

II. SHORT ANSWER TYPE QUESTIONS-I [2 marks each]

Q. 1. Name the physical quantities denated by :

(i) the slope of the distance –time graph

(ii) the area under velocity–time graph

(iii) the slope of velocity–time graph

Ⓐ **(Board Term-II, 2015)**

(DDE 2014) (Board Term-I, 2014)

Q. 2. Explain the following type of motion with one example for each.

(i) acceleration is positive

(ii) acceleration is negative

(iii) acceleration is zero. Ⓐ **(Board Term-I, 2016)**

III. SHORT ANSWER TYPE QUESTIONS-II [3 marks each]

Q. 1. Define velocity and acceleration. Is it possible for a body to have zero velocity but constant acceleration? Justify your answer.

Ⓡ+Ⓐ **(Board Term-I, 2012, 2014)**

AI **Q. 2.** Define speed and velocity. Write their SI units. A body is moving with a velocity of 15 m/s. If the motion is uniform, what will be the velocity after 10 s? Ⓡ+Ⓐ **(Board Term-I, 2015)**

IV. LONG ANSWER TYPE QUESTIONS [5 marks each]

Ⓐ+Ⓤ **Q. 1. (a)** State the relation between distance and time :

(i) When a body is moving with uniform velocity.

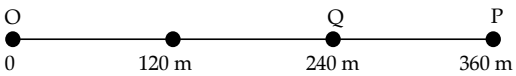
(ii) When a body is moving with variable velocity.

(b) How is distance different from displacement?

(c) A train is travelling at a speed of 90 km/h. Brakes are applied in the train so as to produce a uniform acceleration of 0.5 m/s^2. Find distance covered by train, before it is brought to rest?

Ⓡ+Ⓐ AI **Q. 2. (a)** Differentiate between average velocity and average speed.

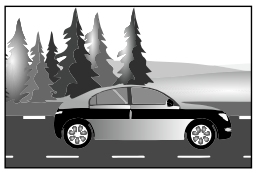
(b) A car is moving along a straight line OP as shown below. It moves from O to P in 18 s and returns from P to Q in 6 s. What are the average velocity and average speed of the car in going (i) from O to P (ii) from O to P and back to Q.) ?



TOPIC-2
All Types of Motion

Revision Notes

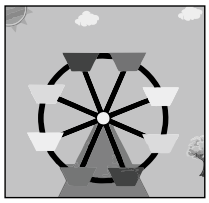
- Various types of motion of can be seen around us. For example, motion along a straight line, Uniform motion, Non-uniform motion, Circular Motion, Uniform circular motion.
- **Motion along a straight line :** It is the simplest type of motion where an object moves along a straight line. For example, a car moving on a straight road.
- **Uniform motion :** A body is said to be in uniform motion, if it travels equal distances in equal intervals of time. For example, a car going along a straight level road at steady speed.
- **Non-uniform motion :** A body is said to have non-uniform motion if it travels unequal distances in equal intervals of time. For example, a moving train. In non-uniform motion, speed of an object is not constant.
- **Circular motion :** Motion along circular track is called circular motion. For example, motion of a giant wheel.



Motion along a straight-line

Non-uniform motion

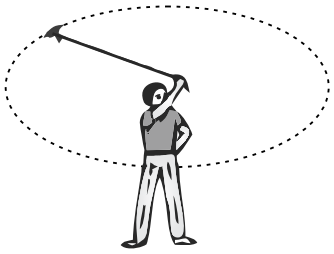
Uniform circular motion

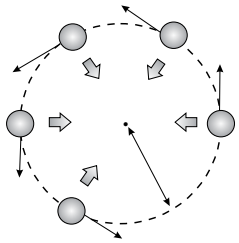


Circular motion

Activity 7.2

- Take a piece of thread and tie a small piece of stone at one of its ends. Move the stone to describe a circular path with constant speed by holding the thread at the other end, as shown in figure.
- Now, let the stone go by releasing the thread. Can you tell the direction in which the stone moves after it is released?
- **Observations** : On being released the stone moves along a straight line tangential to the circular path.
- **Uniform circular motion :** When a body travels along a circular path of constant radius with a constant speed then its motion is uniform circular motion. For example, motion of hands of a clock.
- In a uniform circular motion, the speed of a particle is constant, but its velocity changes as the direction of motion changes, hence it is an accelerated motion.





Uniform circular motion

SELF ASSESSMENT – 2

I. OBJECTIVE TYPE QUESTIONS [1 mark each]

A. Multiple Choice Questions

AI K **Q. 1. Which of the following is an example of uniformly accelerated?**

(a) Bus arriving at a bus stop.

(b) Motion of a free falling body.

(c) A car moving under normal traffic conditions.

(d) A person jogging in a park.

K **Q. 2. Which of the following is an example when we infer the motion indirectly?**

(a) Motion of air

(b) Motion of water

(c) Motion of car

(d) Motion of giant wheel

B. Diagram Based Question

Ⓐ **Q. 1. The distance moved by a student at different intervals of time, while walking to school, is given in the table below :**

Time from the starting point (s)	0	10	20	30	40	50
Distance moved (m)	0	15	30	45	30	60

(a) Draw the distance-time graph for the motion of the student indicating the scale chosen.

(b) What does the shape of the graph suggest about the type of motion ?

(c) Name the physical quantities denoted by the slope of the distance–time graph.

(d) State a condition under which a body moves in such a way that the magnitude of its average velocity is equal to its average speed.

C. Assertion and Reason Type Questions

Directions : In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as :

(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

(c) Assertion (A) is true but reason (R) is false.

(d) Assertion (A) is false but reason (R) is true.

Ⓚ **Q. 1. Assertion :** A boy riding on bicycle in a crowded street "exhibits" non uniform motion.

Reason : The boy covers equal distances in equal intervals of time.

Ⓚ **Q. 2. Assertion :** A stone tied with a piece of thread describing a circular path with constant velocity on being released moves in a straight line.

Reason : Along the circular path direction of motion remains the same at every point.

D. Very Answer short Type Questions

AI **Q. 1.** Give the technical term used for the rate of motion of a body. Ⓡ

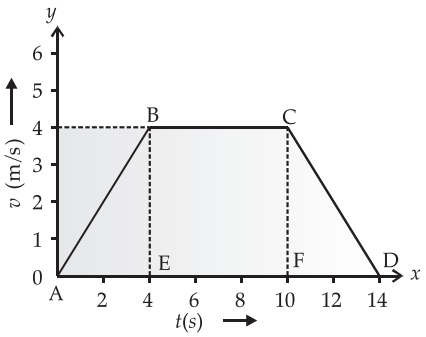
Q. 2. Define circular motion. Ⓡ

II. SHORT ANSWER TYPE QUESTIONS-I [2 marks each]

Q. 1. A body can have zero average velocity but not zero average speed. Justify giving an example.

Ⓐ **(Board Term-I, 2014)**

Q. 2. Study the given graph and answer the following questions.



(i) Which part of the graph shows accelerated motion?

(ii) Which part of the graph shows retarded motion?

(iii) Calculate the distance travelled by the body in first 4 seconds of journey graphically?

Ⓐ **(DDE 2014; Board Term-I, 2012)**

III. SHORT ANSWER TYPE QUESTIONS-II [3 marks each]

Q. 1. (a) Identify the kind of motion in the following cases :

(i) A car moving with constant speed turning around a curve.

(ii) An electron orbiting around nucleus.

(b) An artificial satellite is moving in a circular orbit of radius 36,000 km. Calculate its speed if it takes 24 hours to revolve around the earth. Ⓐ

AI **Q. 2.** A cyclist moving along a circular path of radius 63 m completes three rounds in 3 minutes.

Calculate :

(i) The total distance covered by him during this time.

