6. A worldwide system of measurements in which the units of base quantities were introduced is called
   a) prefixes
   b) international system of units
   c) hexadecimal system
   d) none of above
7. All accurately known digits and first doubtful digit in an expression are known as
   a) non-significant figures
   b) significant figures
   c) estimated figures
   d) crossed figures
8. If zero line of Vernier scale coincides with zero of main scale, then zero error is
   a) positive b) zero
   c) negative d) one
9. zero error of the instrument is
   a) systematic error b) human error
   c) random error d) classified error
10. Length, mass, electric current, time, intensity of light and amount of substance are examples of
   a) base quantities b) derived quantities
   c) prefixes d) quartile quantities

Section (B) Structured Questions

1.

Column A Action	Column B Branch
Cooking Bar B.Q	Thermodynamics
Turning the Bulb on	
Riding a bicycle	
Looking for Giant Galaxies	
Producing a loud sound	
Describing an atom	
Obtaining energy from Earth	

2.

Physical Quantity	S.I Unit	Type
Ampere		
	m^3	
	Sec	Base
Temperature		Base
	N	
Density	Kg per m^3	
Acceleration		

3. Convert the following values.

a) 230 cm = ______________m

b) 250 g = ______________kg

c) 0.5 s = _________________ms

d) 0.8 m = _____________mm

e) 350ms = _________________s

f) 1.2Kg = ______________g

4. An engineer measures the width of an aluminum sheet using Vernier caliper as shown in fig 1.29

a)What is the measurement of the width of aluminum sheet

b)Which gives more precise measurement Vernier caliper, Screw Gauge or meter rule?

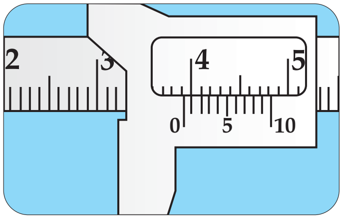


Fig 1.29

5. A pendulum swings as shown if figure 1.30 from X to Y and back to X again

i) What would be the most accurate way of measuring time for one oscillation? with the help of a Stop Watch.

a) Record time for 10 oscillations and multiply by 10

b) Record time for 10 oscillation and divide by 10

c) Record time for one oscillation

d) Record time from X to Y and double it

ii) Suggest an instrument for measuring time period more accurately.

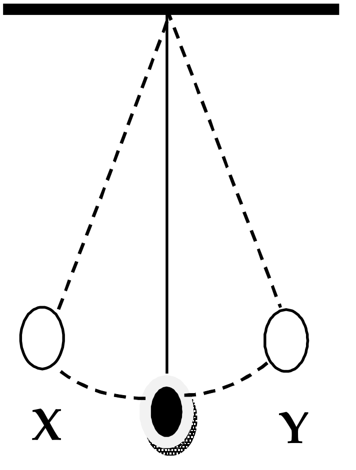


Fig. 1.30

Prefixes

6. write the correct prefix of notion

a) 75000m = 750 __________

b) 2/1000 sec = 1 __________

c) 1/1000000 g = 1 __________

d) 1000000000 m = 1__________

Scientific Notation

7. Write values in standard and scientific notation

a) The radius of 1^{st} orbit of Hydrogen atom is r = 0.53 A^0 = __________

b) 1 light year is 2628000000000m = __________

c) Vacuum pressure 2.7×10^{-4} torr = __________

Density and Volume

8. A wooden piece is made in different shapes take length (l) = radius (r) = 2m Calculate its volume as a:

a)	Sphere	b)	Cube
c)	Cylinder	d)	Pyramid
e)	Cylinder		

9. Find the density of wood as sphere and cube if the mass of wood is 1kg. Is there any change in density due to shape?

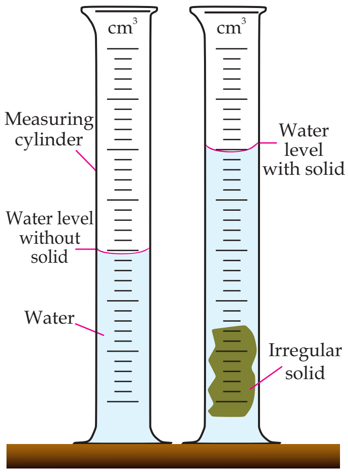


Fig 1.31

10. A measuring cylinder (fig 1.31) is filled with 500cc water. A stone of mass 20g is immersed in to the cylinder such that ,water level rises up to 800cc. Which statement is correct?
    a) The difference between the readings gives the density of stone.
    b) The difference between the readings gives volume of the stone
    c) The final reading gives the density of stone
    d) The final reading gives the volume of stone

Significant Figures

11. Write significant numbers in the following values.
    a) 980 has ________ Significant numbers.
    b) 91.60 has ________ Significant numbers.
    c) 10010.100 has ________ Significant numbers.
    d) 0.0086 has ______ Significant numbers.

