UNIT 2

Motion

EK4S5R

Learning Objectives

Students will be able to

- list the objects which are at rest and which are in motion around them
- understand distance and displacement
- determine the displacement and distance covered by an object describing a circular path
- classify the motion of vehicles as uniform motion and non-uniform motion
- distinguish between speed and velocity
- relate accelerated and unaccelerated motion
- deduce the equations of motion of an object from velocity – time graph
- write the equations of motion for a freely falling body
- understand the nature of circular motion
- identify centripetal force and centrifugal force in day to day life

Introduction

Every object undergoes motion, even stationary objects move along with the speed of earth.

Hence it becomes necessary to study the state of an object at any instant of time. An object under the influence of forces may either be at rest or in motion.

2.1 State of Rest and Motion

Activity 1

Look around you! What do you see? Many things, a row of houses, large trees, small plants, flying birds, running cars and buses and many more

- List the objects which remain fixed at their position, and do not change their position and
- List the objects which keep on changing their position

In physics, the objects which do not change their position are said to be at rest, while those which change their position are said to be in motion. Example: A book lying on a table, the walls of a room (at rest) Cars and buses running on the road, birds and aeroplanes flying in air (in motion). Motion is a relative phenomenon. This means that an object appearing to be in motion to one person can appear to be at rest as viewed by another person. For example, trees on roadside would appear to move backward for a person travelling in a car while the same tree would appear to be at rest for a person standing on road side.

2.2 Types of Motion

Activity 2

Have you ever gone to an amusement park? Have you seen the motion of a giant wheel? List various types of motion of the play machines like children train, dragula ride, etc.

In physics, motion can be classified under the following types for ease of understanding.

Linear motion – where the object moves along a straight line.

Circular motion – where the object moves along a circular path.

Oscillatory motion – where an object describes a repetitive to and fro movement retracing its original path.

Uniform motion – where an object travels equal distance in equal intervals of time.

Random motion – where the motion of the object does not fall in any of the above categories.

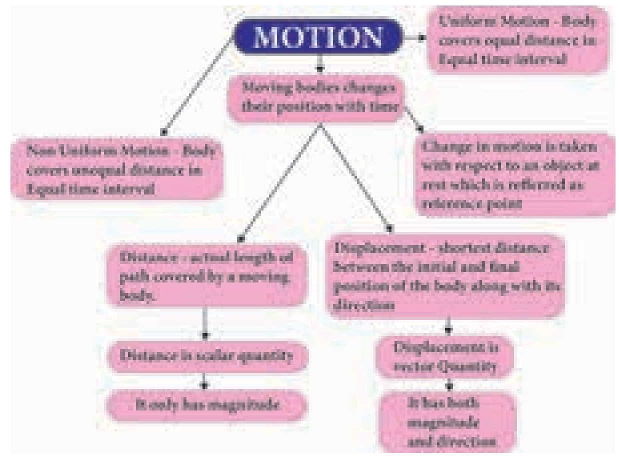
2.3 Distance and Displacement

2.3.1 Distance

The actual length of the path travelled by a moving body irrespective of the direction is called the distance travelled by the body. It is measured in metre in SI system. It is a scalar quantity having magnitude only.

2.3.2 Displacement

It is defined as the change in position of a moving body in a particular direction. It is vector quantity having both magnitude and direction. It is also measured in metre in SI system.



Activity 3

Observe the motion of a car as shown in the Figure 1.

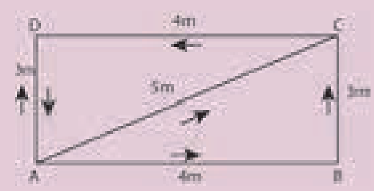


Figure 1 Motion of a car

Now answer the following questions:

1. How much distance is covered by the car through the path ABC and AC and compare the values? From this what do you observe?
2. Which path gives the shortest distance to reach D from A? Either the path ABCD or the path ACD or the path AD. Think!
3. What is the total distance covered by the car when it travels the path ABCDA and where does it finally reach? From this what do you understand? How much distance it covers? What is its displacement?

Activity 4

Tabulate the differences between distance and displacement.

2.4 Uniform and Non Uniform Motion

Activity 5

Tabulate the distance covered by a bus in a heavy traffic road in equal intervals of time and do the same for a train which is not in an accelerated motion. From this table what do you understand?

The bus covers unequal distance in equal intervals of time but the train covers equal distances in equal intervals of time.

2.4.1 Uniform motion

An object is said to be in uniform motion if it covers equal distances in equal intervals of time how so ever big or small these time intervals may be.

For example, suppose a car covers 60 km in first hour, another 60 km in second hour, and again 60 km in the third hour and so on. The motion of the car is uniform. Let us now understand the meaning of the words "how so ever small the time interval may be" used in the definition. In this example, the car travels a distance of 60 km in each hour. In the striker sense, the car should travel 30 km in each half an hour, 15 km in every 15 minutes, 10 km in every 10 minutes, 5 km in every 5 minutes and 1 km in every 1 minute. Only then the motion of the car can be said to be uniform.

2.4.2 Non uniform motion

An object is said to be in non uniform motion if it covers unequal distances in equal intervals of time.

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Consider a bus starting from one stop. It proceeds slowly when it passes crowded area of the road. Suppose, it manages to travel merely 100 m in 5 minutes due to heavy traffic, when it gets out and the road is clear, it speeds up and is able to travel about 2 km in 5 minutes.

We say, the motion of the bus is non uniform i.e. it travels unequal distances in equal intervals of time.