(ii) Net displacement of the cyclist.

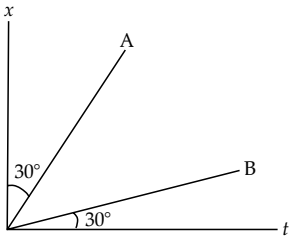
(iii) The speed of the cyclist.

IV. LONG ANSWER TYPE QUESTIONS [5 marks each]

Q. 1. (i) Define circular motion.

(ii) What is the difference between uniform motion in a straight line and circular motion?

(iii) An athlete completes one round of a circular track of diameter 200 m in 40 sec. What will be the distance covered and the displacement at the end of 2 min. and 20 sec.? Ⓡ+ Ⓐ



Q. 2. (i) What is the shape of the path of a body when it is in uniform motion ?

(ii) Give one example of non-uniform motion.

(iii) Two cars A and B have their x-t graphs as shown in figure. Which has greater velocity?

(iv) What is the quantity which is measured by the area occupied below the velocity-time graph?

(v) A body is moving with a velocity of 10 m/s. If the motion is uniform, what will be the velocity after 10 s? Ⓡ+ Ⓐ

TOPIC-3
Equations of Motion

Revision Notes

➢ **Graphical representation of motion:**

- To describe the motion of an object, we can use line graphs. Here, the line graphs show dependence of one physical quantity, such as distance or velocity, on another quantity, such as time.
- Graphs are designed to make it easier for the reader to interpret and understand numerical data.
- In such graphs, time is an independent variable, plotted along X-axis. Distance or velocity is a dependent variable, plotted along Y-axis.

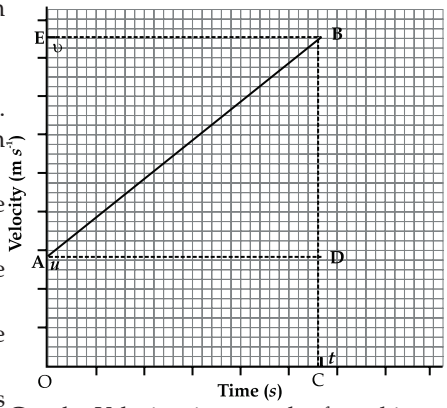
➢ **Here are some examples of graphs representing motion :**

(a) Distance-time graph : The distance-time graph is a straight line parallel to time axis when the object is at rest.

- The nature of distance-time graph is a straight line when the object is in the state of uniform motion.
- Slope of the distance-time graph gives the speed of the object.
- A more steeply inclined distance-time graph indicates greater speed. The nature of distance-time graph is a curve having varying slope when the object has non-uniform motion.

(b) Velocity- time graph : If the velocity of a body remains constant, the velocity-time graph is a horizontal line parallel to the time axis.

- If the velocity of the body changes uniformly at a constant rate, the velocity-time graph is a straight line.
- If the velocity of the object changes non-uniformly, the velocity-time graph is a curve having increasing slope.
- The area enclosed by the velocity-time graph and the time axis represents the displacement.
- The slope of the velocity-time graph gives the acceleration.



Graph : Velocity-time graph of an object

➢ **Equations of motion :** When an object moves along a straight line with uniform acceleration, it is possible to relate its velocity, acceleration during motion and the distance covered by it in a certain time interval by a set of equations. These equations are known as the equations of motion.

Consider the velocity-time graph of an object that moves under uniform acceleration as shown in the figure.

➢ **First Equation of Motion** : Consider a particle moving along a straight line with uniform acceleration 'a'. At $t = 0$, let the particle be at A and u be its initial velocity and when $t = t$, v be its final velocity.

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time}} = \frac{v - u}{t}$$

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

$$v - u = at$$

$$v = u + at \qquad (\text{I}^{\text{st}} \text{ equation of motion})$$

➢ **Second Equation of Motion :**

$$\text{Average velocity} = \frac{\text{total distance travelled}}{\text{total time taken}}$$

$$\text{Average velocity} = \frac{s}{t} \qquad \ldots(\text{i})$$

Average velocity can also be written as $\frac{u+v}{2}$ ...(ii)

From equations (i) and (ii) $\frac{s}{t}=\frac{u+v}{2}$ ...(iii)

The first equation of motion is $v = u + at$. Substituting the value of v in equation (iii), we get

$$\frac{s}{t}=\frac{u+u+at}{2}$$

or $$s=\frac{(u+u+at)\,t}{2}$$

or $s = ut + \frac{1}{2}at^2$ (IInd equation of motion)

➢ **Third Equation of Motion :**

The first equation of motion is $v = u + at$

$$v - u = at \quad \text{...(i)}$$

Average velocity $= \frac{s}{t}$ ...(ii)

Average velocity $= \frac{u+v}{2}$ ...(iii)

From equations (ii) and (iii) we get

$$\frac{u+v}{2}=\frac{s}{t} \quad \text{...(iv)}$$

Multiplying equation (i) and equation (iv), we get

$$(v-u)\times\left(\frac{u+v}{2}\right)=as$$

$$(v-u)(v+u)=2as$$

$[a^2-b^2 = (a+b)(a-b)]$

$$\therefore \quad v^2-u^2=2as$$ (IIIrd equation of motion)

SELF ASSESSMENT – 3

I. OBJECTIVE TYPE QUESTIONS [1 mark each]

A. Multiple Choice Questions

Ⓡ **Q. 1. Slope of a velocity-time graph gives :**

(a) The distance **(b)** The displacement

(c) The acceleration **(d)** The speed

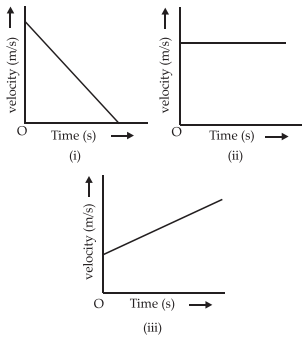
Ⓡ **Q. 2. Area under *v*-*t* graph represents a physical quantity which has the unit :**

(a) m^2 **(b)** m

(c) ms **(d)** ms^{-1}

B. Diagram Based Questions

Ⓚ **Q. 1. Identify the following graphs and answer the questions :**



(a) Which of the graphs indicate negative acceleration? Why ?

(b) What do you infer from the graph where velocity time graph is parallel to the time axis ?

(c) Which of the graphs represent a body moving with initial velocity not equal to zero but with constant acceleration? Justify your answer.

(d) Name the type of motion in which speed remains constant but the velocity of body changes.

C. Assertion and Reason Type Questions

Directions : In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as :

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(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

(c) Assertion (A) is true but reason (R) is false.

(d) Assertion (A) is false but reason (R) is true.

Ⓐ **Q. 1. Assertion :** A tiger can accelerate from rest at the rate of 4 m/s^2.

Reason : The velocity attained by it in 10 s is 40 m/s

Ⓡ **Q. 2. Assertion :** Velocity is the speed of an object in a particular direction.

Reason : SI unit of velocity is same as speed.

C. Very Short Answer Type Questions

Ⓡ **Q. 1.** Give one example of a body whose average velocity is zero.

AI Ⓚ **Q. 2.** Why is the motion of a circulating fan non -uniform?

II. SHORT ANSWER TYPE QUESTIONS-I [2 marks each]

Q. 1. (i) Define weight of a body. Mention the direction in which it acts.

(ii) A stone is thrown vertically upwards with an initial velocity of 40 ms^{-1}. Find the maximum height reached by the stone. What is the net displacement and the total distance covered by the stonen? (Given g = 10 ms^{-2})

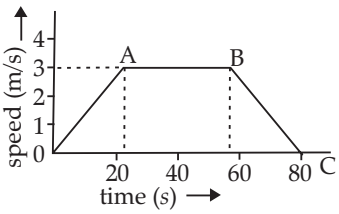
Ⓡ+Ⓐ **(DDE 2014; Board Term-I, 2013)**

Q. 2. A motor cycle moving with a speeed of m/s obtains an acceleration of 0.2 m/s^2. Calculate the speed of the motor cycle after 10 seconds, and the distance travelled by it in this time.

