Chapter 2

Motion

Exercise:

I) Choose the correct answer.

1) The area under velocity – time graph represents the

a) Velocity of the moving object.

b) Displacement covered by the moving object.

c) Speed of the moving object.

d) Acceleration of the moving object.

Ans: d) acceleration of the moving object.

Explanation- Because, the time rate of change of velocity is called as acceleration.

2) Which one of the following is most likely not a case of uniform circular motion?

a) Motion of the Earth around the Sun

b) Motion of a toy train on a circular track.

c) Motion of a racing car on a circular track.

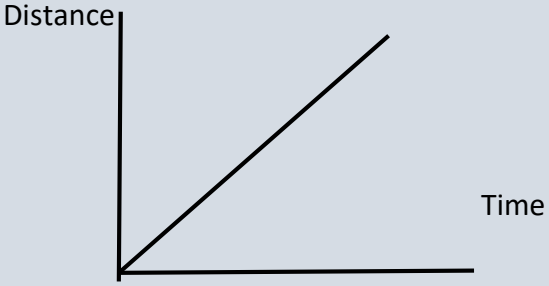
d) Motion of hours' hand on the dial of the clock.

Ans: c) Motion of a racing car on a circular track.

Explanation- Because, the motion of car racing on circular track changes continuously in order to reach the last point fastly.

3) Which of the following graph represents uniform motion of a moving particle?

Ans: b)



Explanation- Because, in above graph the straight line is passing through the origin which means there is linear variation in distance with time. And hence, the velocity is constant. So the motion of a moving object is uniform motion.

4) The centrifugal force is

a) A real force.

b) The force of reaction of centripetal force.

c) A virtual force.

d) Directed towards the centre of the circular path.

Ans: c) a virtual force.

Explanation- Because, it has no real origin.

II) Fill in the blanks.

1) Speed is a _____ quantity whereas velocity is a _____ quantity.

Ans: Speed is a scalar quantity whereas velocity is a vector quantity

Explanation- Because, speed has only magnitude and velocity has both direction and magnitude.

2) The slope of the distance – time graph at any point gives _____

Ans: The slope of the distance – time graph at any point gives speed.

Explanation- Because, the time rate of change of distance is the speed of the object.

3) Negative acceleration is called _____

Ans: Negative acceleration is called retardation or deceleration.

Explanation- Because, negative acceleration means the decrease in acceleration.

4) Area under velocity – time graph shows _____

Ans: Area under velocity – time graph shows acceleration.

Explanation- Because, the time rate of change of velocity is the acceleration of the object.

III) State whether true or false. If false, correct the statement.

1) The motion of a city bus in a heavy traffic road is an example for uniform motion.

Ans: False

Explanation- Because, the motion of bus changes with respect to time in heavy traffic also and hence it is not uniform motion.

2) Acceleration can get negative value also.

Ans: True

Explanation- Because, acceleration can take negative value which is called as retardation of deceleration.

3) Distance covered by a particle never becomes zero but displacement becomes zero.

Ans: True

Explanation- Because, distance is the scalar quantity and displacement is vector quantity which depends on direction also.

4) The velocity – time graph of a particle falling freely under gravity would be a straight line parallel to the x axis.

Ans: False

Explanation- Because, the velocity – time graph of a particle falling freely under gravity would be a straight line perpendicular to the x axis.

5) If the velocity – time graph of a particle is a straight line inclined to X-axis then its displacement – time graph will be a straight line.

Ans: False

Explanation- Because, if the velocity – time graph of a particle is a straight line inclined to X-axis then its displacement – time graph will be parabolic in nature.

IV) Assertion and reason type questions.

Mark the correct choice as:

a) If both assertion and reason are true and reason is the correct explanation of assertion.

b) If both assertion and reason are true but reason is not the correct explanation of assertion.

c) If assertion is true but reason is false.

d) If assertion is false but reason is true.

1) Assertion: The accelerated motion of an object may be due to change in magnitude of velocity or direction or both of them.

Reason: Acceleration can be produced only by change in magnitude of the velocity. It does not depend the direction.

Ans: c. if assertion is true but reason is false.

Explanation- Because, acceleration can be produced by change in magnitude of velocity or direction or both of them.