2.5 Speed, Velocity and Acceleration

2.5.1 Speed

Speed is the rate of change of distance or the distance travelled in unit time. It is a scalar quantity. The SI unit of speed is ms^{-1}. Thus,

Speed = Distance travelled / time taken

2.5.2 Velocity

Velocity is the rate of change of displacement. It is the displacement in unit time. It is a vector quantity. The SI unit of velocity is ms^{-1}. Thus,

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Velocity = Displacement / time taken

2.5.3 Acceleration

Acceleration is the rate of change of velocity or it is the change of velocity in unit time. It is a vector quantity. The SI unit of acceleration is ms^{-2}.

Acceleration = Change in velocity/time
= (Final velocity – initial velocity)/time

$a = (v-u)/t$

Consider a situation in which a body moves in a straight line without reversing its direction.

Case 1: From the above equation if $v > u$, i.e. if final velocity is greater than

Compare speed and velocity

Speed	Velocity
It is the rate of change of distance	It is the rate of change of displacement
It is a scalar quantity having magnitude only	It is a vector quantity having both magnitude and direction
It is measured in ms^{-1} in SI system	It is also measured in ms^{-1} in SI system
Speed in any direction would be a positive quantity, since the distance in any direction is a positive quantity.	Velocity can have both positive and negative values. If velocity in one direction is assumed to be positive then the velocity in the opposite direction would be a negative quantity. Velocity can have zero value also, even for an object under motion.

initial velocity, the velocity increases with time and the value of acceleration is positive.

Case 2: If v < u, i.e. if final velocity is less than initial velocity, the velocity decreases with time and the value of acceleration is negative. It is called negative acceleration.

Note

Negative acceleration is called retardation or deceleration.

If the acceleration has a value of $-2\ ms^{-2}$ when we say that the retardation is $2\ ms^{-2}$ or deceleration is $2\ ms^{-2}$.

Case 3: If v = u, then a = 0. This means that the acceleration is zero when the final velocity is equal to initial velocity

2.6 Graphical Representation of Motion along a Straight Line

Plotting the distance/displacement or speed/velocity on a graph helps us visually understand certain things about time and position.

2.6.1 The distance – time graph for uniform motion

The following Table shows the distance walked by Surya at different times.

Time (minute)	Distance (metre)
0	0
5	500
10	1000
15	1500
20	2000
25	2500

A graph is drawn by taking time along X-axis and distance along Y-axis. The graph is known as distance – time graph. When we look at the distance – time graph of Surya's walk, we notice certain things. First, it is a straight line. We also notice that Surya covers equal distances in

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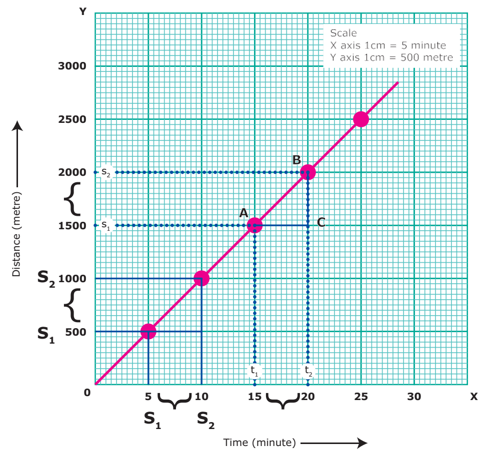


equal intervals of time. We can therefore conclude that Surya walked at a constant speed. Can you find the speed at which Surya walked, from the graph? Yes, you can. The parameter is referred to as the slope of the line.

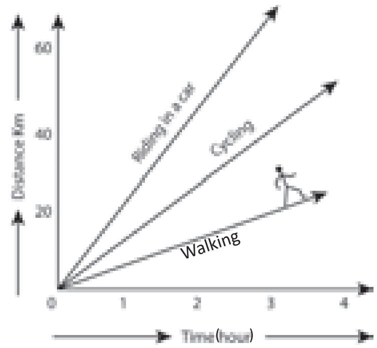
Speed at which Surya walked = distance covered / time taken = BC/AC (From the graph)

= slope of the straight line

= 500 / 5 = 100 ms^{-1}

Steeper the slope (in other words the larger value) the greater is the speed.

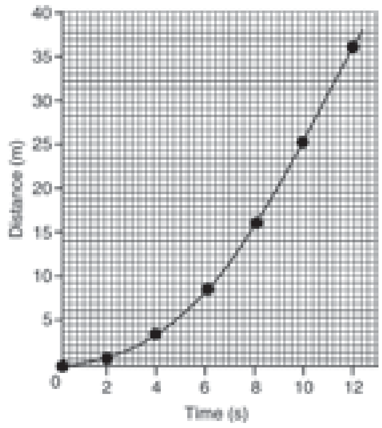
Let us take a look at the distance – time graphs of three different people – Surya walking, Monica cycling and Hari going in a car, along the same path. We know that cycling can be faster than walking and a car can go faster than a cycle. The distance – time graph of the three would be as given in the following graph. The slope of the line on the distance – time graph becomes steeper and steeper as the speed increases.



2.6.2 The distance time graph for non uniform motion

We can also plot the distance – time graph for accelerated motion (non uniform motion). Table given below shows the distance travelled by a car in a time interval of two second.

Time (second)	Distance (metre)
0	0
2	1
4	4
6	9
8	16
10	25
12	36

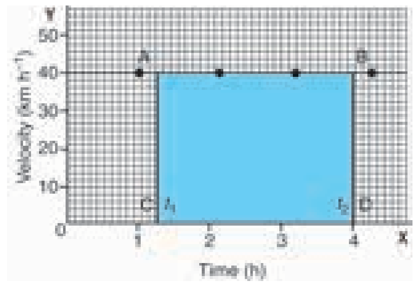


Note that the graph is not a straight line as we got in the case of uniform motion. This nature of the graph shows non – linear variation of the distance travelled by the car with time. Thus, the graph represents motion with non uniform speed.