Ⓐ **(Board Term-I, 2014)**

III. SHORT ANSWER TYPE QUESTIONS-II [3 marks each]

Q. 1. Study the speed time graph of a car alongside and answer the following questions :



Scale :

1 cm = 20 m/s on Y axis

(i) What type of motion is represented by OA?

(ii) Find acceleration from B to C.

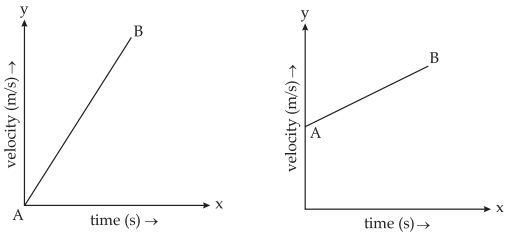
(iii) Calculate the distance covered but the body from A to B. Give reasons for your answer.

Ⓤ+Ⓐ

Ⓚ **Q. 2.** Define uniformly accelerated motion and uniform motion. Also, write any two equations of uniformly accelerated motion.

IV. LONG ANSWER TYPE QUESTIONS [5 marks each]

Q. 1. (i) Give one similarity and one dissimilarity between the two graphs. Ⓤ+Ⓡ



(ii) What do you understand by the term acceleration? What is meant by its being positive or negative? Explain with example. Write its SI units. Ⓐ

Q. 2. (i) Using velocity time graph derive :

$v^2 - u^2 = 2as$.

(ii) A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 m/s, with what velocity will it strike the ground? Ⓐ

NCERT CORNER

Intext Questions

Q. 1. An object has moved through a distance. Can it have zero displacement? If yes, support your answer with an example. [NCERT Q. 1, Page 100]

Ans. Yes, zero displacement is possible if an object has moved through a distance.

Suppose a body is moving in a circular path and starts moving from point A and it returns back at the same point A after completing one revolution, then the distance will be equal to its circumference while displacement will be zero.

Q. 2. A farmer moves along the boundary of a square field of side 10 m in 40 seconds. What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds from his initial position? [NCERT Q. 2, Page 100]

Ans. Given that,

Side of the square field = 10 m

Therefore, perimeter = 10 m × 4 = 40 m

Farmer moves along the boundary in 40 seconds

Time = 2 minutes 20 seconds

= 2 × 60 seconds + 20 seconds

= 140 seconds

Since, in 40 seconds farmer moves 40 m,

Therefore, in 1 second distance covered by farmer = 40 ÷ 40 = 1 m.

in 140 seconds distance covered by farmer = 1 × 140 m = 140 m

Now, number of rotations to cover 140 along the boundary = Total distance/Perimeter

= 140 m ÷ 40 m = 3.5 round

Thus after 3.5 round farmer will at point C (diagonally opposite to his initial position) of the field.

Therefore, displacement AC $= \sqrt{10^2 + 10^2}$
$= \sqrt{200} = 10\sqrt{2}$ m

Thus, after 2 minutes 20 seconds, the displacement of farmer will be equal to $10\sqrt{2}$ m north-east from the initial position.

Q. 3. Which of the following is true for displacement ?

(a) It cannot be zero.

(b) Its magnitude is greater than the distance travelled by an object. **[NCERT Q. 3, Page 100]**

Ans. **(a)** Not true, because if the initial and final positions of the object is the same displacement can become zero.

(b) Not true, because, displacement is the shortest measurable distance between the initial and final positions of an object. It cannot be greater than the magnitude of the distance travelled by an object, but it can be smaller or equal to the distance travelled by an object.

Q. 4. Distinguish between speed and velocity.

[NCERT Q. 1, Page 102]

Ans. **Differences between speed and velocity are :**

S. No.	Speed	Velocity
(i)	It is defined as the rate of change of distance.	It is defined as the rate of change of displacement.
(ii)	It is a scalar quantity.	It is a vector quantity.
(iii)	Speed is velocity without direction.	Velocity is directed speed.
(iv)	Speed may or may not be equal to the magnitude of velocity.	A body may possess different velocities but the same speed.

Q. 5. Under what condition(s) is the magnitude of average velocity of an object equal to its average speed?

[NCERT Q. 2, Page 102]

Ans. As we know,

$$\text{Average velocity} = \frac{\text{Displacement}}{\text{Time interval}}$$

$$\text{Average speed} = \frac{\text{Total path length}}{\text{Time interval}}$$

The magnitude of average velocity of an object will be equal to its average speed in the condition of uniform velocity in a straight-line motion.

Q. 6. What does the odometer of an automobile measure ? **[NCERT Q. 3, Page 102]**

Ans. Odometer is a device that measures the distance travelled by an automobile based on the perimeter of the wheel as the wheel rotates.

Q. 7. What does the path of an object look like when it is in uniform motion ? **[NCERT Q. 4, Page 102]**

Ans. Uniform motion is a motion in which an object covers equal distances in equal intervals of time and moves along a straight line.

Thus, in the case of uniform motion, the path is a straight line in uniform motion.

Q. 8. During an experiment, a signal from a spaceship reached the ground station in 5 minutes. What was the distance of the spaceship from the ground station? The signal travels at the speed of light, that is, 3×10^8 m s^{-1}. **[NCERT Q. 5, Page 102]**

Ans. Given that,

Speed $= 3 \times 10^8$ m s^{-1}

Time $= 5$ minutes
$= 5 \times 60$ seconds
$= 300$ seconds

Using, Distance = Speed × Time

Distance $= 3 \times 10^8 \times 300$ m
$= 900 \times 10^8$ m
$= 9.0 \times 10^{10}$ m

Q. 9. When will you say a body is in : (i) Uniform acceleration? (ii) Non-uniform acceleration ?

[NCERT Q. 1, Page 103]

Ans. **(a)** A body is said to be in uniform acceleration when its motion is along a straight line and its velocity changes by equal magnitudes in equal intervals of time.

(b) A body is said to be in non-uniform acceleration when its velocity changes by unequal magnitudes in equal intervals of time.

Q. 10. A bus decreases its speed from 80 km/h to 60 km/h in 5 s. Find the acceleration of the bus.

[NCERT Q. 2, Page 103]

Ans. Given that,

$u = 80$ km/h $= [80 \times 1000]/3600$ ms^{-1} $= 200/9$ m s^{-1}

$v = 60$ km/h $= [60 \times 1000]/3600$ ms^{-1} $= 150/9$ m s^{-1}

$t = 5$ s

Acceleration, a = ?

We know that, $v = u + at$

$$\Rightarrow a = \frac{v-u}{t} = \frac{\left(\frac{150}{9} - \frac{200}{9}\right)}{5} = \frac{-\frac{50}{9}}{5} = -\frac{10}{9} = -1.1 \text{ m s}^{-2}$$

Therefore, acceleration is –1.1 m s^{-2}

Q. 11 A train starting from a railway station and moving with uniform acceleration attains a speed of 40 km/h in 10 minutes. Find its acceleration.

[NCERT Q. 3, Page 103]

Ans. Given that,

Initial velocity, $u = 0$ m/s

Final velocity, $v = 40$ km/h $= [40 \times 1000]/3600$ m s^{-1}

Time (t) $= 10$ minute $= 60 \times 10 = 600$ s

Acceleration (a) =?