2) Assertion: The Speedometer of a car or a motor-cycle measures its average speed.

Reason: Average velocity is equal to total displacement divided by total time taken.

Ans: d. If assertion is false but reason is true.

Explanation- Because, The Speedometer of a car or a motor-cycle measures its instantaneous speed.

3) Assertion: Displacement of a body may be zero when distance travelled by it is not zero.
Reason: The displacement is the shortest distance between initial and final position.

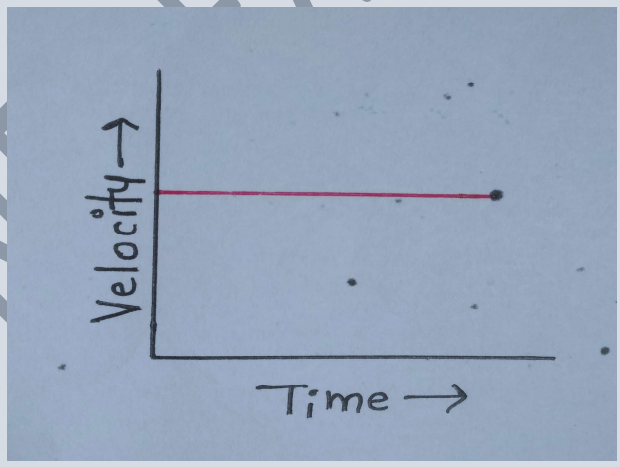
Ans: c. if assertion is true but reason is false.

Because, displacement of the body is zero only when the initial and final position of the body is same but in that case distance cannot be zero.

V) Match the Following.

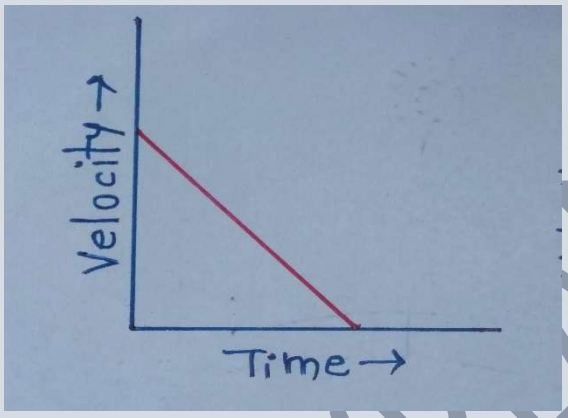
Ans:

1) Motion of a body covering equal distances in equal interval of time

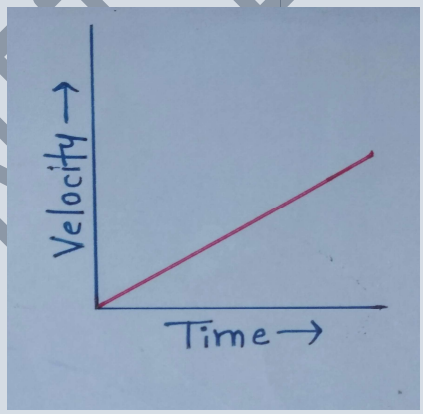


2) Motion with non-uniform acceleration

3) Constant retardation



4) Uniform acceleration



VI) Answer briefly.

1) Define velocity.

Ans:

Velocity of an object is defined as the rate of change of displacement.

Velocity is the vector quantity i.e. it has both magnitude and direction.

Its SI unit is m/s

If the velocity of the moving object is constant then it is called uniform motion.

The object is at rest means its velocity is zero.

The speed and velocity are two different quantities. Speed is a scalar while velocity is the vector quantity.

2) Distinguish distance and displacement.

Ans:

The distance is the actual path traveled by the object which is independent of the direction.

The displacement is the change in position of the object with respect to direction.

Distance is the scalar quantity as it has only magnitude.

Displacement is the vector quantity as it has both direction and magnitude.

The SI unit of both is meter.

If the final and initial position of the objects are same then displacement is zero but distance cannot be zero.

Displacement and distance are same only when the path of object is same and does not changes its direction.

3) What do you mean by uniform motion?

Ans:

When a object or body is travelling with constant velocity throughout its motion then it is called as uniform motion.

That is, in uniform motion body travels an equal distance in equal interval of time.