Unit - 2

KINEMATICS

The word Kinematics is derived from Greek Word kinema.
How an object changes its position in space in a certain time interval without considering the causes of motion it is the study of motion of bodies without any reference of force.

Students Learning Outcomes (SLOs)

After learning this unit students should be able to:

- Describe using examples how objects can be at rest and in motion simultaneously.
- Identify different types of motion i.e., translatory, (linear, random, and circular); rotatory and vibratory motions and distinguish among them.
- Define with examples distance, displacement, speed, velocity and acceleration (with units)
- Differentiate with examples between distance and displacement, speed and velocity.
- Differentiate with examples between scalar and vector quantities.
- Represent vector quantities by drawing.
- Plot and interpret distance-time graph and speed-time graph
- Determine and interpret the slope of distance-time and speed-time graph
- Determine from the shape of the graph, the state of a body (i) at rest (ii)moving with constant speed (iii) moving with variable speed
- Calculate the area under speed-time graph to determine the distance traveled by the moving body.
- Solve problems related to uniformly accelerated motion using appropriate equations
- To rearrange the equation according to the requirement of the problem
- Solve problems related to freely falling bodies using $10\ m/s^2$ as the acceleration due to gravity.

When you throw a ball straight up in the air, how high does it go? When a glass slips from your hand, how much time do you have to catch it before it hits the ground? How will you describe the motion of a jet fighter being catapulted down the deck of an air craft carrier? These and some other similar questions you will learn to answer in this unit.

The branch of physics which is related with the study of motion of objects is called Mechanics.

It is divided in two parts

(i) Kinematics (ii) Dynamics

The word kinematics is derived from Greek word "Kinema" which means motion.

Fig 2.1, Car with respect to tree at rest position

Kinematics is the branch of Mechanics which deals with motion of objects without reference of force which causes motion.

2.1 REST AND MOTION

Have a look around in your classroom, You can observe various things like, table, chairs, books etc all are in state of rest. A car is in the state of rest with respect to trees and bushes around it Fig 2.1. Thus rest can be defined as:

A body is said to be in rest if it does not change its position with respect to its surroundings.

Fig 2.2, Train at station

A train is stationed at the platform. A person can notice that the train does not changes its position with respect to its surroundings, hence the train is in the state of rest Fig 2.2. But as soon as the train starts moving its position continuously changing with respect to its surroundings. Now we can say that the train is in motion. Thus motion can be defined as:

A body is said to be in motion if it changes its position with respect to its surroundings.

Rest and Motion are Relative State

No body in the universe is in the state of absolute rest or absolute motion. If a body is at rest with respect to some reference point at the same time, it can also be in the state of motion with respect to some other reference point.

Fig 2.3, A moving bus

For example, A Passenger sitting in a moving bus is at rest because passenger are not changing their position with respect to other passengers or objects in the bus as shown in fig 2.3. But for another observer outside the bus noticed that the passengers and objects inside the bus are in motion as they are changing their position with respect to observer standing at the road.

Similarly a passenger flying on aeroplane is in motion when observed from ground but at the same times he is at rest with reference to other passengers on board.

SELF ASSESSMENT QUESTIONS:

Q 1. Define Kinematics.

Q 2. When is a body said to be in state of rest?

Q 3. How are rest and motion related to each other?

2.2 TYPES OF MOTION

We observe around us that all objects in universe are in motion. However the nature of their motion is different, some objects move along circular path, other move in straight line while some objects move back and forth only. There are three types of motion.

(i) Translatory motion (linear, circular and random)

(ii) Rotatory motion

(iii) Vibratory motion.

(I) Translatory Motion

Fig 2.4 A train moving along a straight track

Different objects are moving around in different ways. You can observe how various objects are moving? Which objects move along a circular path? Which objects move along a linear path?

A train is moving along a straight track in Fig 2.4. you can observe that every part of the train is moving along that straight path.

This is called translatory motion. Translatory motion can be defined as:

When all points of a moving body move uniformly along the same straight line, such motion is called translatory motion.