We know that, $v = u + at$

$$\Rightarrow a = \frac{v-u}{t} = \frac{\left(\frac{100}{9} - 0\right)}{600} = \frac{1}{54} = 0.0185 \text{ ms}^{-2}$$

$\Rightarrow a = 0.0185$ ms^{-2}

Q. 12. What is the nature of the distance–time graphs for uniform and non-uniform motion of an object ?
[NCERT Q. 1, Page 107]

Ans. **(i)** The distance-time graph for an object in uniform motion is straight line, inclined with the time axis.

(ii) The distance-time graph for an object in non-uniform motion is a curve.

Q. 13. What can you say about the motion of an object whose distance-time graph is a straight line parallel to the time axis ? **[NCERT Q. 2, Page 107]**

Ans. When the distance-time graph is a straight line parallel to time axis, it means that the object is not changing its position.

So, the object is stationary or at rest.

Q. 14. What can you say about the motion of an object if its speed-time graph is a straight line parallel to the time axis? **[NCERT Q. 3, Page 107]**

Ans. When the graph of a speed-time graph is a straight line parallel to the time axis, it means that the speed of the object is not changing with time.

So, the object is performing uniform motion.

Q. 15. What is the quantity which is measured by the area occupied below the velocity-time graph ?
[NCERT Q. 4, Page 107]

Ans. The quantity of displacement is measured by the area occupied below the velocity-time graph.

Q. 16. A bus starting from rest moves with a uniform acceleration of 0.1 m s^{-2} for 2 minutes.

Find :

(a) the speed acquired.

(b) the distance travelled. **[NCERT Q. 1, Page 109]**

Ans. Given that,

Initial velocity (u) = 0 m/s

Acceleration (a) = 0.1 m s^{-2}

Time (t) = 2 minutes

= 2 × 60 seconds

= 120 seconds

(a) The speed acquired :

We know that,

$v = u + at$

$\Rightarrow v = 0 + 0.1 \times 120$ m/s

$\Rightarrow v = 12$ m/s

Thus, the bus will acquire a speed of 12 m/s after 2 minutes with the given acceleration.

(b) The distance travelled :

We know that,

$s = ut + \frac{1}{2}at^2$

$= 0 \times 120 + \frac{1}{2} \times 0.1 \times (120)$

$= 1/2 \times 0.1 \times 14{,}400$ m = 720 m

Thus, bus will travel a distance of 720 m in the given time of 2 minutes.

Q. 17. A train is travelling at a speed of 90 km/h. Brakes are applied so as to produce a uniform acceleration of –0.5 m/s^2. Find how far the train will go before it is brought to rest. **[NCERT Q. 2, Page 109]**

Ans. Given that,

Initial velocity, u = 90 km/h = [90 × 1,000]/3,600 m s^{-1} = 25 m s^{-1}

Final velocity, v = 0 m/s

Acceleration, a = –0.5 m/s^2

Using equation of motion

$$v^2 = u^2 + 2as$$

$$s = \frac{v^2 - u^2}{2a} = \frac{0 - 25^2}{2(-0.5)} = 625\text{m}$$

Therefore, train will go 625 m before it is brought to rest.

Q. 18. A trolley, while going down an inclined plane, has an acceleration of 2 cm/s^2. What will be its velocity 3 s after the start ? **[NCERT Q. 3, Page 109]**

Ans. Given that,

Initial velocity, u = 0 m/s

Acceleration (a) = 2 cm/s^2 = 0.02 m/s^2

Time (t) = 3 seconds

We know that, $v = u = at$

Therefore, $v = 0 + 0.02 \times 3$ m/s

$\Rightarrow v = 0.06$ m/s

Therefore, the final velocity of trolley will be 0.06 m/s after start.

Q. 19. A racing car has a uniform acceleration of 4 m/s^2. What distance will it cover in 10 s after start ?
[NCERT Q. 4, Page 109]

Ans. Given that,

Acceleration, a = 4 m/s^2

Initial velocity, u = 0 m/s

Time, t = 10 s

We know that, $s = ut + \frac{1}{2}at^2$

$\Rightarrow s = 0 \times 10 + \frac{1}{2} \times 4 \times (10)^2$ m

$\Rightarrow s = 2 \times 100$ m

$\Rightarrow s = 200$ m

Thus, racing car will cover a distance of 200 m after start in 10 seconds with given acceleration.

Q. 20. A stone is thrown in a vertically upward direction with a velocity of 5 m/s. If the acceleration of the stone during its motion is 10 m/s^2 in the downward direction, what will be the height attained by the stone and how much time will it take to reach there ? **[NCERT Q. 5, Page 109]**

Ans. Given that,

Initial velocity (u) = 5 m/s

Final velocity (v) = 0 m/s

Acceleration (a) = –10 m/s^2

As we know,

$$v^2 = u^2 + 2as$$

$$0 = (5)^2 + 2 \times (-10) \times s$$

$$s = 1.25 \text{ m}$$

Now, we know that,

$$v = u + at$$

$$0 = 5 + (-10) \times t$$

$t = 5/10$ second

$t = ½$ second $= 0.5$ second

Thus, stone will attain a height of 1.25 m and time taken to attain the height is 0.5 second.

Exercise Questions

Q. 1. An athlete completes one round of circular track of diameter 200 m in 40 s. What will be the distance covered and the displacement at the end of 2 minutes 20 s?

Ans. Given that,

Time taken = 2 minutes 20 s = 140 s.

Radius, $r = 100$ m.

In 40 s, the athlete completes one round.

So, in 140 s, the athlete will complete = $140 \div 40 = 3.5$ round.

Distance covered in 140 s $= 2\pi r$

$$= 2 \times \frac{22}{7} \times 3.5 \times 100 = 2{,}200 \text{ m.}$$

At the end of his motion, the athlete will be in the diametrically opposite position.

Displacement = Diameter = 200 m

Q. 2. Joseph jogs from one end A to another end B of a straight 300 m road in 2 minutes and 30 seconds and then turns around and jogs 100 m back to point C in another 1 minute. What are Joseph's average speeds and velocities in jogging : (a) from A to B and (b) from A to C?

Ans. **(a)** Given that,

For motion from A to B

Distance covered = 300 m

Displacement = 300 m.

Time taken = 150 seconds.

As we know,

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time taken}}$$

$$= \frac{300}{150} = 2 \text{ms}^{-1}$$

$$\text{Average velocity} = \frac{\text{Net displacement}}{\text{Time taken}}$$

$$= \frac{300}{150} = 2 \text{ ms}^{-1}$$

(b) Given that,

For motion A to C :

Distance covered = 300 + 100 = 400 m.

Displacement = AB − CB

= 300 − 100 = 200 m.

Time taken = 2.5 + 1 = 3.5 mins

= 3.5 × 60 = 210 s

$$\text{Average velocity} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{400}{210} = 1.90 \text{ m s}^{-1}$$

$$\text{Average velocity} = \frac{\text{Net displacement}}{\text{Time taken}}$$

$$= \frac{200}{210} = 0.952 \text{ m s}^{-1}$$

Q. 3. Abdul, while driving to school, computes the average speed for his trip to be 20 km h^{-1}. On his return trip along the same route, there is less traffic and the average speed is 30 km h^{-1}. What is the average speed of Abdul's trip?

Ans. Let one side distance = x km.

Time taken for forward trip at a speed of 20 km/h = Distance/Speed $= \frac{x}{20}$ h.

Time taken in return trip at a speed of 30 km/h $= \frac{x}{30}$ h.

$$\text{Total time for the whole trip} = \frac{x}{20} + \frac{x}{30}$$

$$= \frac{3x + 2x}{60}$$

$$= \frac{5x}{60} \text{ h.}$$

Total distance covered = $2x$ km.

We know,

Average speed = Total distance ÷ Total time

$= 2x \div (5x/60) = 24$ km h^{-1}

So, the average speed of Abdul's trip is 24 km h^{-1}

Q. 4. A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of 3.0 m s^{-2} for 8.0 s. How far does the boat travel during this time?