2.6.3 Velocity – Time graph

The variation in velocity of an object with time can be represented by velocity – time graph. In the graph, time is represented along the X – axis and the velocity is represented along the Y – axis. If the object moves at uniform velocity, a straight line parallel to

X-axis is obtained. This Graph shows the velocity – time graph for a car moving with uniform velocity of 40 km/hour.



We know that the product of velocity and time gives displacement of an object moving with uniform velocity.

The area under the velocity – time graph is equal to the magnitude of the displacement.

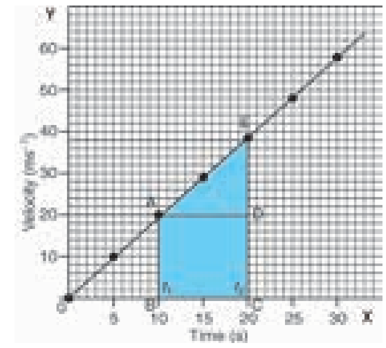
So the distance (displacement) S covered by the car in a time interval of t can be expressed as

S = AC × CD

S = Area of the rectangle ABCD (shaded portion in the graph)

We can also study about uniformly accelerated motion by plotting its velocity – time graph. Consider a car being driven along a straight road for testing its engine. Suppose a person sitting next to the driver records its velocity for every 5 seconds from the speedometer of the car. The velocity of the car in ms^{-1} at different instants of time is shown in the Table below.

Time (Second)	Velocity of the Car (ms^{-1})
0	0
5	9
10	18
15	27
20	36
25	45
30	54



In this case, the velocity – time graph for the motion of the car is shown in graph (straight line). The nature of the graph shows that the velocity changes by equal amounts in equal intervals of time. Thus, for all uniformly accelerated motion, the velocity – time graph is a straight line.

One can also determine the distance moved by the car from its velocity – time graph. The area under the velocity – time graph gives the distance (magnitude of displacement) moved by the car in a given interval of time.

Since the magnitude of the velocity of the car is changing due to acceleration, the distance S travelled by the car will be given by the area ABCDE under the velocity – time graph. That is

S = area ABCDE

= area of the rectangle ABCD + area of the triangle ADE

S = (AB × BC) + ½ (AD × DE)

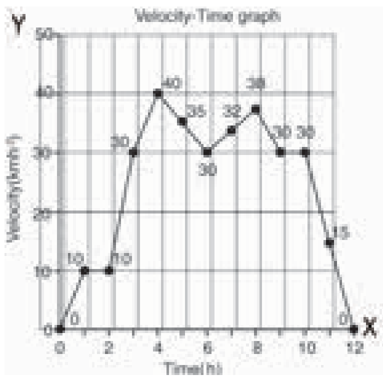
The area ABCDE can also be calculated by considering the shape as trapezium. Area of the quadrangle ABCDE can also be calculated by calculating the area of trapezium ABCDE. It means

S = area of trapezium ABCDE

= ½ × sum of length of parallel sides × distance between parallel sides

S = ½ × (AB + CE) × BC

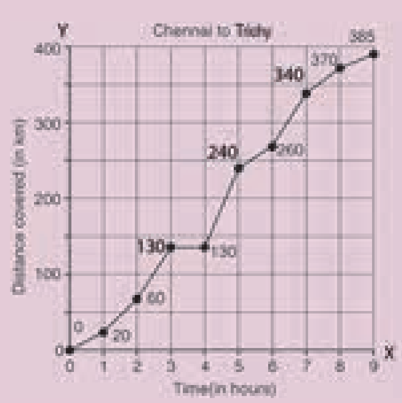
In the case of non uniformly accelerated motion, distance – time graph, velocity – time graphs can have any shape as shown in Figure below:



Study the velocity – time graph of the car and answer the following questions:

- *What was the maximum value of velocity during the journey?*
- *Was the velocity constant during any part of the journey? If so, when was it?*
- *What was the maximum value of acceleration during the journey? When did it occur?*
- *When did the car slow down?*
- *What was the value of acceleration during the period between 10^{th} and 12^{th} hour?*

Activity 6



The whole class can divide themselves into small groups, study the distance-time graph of the bus travelling from Chennai to Trichy and discuss the questions given below:

- *What is the total distance between Chennai and Trichy?*
- *How long did the bus take for the full journey?*
- *Was the speed of the bus constant?*
- *Did the bus halt for a while during the journey?*
- *If it halted, how long was the halt?*
- *Simply, by looking at the inclination of the graph line, can you tell when the speed was the greatest?*
- *What was the maximum speed that the bus attained during the journey?*

DO YOU KNOW?

The magnitude of instantaneous velocity is equal to the instantaneous speed at the given instant. The speedometer of an automobile measures the instantaneous speed of the automobile. In a uniform motion in one dimension, the average velocity = instantaneous velocity. Instantaneous velocity is also called velocity and instantaneous speed also called simply speed.

2.7 Equations of Motion

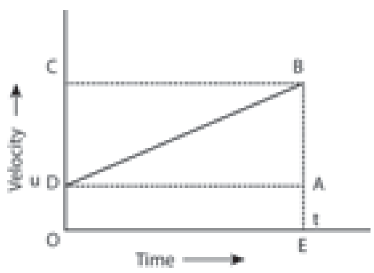
Newton studied the motion of an object and gave a set of three equations of motion. These equations relate the displacement, velocity, acceleration and time of an object under motion. An object is in motion with initial velocity u attains a final velocity v in time t due to acceleration a, with displacement s.