For example, the hour hand, minute hand and second hand in a clock are performing uniform motion,

The motion of earth around the sun and motion of moon around the earth are the best examples of uniform motion.

4) Compare speed and velocity.

Ans:

Speed is the physical quantity having only magnitude.

It is the unit distance travelled in a unit time and it is the scalar quantity.

Its SI unit is m/s.

Velocity is the physical quantity having both magnitude and direction.

It is the unit displacement travelled in a unit time and it is a vector quantity.

Its SI unit is m/s

Velocity of the objects depends on the direction of the object moving.

Velocity may be negative but speed never negative.

5) What do you understand about negative acceleration?

Ans:

Acceleration is the rate of change of velocity in a unit time.

It is a vector quantity and its SI unit is m/s^2.

Accelerated motion is also called as non-uniform motion.

When the velocity of the object changes with time then only accelerated motion is possible.

If the final velocity is less than initial velocity i.e. the velocity decreases with time then the acceleration will be negative.

The negative acceleration is called as the retardation or deceleration

If the acceleration is $5m/s^2$ then deceleration is $-2m/s^2$.

For example: when the stone is thrown upward then it is under deceleration, the bus approaching to bus stop are the examples of retardation.

6) Is the uniform circular motion accelerated? Give reasons for your answer.

Ans:

The motion of the object along the circular path with constant speed but continuous change in direction with time is called as uniform circular motion.

In uniform circular motion speed is constant but direction of motion changes continuously and hence, it is an accelerated motion.

That means, in uniform circular motion the speed is constant but velocity is different at each point on the circular path.

7) What is meant by uniform circular motion? Give two examples of uniform circular motion.

Ans:

The motion of a body in which the speed of body remains constant but its direction changes continuously along a circular path or on the circumference of a circle is called as uniform circular motion.

The change in direction leads to acceleration so uniform circular motion is the accelerated motion.

For example: the motion of the hour hand, minute hand and second hand in a clock is the uniform circular motion.

The motion of earth around the sun and the motion of moon around the earth are the examples of uniform circular motion.

VII) Answer in detail.

1) Derive the equations of motion by graphical method.

Ans:

The relation between displacement, velocity, acceleration and time of a moving object is given by three equations which are called as equations of motion.

It was studied by Newton.

This three equations of motion are

$$v = u + at$$
$$s = u\,t + \tfrac{1}{2}\,a\,t^2$$
$$v^2 = u^2 + 2a\,s$$

The derivation of these three equations is given by graphical method which is as follows:

The following figure shows the change in velocity with respect to time for a uniform accelerated motion.

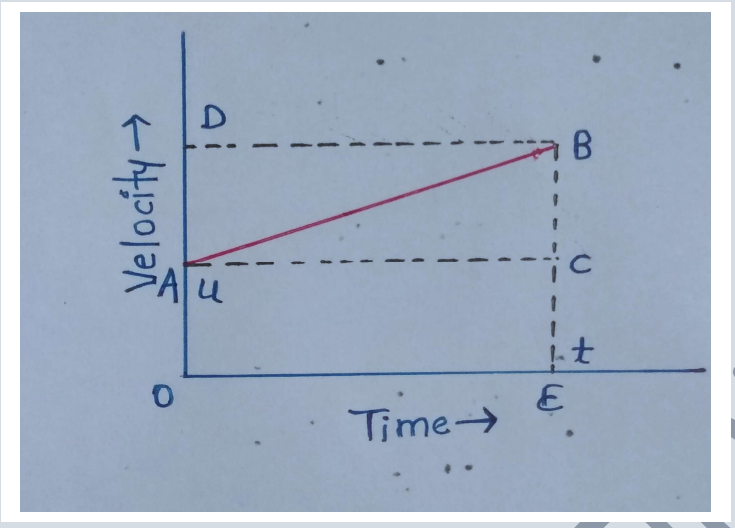


Fig. Graphical method to derive equation of motion

Let the object starts from point A with initial velocity u, the velocity of the object is increasing with time and finally it reaches to the point D on the graph.

Initial velocity of the object = u =OA = EC

Final velocity of the object = v = OD = EB

And t is the time required to the object to reach from initial to final position.

t = OE = AC

By definition of acceleration,

Acceleration = (change in velocity)/ time

= (final velocity – initial velocity)/ time

$a = (v - u)/t$

$a\,t = v - u$

$v = u + a\,t$

This is the first equation of motion.