Ans. Given that,

$u = 0$ m/s

$a = 3$ m s^{-2}

$t = 8$ s

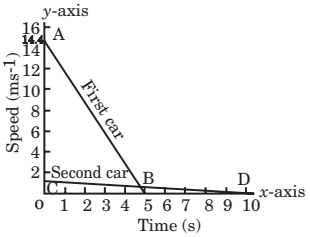
Using, $s = ut + \frac{1}{2}at^2$

$$s = 0 \times 8 + \frac{1}{2} \times 3 \times 8^2 = 96 \text{ m.}$$

Q. 5. A driver of a car travelling at 52 km h^{-1} applies the brakes and accelerates uniformly in the opposite direction. The car stops after 5 seconds. Another

driver going at 3 km h^{-1} in another car applies his brakes slowly and stops in 10 s. On the same graph paper, plot the speed versus time graphs for two cars. Which of the two cars travelled farther after the brakes were applied?

Ans. In the following graph, AB and CD are the time graphs for the two cars whose initial speeds are 52 km/h (14.4 m/s) and 3 km/h (.83 m/s), respectively.



Distance covered by the first car before coming to rest = Area of triangle AOB

$$= \frac{1}{2} \times AO \times BO$$

$$= \frac{1}{2} \times 52 \text{ km h}^{-1} \times 5 \text{ seconds}$$

$$= \frac{1}{2} \times (52 \times 1{,}000 \times 1/3600) \text{ ms}^{-1} \times 5 \text{ seconds}$$

$$= 36.1 \text{ m}$$

Distance covered by the second car before coming to rest = Area of triangle COD

$$= \frac{1}{2} \times CO \times DO$$

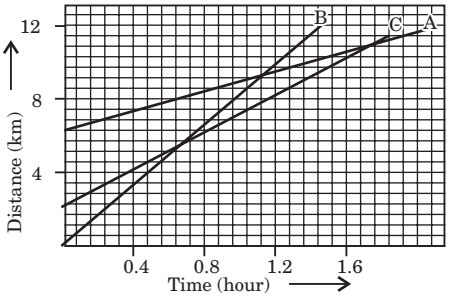
$$= \frac{1}{2} \times 3 \text{ km h}^{-1} \times 10 \text{ s}$$

$$= \frac{1}{2} \times (3 \times 1{,}000 \times 1/3600) \text{ ms}^{-1} \times 10 \text{ s}$$

$$= 4.167 \text{ m}$$

Thus, the first car travels farther than the second car after they applied the brakes.

Q. 6. Following figure shows the distance-time graph of three objects A, B and C. Study the graph and answer the following questions :



(a) Which of the three is travelling the fastest?

(b) Are all three ever at the same point on the road?

(c) How far has C travelled when B passes A?

(d) How far has B travelled by the time it passes C?

Ans. According the graph given above :

(a) B is travelling fastest as he is taking less time to cover more distance.

(b) All three are never at the same point on the road.

(c) Approximately 6 km [as 8 – 2 = 6]

(d) Approximately 7 km [as 7 – 0 = 7]

Q. 7. A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 m s^{-2}, with what velocity will it strike the ground? After what time will it strike the ground?

Ans. Given that,

$$u = 0 \text{ m/s},$$
$$s = 20 \text{ m},$$
$$a = 10 \text{ m s}^{-2},$$

Using,

$$v^2 - u^2 = 2as$$

We have, $v^2 - 0^2 = 2 \times 10 \times 20 = 400$

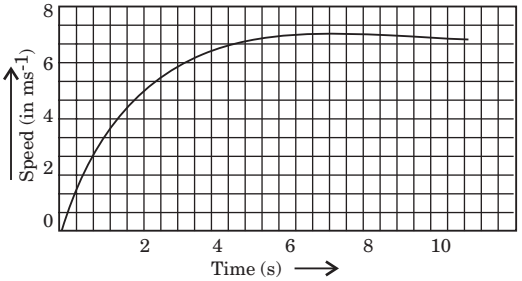
$\Rightarrow$ $v = 20 \text{ m s}^{-1}$

and $$t = \frac{v - u}{a}$$

$$= 20 \div 10$$

$$= 2 \text{ seconds}$$

Q. 8. The speed–time graph for a car is shown in Figure :

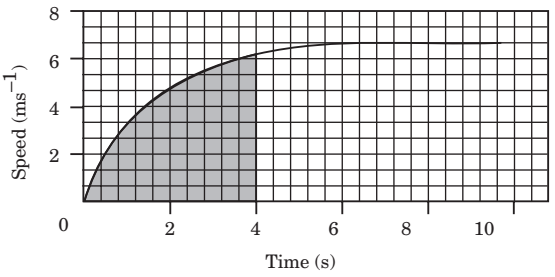


(a) Find how far does the car travel in the first 4 seconds. Shade the area on the graph that represents the distance travelled by the car during the period.

(b) Which part of the graph represents uniform motion of the car?

Ans. (a) Distance covered = Area under speed = Time graph

Shaded area representing the distance travelled is as follows :



$\therefore$ Distance = No. of small squares shaded × Area of each small square

$$= 62 \times {}^{2}/_{3} \text{ m s}^{-1} \times {}^{2}/_{5} = 16.53 \text{ m}$$

(b) After 6 seconds the car moves in uniform motion (at a speed of 6 m/s).

Q. 9. State which of the following situations are possible and give an example of each of the following :

(a) an object with a constant acceleration but with zero velocity.

(b) an object moving in a certain direction with an acceleration in the perpendicular direction.

Ans. **(a)** Yes, a body can have acceleration even when its velocity is zero. When a body is thrown up, the highest point of its velocity is zero but it has acceleration which is equal to acceleration due to gravity.

(b) Yes, an object moving horizontally is acted upon by acceleration due to gravity that acts vertically downwards.

Q. 10. An artificial satellite is moving in a circular orbit of radius 42,250 km. Calculate its speed if it takes 24 hours to revolve around the earth.

Ans. Given that,

r = 42,250 km = 4,22,50,000 m

T = 24 hours = 24 × 60 × 60 seconds

Using speed,

$v = 2\pi r \div T$

$v = (2 \times 3.14 \times 4,22,50,000) \div (24 \times 60 \times 60)$

$= 3070.9\ ms^{-1}$

$= 3.07$ km/s

NCERT EXEMPLAR

Multiple Choice Questions

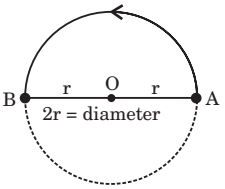
Q. 1. A particle is moving in a circular path of radius *'r'*. The displacement after half a circle would be :

(a) Zero. **(b)** πr.

(c) 2r. **(d)** $2\pi r$.

Ans. Correct option : (c)

Explanation : As we know that displacement is the shortest path between the final and the initial positions. In this case :



Displacement = AB

= Shortest distance between initial and final positions

$= r + r = 2r$

Q. 2. A body is thrown vertically upwards with velocity '*u*', the greatest height '*h*' to which it will rise is

(a) u/g. **(b)** $u^2/2g$.

(c) u^2/g. **(d)** $u/2g$.

Ans. Correct option : (b)

Explanation : A body is thrown vertically upwards. So, at the maximum height, final velocity of body = 0 m/sec

Use kinematics formula : $v^2 = u^2 + 2as$

Where, $v = 0$, $a = -g$, $s = h$

Putting the values- $0 = u^2 - 2gh$

So, $h = u^2/2g$

Hence, maximum height attained by body is $u^2/2g$.