The three equations of motion can be written as,

$$v = u + at$$
$$s = ut + \frac{1}{2} a t^2$$
$$v^2 = u^2 + 2as$$

Let us try to derive these equations by graphical method.

Equations of motion from velocity – time graph:



Graph shows the change in velocity with time for an uniformly accelerated object. The object starts from the point D in the graph with velocity u. Its velocity keeps increasing and after time t it reaches the point B on the graph.

The initial velocity of the object = u = OD = EA

The final velocity of the object = v = OC = EB

Time = t = OE = DA

Also from the graph we know that, AB = DC

2.7.1 First equation of motion

By definition, acceleration = change in velocity / time

= (final velocity – initial velocity)/ time

= (OC – OD) / OE

= DC / OE

a = DC / t

DC = AB = at

From the graph EB = EA + AB

$$\boxed{v = u + at} \quad (1)$$

This is first equation of motion.

2.7.2 Second equation of motion

From the graph the distance covered by the object during time t is given by the area of quadrangle DOEB

s = area of the quadrangle DOEB

= area of the rectangle DOEA + area of the triangle DAB

= (AE × OE) + (1/2 × AB × DA)

$$\boxed{s = ut + \frac{1}{2} at^2} \quad (2)$$

This is second equation of motion.

2.7.3 Third equation of motion

From the graph the distance covered by the object during time t is given by the area of the quadrangle DOEB. Here DOEB is a trapezium. Then

S = area of trapezium DOEB

= ½ × sum of length of parallel side × distance between parallel sides

= ½ × (OD + BE) × OE

S = ½ × (u + v) × t

since a = (v – u) / t or t = (v – u)/a

Therefore s = ½ × (v + u) × (v – u)/a

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

$$\boxed{v^2 = u^2 + 2as} \quad (3)$$

This is third equation of motion.

Motion of objects under the influence of gravitational force of the earth – Freely falling body:

Activity 7

Take a large stone and a small eraser. Stand on the top of a table and drop them simultaneously from the same height? What do you observe?

Activity 8

Take a small eraser and a sheet of paper. Stand on the top of a table and drop them simultaneously from the same height? What do you observe?

Activity 9

Take two sheets of paper having same mass. Now, crumple one of the sheets into a ball and drop the sheet and the ball from the same height. What do you observe?

In activity 7, both the stone and the eraser have reached the surface of the earth almost at the same time but in activity 8, the eraser reaches first, the sheet of paper reaches later. In activity 9, the paper crumpled into a ball reaches ground first and plain sheet of paper reaches later, although they have equal mass. Do you know the reason? When all these objects are dropped in the absence of air medium (vacuum), all would have reached the ground at the same time. In air medium, due to friction, air offers resistance to the motion of free falling objects. The resistance offered by air is negligibly small when compared to the gravitational pull acting on the stone and rubber (in activity 7). Hence, they reach the ground at the same time. But, in activity 8, the air resistance exerted on the sheet of paper is much higher than that on the eraser. Again in activity 9, the air resistance offered to the plain sheet of paper is much higher than that offered to the paper ball. This is because the magnitude of air resistance depends on the area of objects exposed to air. If we do experiment in a tall glass jar from which air has been sucked out, both the paper and the eraser would fall at the same rate. Galileo dropped different objects from the top of the Leaning Tower of Pisa in Italy to prove the same. We know that an object experiences acceleration during free fall. This acceleration experienced by an object is independent of mass. This means that all objects hollow or solid, big or small, should fall at the same rate.

DO YOU KNOW?

Can a body have zero velocity and finite acceleration?

Yes, when a body is thrown vertically upwards in space, then at the highest point, the body has zero velocity and acceleration equal to the acceleration due to the gravity.

The equation of motion for a freely falling body can be obtained by replacing ‘a’ in equations 1 to 3 with g, the acceleration due to gravity. For an object falling freely, its initial velocity u = 0. Thus we get the following equations

$$v = gt, \quad s = \tfrac{1}{2} gt^2, \quad v^2 = 2gh$$

when we through an object vertically upwards, it moves against the acceleration due to gravity. Hence g is taken to be –g in such cases.

Uniform circular motion

Activity 10

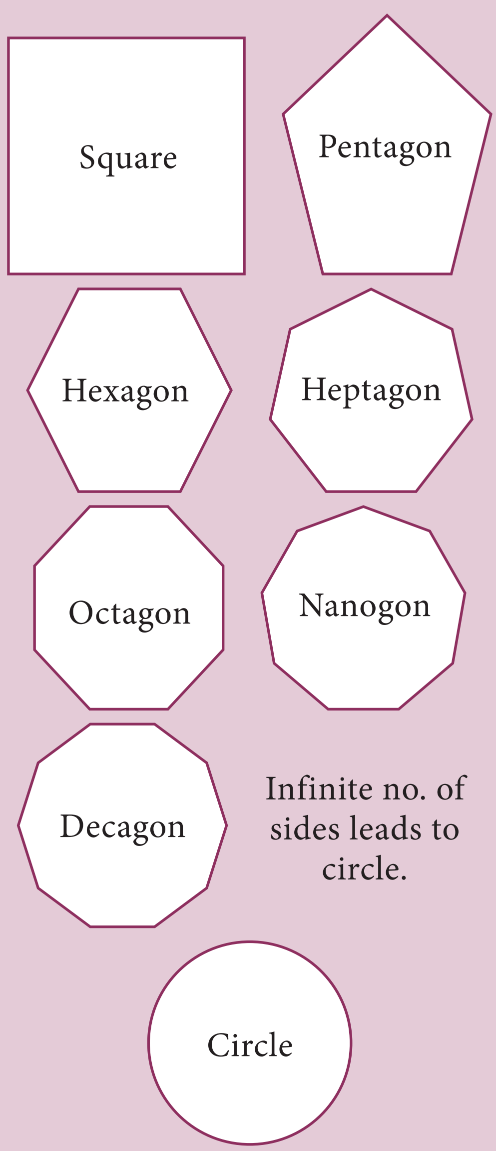
1. Draw a square path as shown in following Figure.
2. Place the tip of your pencil on the middle of any side of the square path.
3. Note how many times you have to change the direction while tracing the complete path.