Fig 2.5 Moving bus

(a) Linear Motion:

We observe many objects moving along straight line. The motion of a bus in a straight line on road is called linear motion Fig. 2.5. Thus the linear motion can be defined as:

Motion of a body along a straight line is called linear motion.

Fig 2.6
An artificial satellite

(b) Circular Motion:

An artificial satellite moving around the Earth along circular path is an example of circular motion Fig 2.6. Thus circular motion can be defined as:

Motion of a body along a circular path is called circular motion.

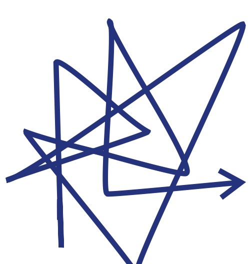


Fig 2.7 Random motion

(c) Random Motion

You must have observed the motion of flies, insects and birds? They suddenly change their direction. The path of their motion is always irregular. This type of motion is known as random motion . The random motion can be defined as :

Irregular motion of an object is called random motion.

The motion of butterfly, house fly, dust and smoke particles along zigzag paths are examples of random motion. The motion of the particles of a gas or a liquid known as the Brownian motion which is an example of random motion Fig2.7.

Fig 2.8 (a) Spinning top

(ii) Rotatory Motion

Have you noticed the type of motion of fan and spinning top? Every point of the top moves in a circle around a fixed axis. Thus every particle of the top possess circular motion Fig 2.8(a).

Fig 2.8 (b) A wheel

But the top as whole moves around an axis which passes through top itself so the motion of top is rotatory Thus rotatory motion can be defined as:

The motion of the body around a fixed axes which passes through body itself is called spin or rotatory motion.

Fig 2.8 (c) Ferris wheel

The motion of a wheel about the axle, the motion of a rider on the Ferris wheel are some examples of rotatory motion Fig 2.8 (a, b, c).

(iii) Vibratory Motion

Look at the motion of child in swing Fig 2.9(a). when swing is pulled away from its mean position and then released, the swing start moving back and forth about the mean position. This type of motion is called vibratory or oscillatory motion. Thus vibratory motion can be defined as:

Fig 2.9 (a) Motion of child in swing

Fig 2.9 (b)
Clock's pendulum

Back and forth motion of a body about its mean position is called vibratory or oscillatory motion.

There are many examples of vibratory or oscillatory motion in daily life. for example, motion of the clock's pendulum Fig 2.9 (b).

Distinguish between Translatory, Vibratory and Rotatory

Translatory Motion	Rotatory Motion	Vibratory Motion
A body moves along a straight line.	The spinning of a body about its axis.	The body move back and forth about mean position.
Movement of an object from one place to another.	The motion of an object about fixed point.	The body moves up and down.
All particles of the rigid body move with the same velocity at every instant of time.	The motion of a rigid body about a fixed axis. Every particle of body move in a circular path	An object repeat its motion itself.

SELF ASSESSMENT QUESTIONS:

Q 4. Define Translatory Motion?

Q 5. What is vibratory motion?

Q 6. Differentiate between translatory motion, rotatory motion and vibratory motion.

2.3 DESCRIBING MOTION

The motion of an object can be described by specifying its position, change in position. speed, velocity and acceleration.

(i) Distance and Displacement

A person can use three different paths to move from place A to an other place B. It can be used to illustrate meaning of distance and displacement Fig 2.10.

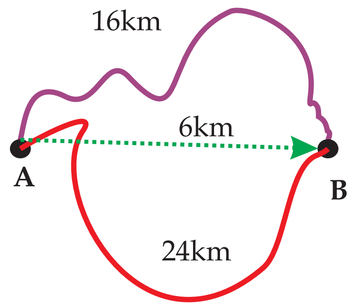


Fig 2.10
Distance and displacement

What if the person moves back from B to A along any of the three paths. The person covers the distance is either 16 km (purple path) or 24 km (red path).
While the person is back at A so, the net displacement becomes zero.

Thus distance and displacement can be differentiated as follows:

Distance	Displacement
➢ The total length covered by moving body without mentioning direction of motion.	➢ The distance measured in straight line in a particular line.
➢ It is an scalar quantity.	➢ It is a vector quantity.
➢ The S.I unit is **metre (m).**	➢ The S.I unit is **metre (m).**
➢ The distance traveled by the person from A to B is either 16 km (purple path) or 24 km (red path)	➢ The displacement of the person is 6 km from A to B due west of A.