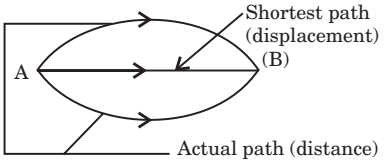
Q. 3. The numerical ratio of displacement to distance for a moving object is :

(a) always less than 1 **(b)** always equal to 1

(c) always more than 1 **(d)** equal or less than 1

Ans. Correct option : (d)

Explanation : Displacement is the shortest distance between initial and final points while distance is the length of path. Displacement of an object can be less than or equal to the distance covered by the object, because the magnitude of displacement is not equal to distance. However, it can be equal if the motion is along a straight line without any change in direction.



Q. 4. If the displacement of an object is proportional to square of time, then the object moves with

(a) uniform velocity

(b) uniform acceleration

(c) increasing acceleration

(d) decreasing acceleration

Ans. Correct option : (b)

Explanation : From the second equation of motion, we find that

$$s = ut + \frac{1}{2}at^2$$

If object starts from rest, that is, initial velocity (u) = 0 and moves with an acceleration (a) in time (t)

Then,

$$s = 0 \times t + \frac{1}{2}at^2$$

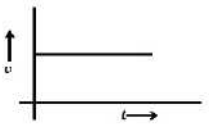
$$s = \frac{1}{2}at^2$$

$$s \propto t^2$$

[If a = constant]

So, the object move with constant or uniform acceleration.

Q. 5. From the given $v-t$ graph shown in Figure, it can be inferred that the object is



(a) in uniform motion.
(b) at rest.
(c) in non-uniform motion.
(d) moving with uniform acceleration.

Ans. Correct option : (a)

Explanation : From the given v-t graph, it is clear that the velocity of the object is not changing with time that means there is no change in velocity or zero acceleration. So, the object is in uniform motion.

Q. 6. Suppose a boy is enjoying a ride on a merry-go-round which is moving with a constant speed of 10 m s^{-1}. It implies that the boy is :

(a) at rest.
(b) moving with no acceleration.
(c) in accelerated motion.
(d) moving with uniform velocity.

Ans. Correct option : (c)

Explanation : We know that speed is only the magnitude of velocity. Speed does not contain direction. So, in merry-go-round, speed is constant but velocity is not constant, because its direction goes on changing, that is, there is acceleration in the motion. So, we can say that the boy is in accelerated motion.

Q. 7. Area under a $v-t$ graph represents a physical quantity which has the unit

(a) m^2 **(b)** m
(c) m^3 **(d)** m s^{-1}

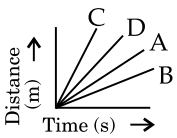
Ans. Correct option : (b)

Explanation : Area under v-t graph represents displacement whose unit is meter 'm'. Because, unit of velocity v = m/s

Unit of (v-t) graph = $\frac{\text{m}}{\text{s}} \times \text{s} = \text{m}$ and unit of time 't' is second 's'.

So that, the unit of (v-t) graph is meter (m).

Q. 8. Four cars A, B, C and D are moving on a levelled road. Their distance (m) versus time (s) graphs is shown in Figure. Choose the correct statement :



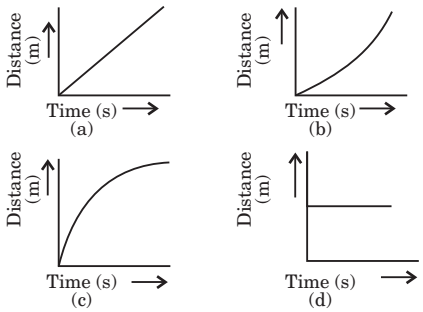
(a) Car A is faster than car D.
(b) Car B is the slowest.
(c) Car D is faster than car C.
(d) Car C is the slowest.

Ans. Correct option : (b)

Explanation : As we know that the slope of distance-time graph represents the speed.

From the above graph, it is clear that the slope of distance-time graph for car B is less than all other cars. So, the slope is minimum for car B. Hence, car B is the slowest.

Q. 9. Which of the following figures represents uniform motion of a moving object correctly?



Ans. Correct option : (a)

Explanation : For uniform motion, the distance-time graph is a straight line with slope of 45° because in uniform motion, object covers equal distances in equal intervals of time.

Q. 10. Slope of a velocity-time graph gives :

(a) the distance
(b) the displacement
(c) the acceleration
(d) the speed

Ans. Correct option : (c)

Explanation : The slope of the graph indicates the rate of acceleration (or deceleration if the graph is pointing downwards) of the object.

Q. 11. In which of the following cases of motions, the distance moved and the magnitude of displacement is equal :

(a) if the car is moving on straight road
(b) if the car is moving in circular path
(c) the pendulum is moving to and fro
(d) the earth is revolving around the Sun

Ans. Correct option : (a)

Explanation : As we know that displacement is the shortest path between initial and find paths. So, the distance moved and magnitude of displacement is equal only in the case of motion along a straight line. So, for a car moving on straight road, distance moved and magnitude of displacement are equal.

Short Answer type Questions

Q. 12. The displacement of a moving object in a given interval of time is zero. Would the distance travelled by the object also be zero? Justify your answer.

Ans. No, it is not true that if displacement is zero distance would be zero. As we know that the displacement is the shortest distance between the initial and final positions of an object and distance is the total distance travelled by an object.

The distance in this case will not be zero because distance is the total length of the path travelled by the body. If the object comes back to its initial position, then length of path travelled is not zero.

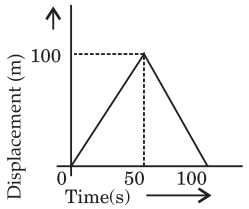
Q. 13. How will the equations of motion for an object moving with a uniform velocity change?

Ans. Acceleration $a = 0$, $v = u$

$$s = ut$$

$$v^2 - u^2 = 0$$

Q. 14. A girl walks along a straight path to drop a letter in the letter box and comes back to her initial position. Her displacement-time graph is shown in the figure. Plot a velocity-time graph for the same.



Ans. From the given displacement-time graph, we can interpret that :

(i) Initial velocity is zero as displacement and time are zero.

(ii) Velocity after 50 seconds :

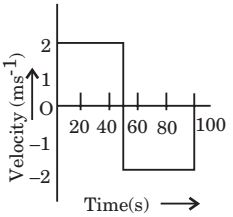
= Displacement/Time

= 100/50 = 2 m/s forward, and –2m/s

(iii) Velocity after 100 seconds :

= Displacement/Time

= 0/100 = 0/s



Hence, the velocity with time table is given below :

v (m/s)	0	± 2	0
t (seconds)	0	50	100

Q. 15. A car starts from rest and moves along the x-axis with constant acceleration 5 m s^{-2} for 8 seconds. If it then continues with constant velocity, what distance will the car cover in 12 seconds since it started from the rest ?

Ans. Given that,

Initial velocity = 0

Acceleration = 5 m/s^2

Time = 8 seconds

From the first equation of motion :

$$v = u + at$$

$$v = 0 + 5 \times 8$$

$$v = 40 \text{ m/s}$$

Again, from the second equation of motion :

$$s = ut + \frac{1}{2}at^2$$

Put the values $t = 8$ seconds and $a = 5$ m/s^2

$$s = 0 \times 8 + \tfrac{1}{2} 5 (8)^2$$

$$s = 160 \text{ m}$$

Now time t =12 seconds

After 8 seconds, the car continues with constant velocity, that is, the car will move with a velocity of 40 m/s. So, remaining time 't' = 12 – 8 = 4 seconds

The distance covered in the last 4 seconds :

$$s = \text{Velocity} \times \text{Time}$$

$$= 40 \times 4 = 160 \text{ m}$$

[We have used the direct formula because after 8 seconds, car is moving with constant velocity, that is, zero acceleration].

Total distance travelled in 12 seconds from the start

$D = s + s' = 160 + 160 = 320$ m

Q. 16. A motorcyclist drives from A to B with a uniform speed of 30 km h^{-1} and returns back with a speed of 20 km h^{-1}. Find its average speed.