4. Now repeat this action for a pentagon, hexagon, octagon and note the number of times one changes the direction to complete the path.

   This shows that as we increase the number of sides, we have to keep changing direction more and more times.

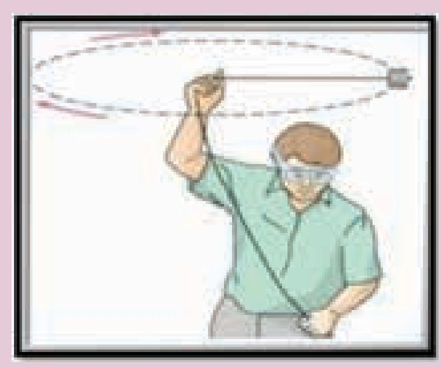
5. If you increase the number of sides of the polygon and make it infinite, how many times will you have to change the direction? What will be the shape of the path?

   And when we increase the number of sides to infinity, the polygon becomes a circle.



Activity 11

1. Take a piece of thread and tie a small piece of stone at one of its ends. Rotate the stone to describe a circular path with constant speed by holding the thread at the other end as shown in Figure below.
2. Now, release the thread and let the stone go.
3. Can you tell the direction in which the stone moves after it is released?
4. Repeat the activity for a few times, and releasing the stone at different positions of the circular path. Check whether the direction in which the stone moves remains the same or not.



If you carefully observe, on being released the stone moves along a straight line tangential to the circular path. This is because once the stone is released, it continues to move along the direction it has been moving at that instant. This shows that the direction of motion changed at every point when the stone was moving along the circular path. When an object moves with constant speed along a circular path, the motion is called uniform circular motion. When an object is moving with a constant speed along a circular path, the velocity changes due to the change in direction. Hence it is an accelerated motion.

Examples of uniform circular motion.

1. Revolution of earth around the sun.
2. Revolution of moon around the earth.
3. The tip of the second's hand of a clock.

If an object, moving along a circular path of radius r, takes time T to come back to its starting position, the speed v is given by,

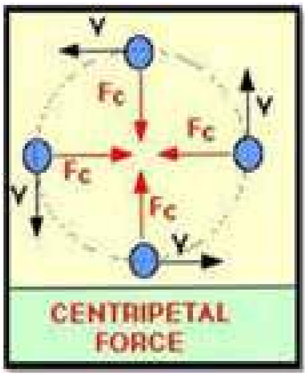
Speed = circumference/time taken

$V = 2\pi r/T$

Giant Wheel moves in a vertical circular path.

2.8 Centripetal Acceleration and Centripetal Force

A body is said to be accelerated, if the velocity of the body changes either in magnitude or in direction. Hence the motion of a stone in circular path with constant speed and continious changes of direction is an accelerated motion. There must be an acceleration acting along the string directed inwards, which makes the stone to move in circular path.



This acceleration is known as centripetal acceleration and the force is known as centripetal force. Since the centripetal acceleration is directed radially towards the centre of the circle, the centripetal force must act on the object radially towards the centre.

Let us consider an object of mass m, moving along a circular path of radius r, with a velocity v, its centripetal acceleration is given by

$$a = v^2/r$$

Hence, the magnitude of centripetal force is given by,

F = mass × centripetal acceleration

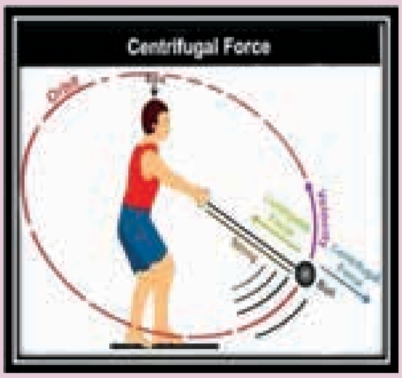
$F = mv^2/r$

Note

Any force like gravitational force, frictional force, magnetic force, electrostatic force etc., may act as a centripetal force.

Activity 12

Take a piece of rope and tie a small stone at one end. Hold the other end of the rope and rotate it such that the stone follows a circular path. Will you experience any pull or push in your hand? What do you infer?



In this activity, a pulling force that acts away from the centre is experienced. This is called as centrifugal force.

2.9 Centrifugal Force

Force acting on a body away from the centre of circular path is called centrifugal force. Thus centrifugal force is in a direction opposite to the direction of centripetal force. Its magnitude is same as that of centripetal force. The dryer in a washing machine is an example for the application of centrifugal force.

DO YOU KNOW?

How do we separate cream from milk?

A separator is a high speed spinner. It acts on the same principle of centrifuge machines. The bowl spins at very high speed causing the heavier contents of milk to move outward in the bowl pushing the lighter contents inward towards the spinning axis. Cream is lighter than other components in milk. Therefore, skimmed milk which is denser than cream is collected at outer wall of the bowl. The lighter part of cream is pushed towards the centre from where it is collected through pipe.