From graph, the area under the curve AOEB gives the distance covered by the object during time t,

S = Area (quadrilateral AOEB)

= Area (rectangle AOEC) +Area (triangle ACB)

s = CE * OE + (1/2 *CB * AC)

= u t + ½ (v – u) t

= u t + ½ (a t) t since v – u = a t

$s = u t + ½ a t^2$

This is the second equation of motion.

We know that, the area under the curve AOEB gives the distance covered by the object during time t and it is a trapezium,

s = Area of trapezium AOEB

s = ½ * (sum of lengths of parallel sides)* (distance between parallel sides)

s = ½ (OA + EB) * OE

s = ½ (u + v) * t

s = ½ (u + v) * (v-u/a)

$2as = (v + u) * (v – u)$

$2as = v^2 – u^2$

$v^2 – u^2 = 2as$

This is the third equation of motion.

1) Explain different types of motion.

Ans:

The change in position of the object with respect to time and its surroundings is called as motion.

There are different types of motion on the basis of their path and velocity which are as follows:

a) Translational motion: when the object moves from one position to another then it is called as translational motion.

e.g. Motion of moving car

b) Rectilinear motion: when the object moves along the straight line path then it is called as rectilinear motion.

e.g. motion of car along a straight line path

c) Circular motion: when the object is moving along the circumference of a circle or along the circular path then it is called circular motion. If the speed is constant in circular motion then it is called as uniform circular motion.

e.g. motion of hour hand in clock

d) Rotational motion: when the object described the concentric circles around the fixed axis called axis of rotation then that motion is called as rotational motion.

e.g. Rotating wheel of vehicle

e) Vibrational motion or Oscillatory motion: when the object performs the to and fro motion about its mean position then it is called as vibrational motion.

e.g. motion of needle of saving machine.

f) Periodic motion: when the object repeats its motion after equal interval of time then it is called as periodic motion.

e.g. motion of earth around the sun

VIII) Exercise Problems.

1) A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 ms–2, with what velocity will it strike the ground? After what time will it strike the ground?

Ans:

As the ball is dropped from height then its initial velocity u = 0

Striking velocity to the ground = v =?

Height of the ball dropped is = s = 20 m

Velocity increases uniformly at the rate of 10 m/s^2 means acceleration of the ball = a = 10 m/s^2

Then, by third equation of motion, $v^2 = u^2 + 2a\,s$

$$v^2 - u^2 = 2a\,s$$
$$v^2 - 0 = 2\,(10)\,(20)$$
$$v^2 = 400$$

$v = 20$ m/s

And, by first equation of motion, $v = u + at$

$$(v - u)/a = t$$
$$(20 - 0)/ 10 = t$$

$t = 2$ s

Thus, the ball strike the ground with velocity 20 m/s after time 2s.

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

Ans:

Given that, diameter of circular track = 200 m

Radius of circular track = r = 100 m

The athlete complete one round in 40 seconds.

The no. of rounds in 2 minute 20 seconds = 2* 60 + 20 = 140 seconds

Hence, the no. of rounds in 140 seconds = 140 / 40 = 3.5

In one round covers the distance equal to circumference of the circle.

Hence, in 3.5 rounds the distance covered is = $3.5 * 2\pi r$

$$= 3.5 * 2* 3.14* 100 = 2198 \text{ m}$$

But, after one complete round the displacement should be zero and hence after completion of three rounds the displacement will be zero.

Hence the displacement is possible only in remaining half round due to which it is at the diametrically opposite position of the initial position.

Thus, the total distance covered is 2198 m and the displacement is 200 m

3) A racing car has a uniform acceleration of 4 ms–2. What distance it covers in 10 s after the start?

Ans:

Given that, initial velocity of car is zero, hence, u = 0

Acceleration = 4 m/s2

Time = t = 10 s

By second equation of motion, we write

$s = u\,t + \frac{1}{2}\,a\,t^2$

$s = 0 + \frac{1}{2} * 4 * 100 = 200$ m

Thus, the distance covered by the racing car after 10 s is 200 m.