Ans. Let the distance between A and $B = x$ km.

Time taken in driving from A to B,

$$t_1 = \frac{\text{Distance}}{\text{Speed}} = \frac{x}{30} \text{ h} \qquad \left[\because \text{Time} = \frac{\text{Distance}}{\text{Speed}}\right]$$

Similarly, time taken in returning from B to A,

$$t_2 = \frac{\text{Distance}}{\text{Speed}} = \frac{x}{20} \text{ h}$$

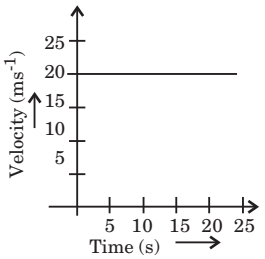
$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{x + x}{t_1 + t_2}$$

$$= \frac{x + x}{\frac{x}{30} + \frac{x}{20}} = \frac{2x}{\frac{2x + 3x}{60}}$$

$$= \frac{2x \times 60}{5x} = 2 \times 12 = 24 \text{ km h}^{-1}$$

Hence, average speed of the motorcyclist is 24 km h^{-1}

Q. 17. The velocity-time graph in figure shows the motion of a cyclist. Find (i) its acceleration, (ii) its velocity and (iii) the distance covered by the cyclist in 15 seconds.



Ans. (i) From the given graph it is clear that velocity is constant with time so the acceleration will be zero. $a = 0$

(ii) From the given graph, there is no change in velocity with time. So, velocity after 15 seconds will remain same as 20 m/sec.

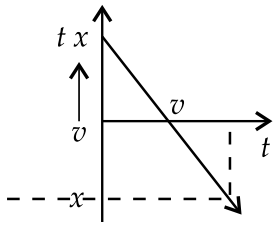
(iii) Area under the covered curve denotes the distance :

$$s = v \times t$$

$$= 20 \times 15 = 300 \text{ m}$$

Q. 19. Draw a velocity versus time graph of a stone thrown vertically upwards and then coming downwards after attaining the maximum height.

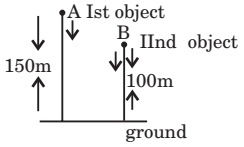
Ans. If velocity upwards is taken as positive, then it is negative downwards. The acceleration due to gravity always acts downwards. So the slope of the graph is –g. The maximum velocity is shown as *x*.



Long Answer type Questions

Q. 19. An object is dropped from rest at a height of 150 m and simultaneously another object is dropped from rest at a height 100 m. What is the difference in their heights after 2 seconds if both the objects drop with same accelerations ? How does the difference in heights vary with time ?

Ans. **(a) For the first object :**



Given that,

Initial velocity, $u = 0$

Time, $t = 2$ seconds

From the second equation of motion :

Distance covered by first object in first 2

$$h = ut + \frac{1}{2}gt^2$$

$$h = 0 \times 2 + \frac{1}{2} \times 10 \times 2^2$$

$h = 20$ m

Height of first object from the ground after 2 seconds-

$h_1 = 150 - 20$ m $= 130$ m

(b) For the second object :

Given that,

Initial velocity, $u = 0$

Time, $t = 2$ seconds

From the second equation of motion,

Distance covered by second object in first 2 seconds-

$$h = ut + \frac{1}{2}gt^2$$

$$h = 0 \times 2 + \frac{1}{2} \times 10 \times 2^2$$

$h = 20$ m

Height of second object from the ground after 2 seconds :

$h_2 = 100 - 20$ m $= 80$ m

Now, difference in their heights after 2 seconds = $h_1 - h_2 = 130 - 80 = 50$ m

The difference in heights of the objects will remain same with time as both the objects have been dropped from rest and are falling with same acceleration (*i.e.*, acceleration due to gravity).

Q. 20. An object starting from rest travels 20 m in first 2 seconds and 160 m in next 4 seconds. What will be the velocity after 7 seconds from the start ?

Ans. Given that,

Initial velocity, $u = 0$ m/s

Distance travelled, $s = 20$ m

Time, $t = 2$ sec.

From second equation of motion :

$$s = ut + \frac{1}{2}at^2$$

$$20 = 0 \times 2 + 1/2\, a\, (2)^2$$

$$20 = 2a$$

$$a = 10 \text{ m/s}^2$$

Velocity at the end of 2 seconds : $v = u + at$

$$v = 0 + 10 \times 2$$

$$v = 20 \text{ m/s}$$

After 4 seconds, it covers a distance of 160 m. So,

$$160 = 20 \times 4 + \frac{1}{2}\,(a)4^2$$

$$160 = 80 + 8a$$

$$8a = 80$$

$$a = 10 \text{ m/s}^2$$

It shows that acceleration is uniform. So, velocity at the end of 7 seconds from start : $v = u + at$

$$= 0 + 10 \times 7 = 70 \text{ m/s}$$

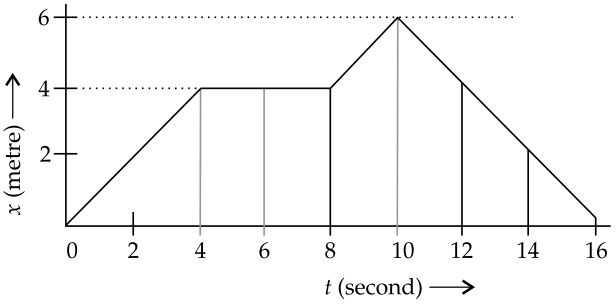
$\therefore$ Velocity after 7 seconds from the start is 70 m/s

Q. 21. Using following data, draw time - displacement graph for a moving object :

Time (s)	0	2	4	6	8	10	12	14	16
Displacement (m)	0	2	4	4	4	6	4	2	0

Use this graph to find average velocity for first 4 s, for next 4 s and for last 6 s.

Ans.



Average velocity for first 4 s.

$$\text{Average velocity} = \frac{\text{Change is displacement}}{\text{Total time taken}}$$

$$v = \frac{4-0}{4-0} = \frac{4}{4} = 1 \text{ m s}^{-1}$$

For next 4 s, $v = \frac{4-4}{8-4} = \frac{0}{4} = 0 \text{ m s}^{-1}$

(or as x remains the same from 4 to 8 seconds, velocity is zero)

For last 6 s, $v = \frac{0-6}{16-10} = -1 \text{ m s}^{-1}$

Q. 22. An electron moving with a velocity of 5×10^4 m s^{-1} enters into a uniform electric field and acquires a uniform acceleration of 10^4 m s^{-2} in the direction of its initial motion.

(i) Calculate the time in which the electron would acquire a velocity double of its initial velocity.

(ii) How much distance the electron would cover in this time ?

Ans. Given that,

Initial velocity of the electron, $u = 5 \times 10^4$ m/s

Acceleration of the electron, $a = 10^4$ m/s^2

(i) Using first equation of motion, $v = u + at$

$2u = u + at$

[since 'v' is double of initial velocity (u)]

$$t = \frac{u}{a} = \frac{5 \times 10^4}{10^4} \qquad [v = 2u, \text{ given}]$$

$= 5$ s

(ii) Distance covered in this time is, $s = ut + \frac{1}{2}at^2$

$s = (5 \times 10^4) \times 5 + \frac{1}{2} \times 10^4 \times 5^2$

$s = 3{,}75{,}000$ m

$s = 37.5 \times 10^4$ m

Q. 23. Obtain a relation for the distance travelled by an object moving with a uniform acceleration in the interval between fourth and fifth seconds.