Spin dryer – centrifugal force

1-rotating metal drum

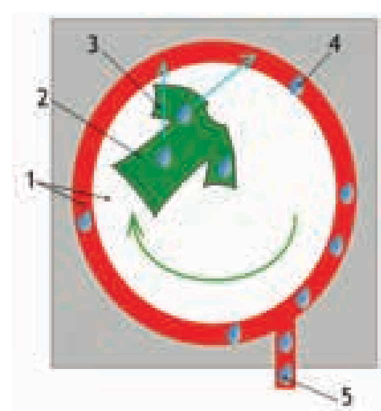
2&3 - wet cloth

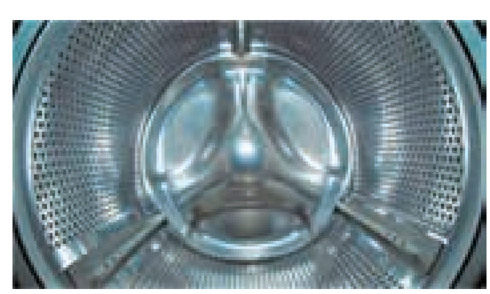
DO YOU KNOW?

When you go for a ride in a merry-go-round in amusement parks, what force do you experience? We experience an outward pull as merry-go round rotates about vertical axis. This is due to centrifugal force.

4-water droplet

5-let out of droplets





A spin dryer removes excess water from clothing by rotating a perforated drum at high speed. The water is thrown out through the holes. The clothes keep moving in a circle because the contact force of the drum provides centrifugal force.

2.10 Summary

- Motion is a change of position, which can be described in terms of the distance moved or the displacement.
- The motion of an object could be uniform or non-uniform depending on its velocity.
- The speed of an object is the distance covered per unit time and velocity is the displacement per unit time.
- The acceleration of an object is the change in velocity per unit time.
- Uniform and non-uniform motion of object can be shown through graphs.

The motion of an object at uniform acceleration can be described with the help of three equations, namely

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

where u is initial velocity of the object, v is its final velocity, s is the distance travelled in time t, a is the acceleration.

For a freely falling body the acceleration a is replaced by g.

An object under uniform circular motion experiences centripetal force.

A-Z GLOSSARY

1. **Motion** an object's change in position
2. **Distance** is a scalar quantity that refers to "how much length an object has covered" during its motion
3. **Displacement** is an object's change in position, only measuring from its starting position to the final position
4. **Speed** the rate of motion at which the object moves (distance/time)
5. **Velocity** the speed of an object in a particular direction
6. **Acceleration** change in velocity either magnitude or direction
7. **Circular motion** circular motion is a movement of an object along the circumference of a circle or rotation along a circular path
8. **Centripetal force** a force which acts on a body moving in a circular path and is directed towards the centre
9. **Centrifugal force** a force, arising from the body's inertia, which appears to act on a body moving in a circular path and is directed away from the centre
10. **Gravity** a force of attraction between object and the centre of Earth, due to their masses

ICT CORNER

FORCE AND MOTION

Newton's second law says a force acting on the object either change it's direction or acceleration or both. F=ma

This activity proves that:

Step 1. Type the following URL in the browser or scan the QR code from your mobile.Youcan see a wheel barrow full of load on the screen. Below that you can see two sets of people also.

Step 2. Place different number of peoples on both the side of the rope. Click go. According to the force given by the people the wheel barrow moves to anyone of the side. If the number of people is equal on both the sides the load will not move.

Step 3. By changing the number of people you can see the force and motion.

https://phet.colorado.edu/en/simulation/forces-and-motion-basics

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EXERCISE

I. Solved Examples

1. An object travels 16m in 4s and then another 16m in 2 s. What is the average speed of the object?

Sol: Total distance travelled by the object = 16 m + 16 m = 32m
Total time taken = 4s + 2s = 6s
Average speed =

$$\frac{\text{Total distance travelled}}{\text{total time taken}} = \frac{32m}{6s} = \frac{32}{6} = 5.33 ms^{-1}$$

Therefore, the average speed of the object is $5.33 ms^{-1}$

2. The brakes applied to a car produce an acceleration of 6 ms^{-2} in the opposite direction to the motion. If the car takes 2s to stop after the application of brakes. Calculate the distance it travels during this time.

Sol: We have been given $a = -6\ ms^{-2}$, $t = 2s$ and $v = 0$

From the equation of motion $v = u + at$

$0 = u + (-6 \times 2)$

$0 = u - 12$

$u = 12\ ms^{-1}$

$s = ut + ½\ at^2$

$= (12\times2) + ½\ (-6\times2\times2)$

$= 24-12$

$s = 12m$

Thus, the car will move 12m before it stops after the application of brakes.

3. Surya swims in a 90 m long pool. He covers 180 m in 60 s by swimming from one end to the other and back along the same straight path. Find the average speed and the average velocity of Surya.

Sol: Average speed = $\frac{\text{Distance covered}}{\text{time taken}} = \frac{180m}{60s} = 3 ms^{-1}$

Average velocity = $\frac{\text{Displacement}}{\text{time taken}} = \frac{0m}{60s} = 0$

The average speed of Surya is 3 ms^{-1} and his average velocity is 0

4. A 100 m long train crossed a bridge of length 200 m in 50 s with constant velocity. Find the velocity of the train.

Sol: Distance travelled by the train = length of the train + length of the bridge
= 100 m + 200 m
= 300 m
Velocity of the train =

$$\frac{\text{Distance travelled by the train}}{\text{time taken}} = \frac{300}{50}$$

= 6 ms^{-1}

5. A sound is heard 5 s later than the lightning is seen in the sky on a rainy day. Find the distance of location of lightning? Given the speed of sound = 346 ms^{-1}

Speed = $\frac{\text{Distance}}{\text{time}}$

Distance = speed × time = 346 × 5 = 1730m

Thus, the distance of location of lightning = 1730 m

6. A 900 kg car moving at 10 m s^{-1} takes a turn around a circle with a radius of 25 m. Determine the acceleration

and the net force acting upon the car.

When the car turns around circle, it experiences centripetal acceleration

$$a = \frac{\upsilon^2}{r}$$

The solution is as follows: $a = \frac{(10)^2}{25}$

$$a = \frac{100}{25}$$

$a = 4 \text{ m s}^{-2}$

To determine the net force acting upon the car, use the equation F = m a.

$F = m a \quad F = 900 \times 4 \quad F = 3600 \text{ N}$

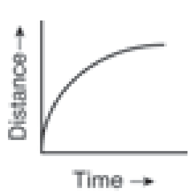
II. Multiple Choice Questions

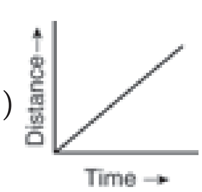
1. Slope of the velocity - time graph gives

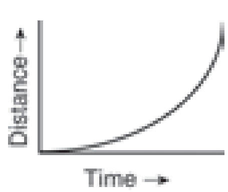
a) speed b) displacement

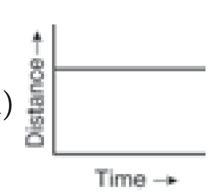
c) distance d) acceleration

2. Which of the following graph represents uniform motion of a moving particle?

a) 

b) 

c) 

d) 

3. A body moving with an initial velocity $5ms^{-1}$ and accelerates at $2ms^{-2}$. Its velocity after 10s is

a) $20ms^{-1}$ b) $25ms^{-1}$

c) $5ms^{-1}$ d) $22.55ms^{-1}$

4. In a 100 m race, the winner takes 10s to reach the finishing point. The average speed of the winner is

a) $5ms^{-1}$ b) $20ms^{-1}$

c) 40 ms^{-1} d) 10 ms^{-1}

5. The area under velocity – time graph represents

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

6. A car is being driven at a speed of 20 ms^{-1} when brakes are applied to bring it to rest in 5 s. The deceleration produced in this case will be

a) $+4 \text{ ms}^{-2}$ b) -4 ms^{-2}

c) -0.25 ms^{-2} d) $+0.25 \text{ ms}^{-2}$

7. Unit of acceleration is

a) ms^{-1} b) ms^{-2}

c) ms d) ms^2

8. 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.

9. The force responsible for drying of clothes in a washing machine is ....

a) Centripetal force

b) Centrifugal force

c) Gravitational force

d) Electro static force

10. The centrifugal force is ....

a) Real force

b) The force of reaction of centripetal force

c) Virtual force

d) Directed towards the centre of the circular path.

III. Fill in the Blanks

1. Speed is a _____________ quantity whereas velocity is a _____________ quantity
2. The slope of the distance – time graph at any point gives ___________
3. Consider an object is rest at position x = 20m. Then its displacement – time graph will be straight line to _____________ the axis.
4. Negative acceleration is called _____________
5. Area under velocity – time graph shows _____________

IV. True or False

1. The motion of a city bus in a heavy traffic road is an example for uniform motion.
2. Acceleration can get negative value also.
3. Distance covered by a particle never becomes zero between any interval of time but displacement becomes zero.
4. The velocity – time graph of a particle falling freely under gravity would be straight line parallel to the x axis.
5. If the velocity – time graph of a particle is a straight line inclined to time axis then its displacement – time graph will be a straight line?

V. Assertion and Reason Type Question

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.

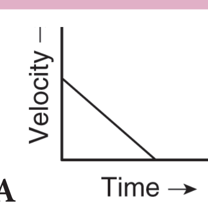
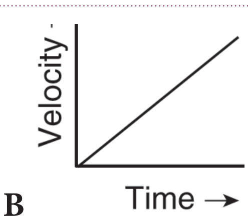
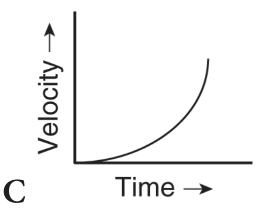
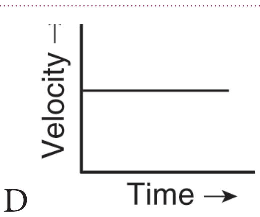
2. Assertion: The Speedometer of a car or a motor-cycle measures the average speed of it.

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

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.

VI. Match the Following

List I	List II
Motion of a body covering equal distances in equal interval of time	 A
Motion with non uniform acceleration	 B
Constant retardation	 C
Uniform acceleration	 D

VII. Short Answer Questions

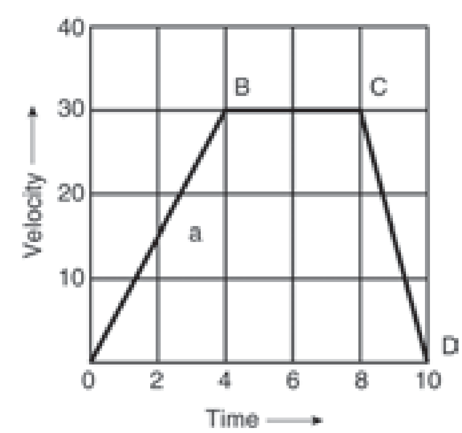
1. Define velocity?
2. Distinguish distance and displacement?
3. What do you mean by uniform motion?
4. Compare speed and velocity?
5. What do you understand about negative acceleration?
6. What remains constant in uniform circular motion? And What Changes continuously in uniform circular motion?
7. Is the uniform circular motion accelerated? Give reasons for your answer?
8. What is meant by uniform circular motion? Give two examples of uniform circular motion.