Ans. From second equation of motion,

Distance travelled in 't' seconds, $s = ut + \frac{1}{2}at^2$

Distance travelled in 4 seconds,

$s_4 = u \times 4 + a\frac{1}{2}a(4)^2$

$= 4u + \frac{1}{2} \times a \times 16 = 4u + 8a$

(s_4 = Distance travelled in four seconds

Again, distance travelled in 5 s

$s_5 = ut + \frac{1}{2}at^2$

$= u \times 5 + \frac{1}{2}a(5)^2 = 5u + \frac{25}{2}a$

(s_4 = Distance travelled in five seconds

So, distance travelled in the intervals between fourth and fifth seconds.

$$s = s_5 - s_4$$

$$= \left(5u + \frac{25}{2}a\right) - (4u + 8a)$$

$$= 5u + \frac{25}{2}a - 4u - 8a$$

$$= 5u - 4u + \frac{25}{2}a - 8a$$

$$= u + \frac{25a - 16a}{2}$$

$$= u + \frac{9}{2}a$$

So, the relation will be $\left(u + \frac{9}{2}a\right)$

Q. 24. Two stones are thrown vertically upwards simultaneously with their initial velocities u_1 and u_2, respectively. Prove that the heights reached by them would be in the ratio of $u_1^2 : u_2^2$ (Assume upward acceleration is $-g$ and downward acceleration to be $+g$).

Ans. Given that,

Initial velocities = u_1 and u_2

Acceleration due to gravity = g

Taking '$-g$' as the object is moving against the gravity, vertically upwards.

Let the final velocities = v_1 and v_2

Now, we know that,

$$s = \frac{v^2 - u^2}{2g}$$

For object 1 :

$$s_1 = \frac{v_1^2 - u_1^2}{-2g}$$

Putting $v = 0$

$$s_1 = \frac{-u_1^2}{-2g} = \frac{u_1^2}{2g} \qquad \ldots \text{(i)}$$

Similarly, for second object :

$$s_2 = \frac{u_2^2}{2g} \qquad \ldots \text{(ii)}$$

Divide (i) by (ii)

$$\frac{s_1}{s_2} = \frac{\left(\frac{u_1^2}{2g}\right)}{\left(\frac{u_2^2}{2g}\right)}$$

Therefore,

$$\frac{s_1}{s_2} = \frac{u_1^2}{u_2^2} \text{ or } u_1^2 : u_2^2$$

Hence proved.

BOARD CORNER

Short Answer Type Questions

Q. 1. Explain the difference between:

(i) Distance and displacement.

(ii) Speed and velocity.

[KVS, 2019, Agra Region]

Ans. (i)

Distance	Displacement
1. It is the length of the path travelled by body in a certain interval of time.	It is the shortest distance between the initial and final positions of a body.
2. It is a scalar quantity.	It is a vector quantity.
3. It cannot be zero.	It can be zero.

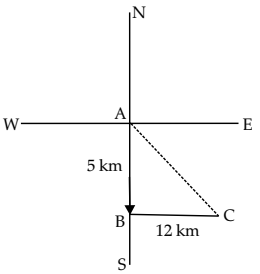
(ii)

Speed	Velocity
1. It is the distance travelled by an object in a given interval of time.	It is the displacement of an object in a given interval of time.
2. It does not have any direction.	It has a unique direction.
3. The speed of an object can never be zero.	The velocity of an object can be negative, positive or equal to zero.

3

Q. 2. Mr. Kumar while going to his office, first goes 5 km south to drop his mother at a temple, then he turns and goes 12 km towards east. calculate: (i) Total distance covered (ii) net displacement of Mr. Kumar. [KVS 2018, Agra Region]

Ans.



(i) Distance = Total length of the path

= AB + BC

= 5 + 12

= 17 km

(ii) Displacement = Shortest distance between initial position and final position.

AC = $(AB)^2 + (BC)^2$ (pythagoras theorem)

$= 5^2+12^2 = 25 = 144$

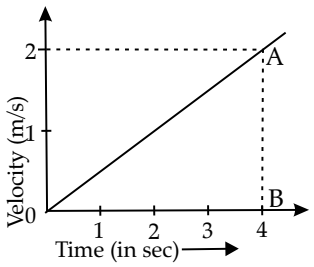
$= 169 = 13$ km. **3**

Q. 3. The velocity-time graph of a object moving in a definite direction is shown in the following figure. Answer the question based on this figure.

(a) What is the velocity of the particle at point 'A'?

(b) What does the slope of a graph represent?

(c) Calculate the distance travelled in 4 seconds.



Ans.

(a) Velocity = 2 m/s

(b) The uniform acceleration of the moving object is equal to the slope of the straight line.

(c) Distance covered in 4 sec.

= Area under graph of ΔAOB

$= \frac{1}{2} \times OB \times AB = \frac{1}{2} \times 4\ s \times 2\ ms^{-1}$

= 4 m **1 + 1 + 1**

Commonly Made Error

- Students often draw incorrect graph. Many of them forget to write the variables.

Answering Tip

- While plotting a graph of distance-time or velocity-time graphs, both independent and dependent variables must be written.

Q. 4. A train starting a railway station and moving with uniform acceleration attains a speed of 40 km/h in 10 min. Find its acceleration in S.I. units.

[KVS, 2018, Agra Region]

Ans. Initial Velocity of train, $u = 0$

Final Velocity of train, $v = 40$ km/h

$= 40 \times \frac{5}{18}\ ms^{-1}$

$= 11.11\ ms^{-1}$

Time taken = 10 min = 10 x 60 = 600 s

Acceleration $a = \frac{v-u}{t} = \frac{11.11-0}{600}$

$= 0.0185 \text{ m/s}^2$

$= 1.85 \times 10^{-2} \text{ m/s}^2$

Hence, acceleration of the train is $1.85 \times 10^{-2} \text{ m/s}^2$ **3**

Ⓚ Q. 5. State which of the following situations are possible and give an example for each of these :

(i) a body with a constant acceleration but with zero velocity.

(ii) an object moving in a certain direction with an acceleration in the perpendicular direction.

[KVS, 2018, Agra Region]

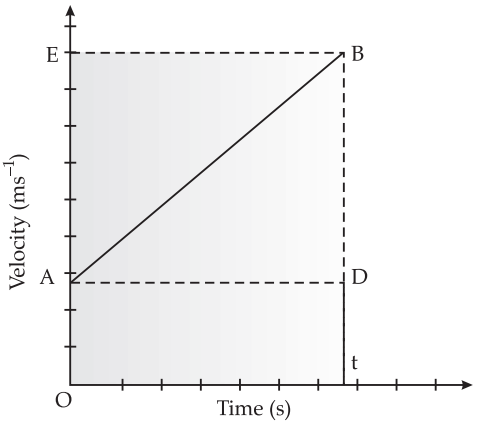
Ans. (i) (a) Possible : When a ball is thrown up at maximum height, it has zero velocity, although it will have constant acceleration down wards due to gravity, which is equal to 9.8 m/s^{-2}.

(b) Possible : When a car is moving in a circular track at constant speed, its acceleration is perpendicular to its direction. **3**

Ⓚ Q. 6. Derive an equation for position time relation by graphical method. [KVS, 2018, Agra Region]

Ans. Derivation of second equation of motion or equation for position-time relation :

Let us consider that the object has travelled a distance s in time t under uniform acceleration *a*.



As in the graph, the distance travelled by the object is obtained by the area enclosed within OABC under the velocity-time graph AB.

Thus, the distance s travelled by the object is given by

s = area OABC (which is trapezium)

= area of the rectangle OADC + area of the triangle ABD

$= \text{OA} \times \text{OC} + \frac{1}{2} (\text{AD} \times \text{BD})$

Substituting OA = u, OC = AD = t

and BD = at, we get

$s = u \times t + (\frac{1}{2} (t \times at)$

or $s = ut + = \frac{1}{2} at^2$