VIII. Paragraph Questions

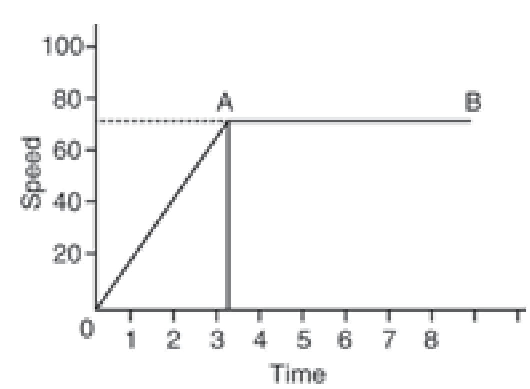
1. Derive equations of motion by graphical method.

IX. Exercise Problems

1. During an experiment, a signal from a spaceship reached the ground station in five seconds. What was the distance of the spaceship from the ground station? The signal travels at the speed of light that is 3×10^8 ms^{-1}
2. A ball is gently dropped from a height of 20m. 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?
3. 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?
4. A racing car has a uniform acceleration of 4 ms^{-2}. What distance it covers in 10 s after start?
5. A train travelling at a speed of 90 kmph. Brakes are applied so as to produce a uniform acceleration of -0.5 ms^{-2}. Find how far the train will go before it is brought to rest?
6. The adjacent diagram shows the velocity time graph of a body. During what time interval is the motion of the body accelerated. Find the acceleration in the time interval mentioned in part 'a'. What is the distance travelled by the body in the time interval mentioned in part a?



7. The following graph shows the motion of a car. What do you infer from the graph along OA and AB? What is the speed of the car along AB and what time it reached this speed



8. From the following Table, check the shape of the graph

Time (s)	0	2	4	6	8	10	12
Velocity(ms^{-1})	0	20	40	40	40	20	0

QUESTION PAPER - I

I. Choose the best answer

1. The area under velocity time graph represents
   a. Velocity of the moving object
   b. Displacement covered by the moving object
   c. Speed of the moving object

2. Unit of acceleration is
   a. Ms^{-1} b. ms^{-2}
   c. ms d. ms^{2}

3. When a body starts from rest, the acceleration of the body after 2second in _____________ of its displacement
   a. Half b. Twice
   c. Four times d. One fourth

II. Short answer Questions

1. A bus travel, a distance of 20km from Chennai central airport in 45 minutes. What is the average speed?
2. Why did the actual speed differ from average speed!
3. Mention the uses of velocity–time graph
4. The speed of a particle is constant. Will it have acceleration? Justify with an example
5. Distinguish distance and displacement of a moving object

III. Answer the following Question briefly

Derive the three equations of motion by graphical method.

QUESTION PAPER - II

I. Choose the best answer

1. In a 100 m race, the winner takes 10s to reach the finishing point. The average speed of the winner is ___________ ms^{-1}
   a) 5 b) 10
   c) 20 d) 40

2. Force involved in uniform circular motion is given by ________________
   a) $f = \frac{mv^2}{r}$ b) f = mvr
   c) $f = \frac{mr^2}{v}$ d) $f = \frac{v^2}{r}$

II. Choose correct statement

1. Action and reaction forces act on same object

   Action and reaction forces act on different objects

   Both (a) and (b) are possible

   Neither (a) nor (b) is correct

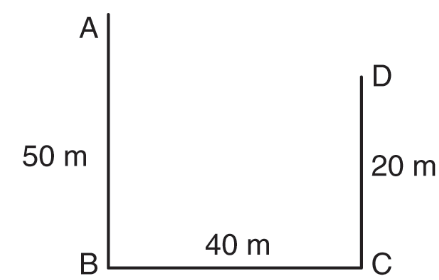
III. Short answer Questions

1. A motorcycle travelling at $20ms^{-1}$ has an acceleration of $4ms^{-2}$. What does it explains about the velocity of the motorcycle.

2. Complete of following sentences
   a. The acceleration of the body that moves with a uniform velocity will be ________
   b. A train travels from A to station B with a velocity of 100 km/h and returns from station B to station A with a velocity of 80km/h. Its average velocity during the whole journey in ______________ and its average speed is ____________
3. Distinguish speed and velocity.
4. What is meant by negative acceleration?

IV. Answer the following Question

A boy moves along the path ABCD. What is the total distance Covered by the boy? What is his net displacement?



REFERENCE BOOKS

1. Advanced Physics by: M. Nelkon and P. Parker, C.B.S publications, Chennai
2. College Physics by: R.L.Weber, K.V. Manning, Tata McGraw Hill, New Delhi.
3. Principles of Physics (Extended) - Halliday, Resnick & Walker, Wiley publication, New Delhi.

INTERNET RESOURCES

http://www.ducksters.com/science/physics/motion_glossary_and_terms.php

http://www.physicsclassroom.com/mmedia/circmot/ucm.cfm

http://www.physicsclassroom.com/Class/1DKin/U1L1d.cfm

http://www.physicsclassroom.com/Class/1DKin/U1L1e.cfm

https://brilliant.org/wiki/uniform-circular-motion-easy/

Centrifugal force

https://www.youtube.com/watch?v=Rv4pnUlf0PQ