(ii) Speed and Velocity

The speed of an object determines how fast an object is moving? It is rate of change of position of an object. There are many ways to determine speed of an object. These methods depend on measurement of two quantities.

- The distance traveled
- The time taken to travel that distance

Thus the average speed of an object can be calculated as:

$$\text{Speed} = \frac{\text{distance traveled}}{\text{time taken}}$$

$$V = \frac{S}{t}$$

The equation for average speed in symbols can be written as :

$$V = \frac{S}{t} \quad \text{..............(eq 2.1)}$$

Where, "V" is the speed of the object, "S" distance traveled by it and "t" time taken by it. Thus average speed can be defined as:

Distance covered by an object in a unit time is called speed.

The equation (2.1) gives only average speed of the body it can not be said that it was traveling with uniform speed or non uniform speed. For example, a racing car can be timed by using a stop watch over a fixed distance say, 500m Fig 2.11. Dividing distance by time gives the average speed, but it may speed up or slow down along the way. Speed is a scalar quantity and its S.I unit is ms^{-1}.

Do You Know!

Average speed of different animals and objects :

Animal /Object	Speed (kmh^{-1})
White-tailed deer	48
Ren deer	60-80
cheetah	100-120
Walking man	6
Grand prix car	360
Passenger jet	900
Sound	1200
Space shuttle	36000

Fig 2.11
A racing car

Uniform speed

An object covers an equal distance in equal interval of time its speed is known as uniform speed.

Velocity

Velocity means speed of an object in a certain direction. Velocity is a vector quantity. thus velocity of an object can be defined as:

Rate of change of displacement with respect to time is called velocity.

$$\text{Velocity} = \frac{\text{Change in displacement}}{\text{time taken}}$$

$$\mathbf{v} = \frac{\Delta \mathbf{d}}{\mathbf{t}} \quad \text{..............} \mathbf{(2.2)}$$

Here **d** is displacement of the moving object, **t** is time taken by object and **v** is velocity. SI unit of velocity is ms^{-1}.

The velocity of an object is constant when it moves with constant speed in one direction. The velocity of object does not remain constant when it changes direction with out changing its speed, or it changes speed with no change in direction. Thus average velocity of an object is given by

$$\text{Velocity} = \frac{\text{total displacement}}{\text{total time taken}}$$

Uniform velocity:

A body is said to have uniform velocity if it cover equal distance in equal interval of time in a particular direction .

Worked Example 1

A car travels 700m in 35 seconds what is the speed of car?

Solution

Step 1: Write the known quantities and point out quantities to be found.

$$d = 700m$$
$$t = 35s$$
$$v = ?$$

Step 2: Write the formula and rearrange if necessary.

$$v = \frac{d}{t}$$

Step 3: Put the value in formula and calculate

$$v = \frac{700}{35} = 20ms^{-1}$$

Thus the average speed of car is $20ms^{-1}$.

Worked Example 2

The speed of train is 108 kmh^{-1}. How much distance will be covered in 2 hours?

Solution

Step 1: Write the known quantities and point out quantities to be found.

$$v = \frac{108\ km}{h} = \frac{108 \times 1000\ m}{3600\ s} = 30ms^{-1}$$
$$t = 2h = 2 \times 3600s = 7200s$$
$$d = ?$$

Step 2: Write the formula and rearrange if necessary

$$v = \frac{d}{t}$$
$$d = v \times t$$

Step 3: Put value in formula and calculate

$$d = 30 \times 7200 = 216000m$$

Thus distance traveled by train is 216000m.

Acceleration

An object accelerates when its velocity changes. Since velocity is a vector quantity so it has both magnitude and direction. Thus acceleration is produced when ever:

- Velocity of an object changes
- Direction of motion of the object changes,
- Speed and direction of motion of the object change.

Thus acceleration can be defined as:

Rate of change of velocity of an object with respect to time is called acceleration.

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

$$a = \frac{\Delta v}{t} \qquad \because \ \Delta v = v_f - v_i$$

$$\therefore \quad a = \frac{v_f - v_i}{t} \quad \text{...............(eq 2.3)}$$

Acceleration is a vector quantity. Its SI unit is metre per second per second (**ms^{-2}**).

When velocity of an object increases or decreases with passage of time, it causes acceleration. The increase in velocity gives rise to positive acceleration Fig 2.12(a). It means the acceleration is in the direction of velocity. Whereas acceleration due to decrease in velocity is negative and is called **deceleration** or *retardation* Fig 2.12(b).The direction of deceleration is opposite to that of change velocity.

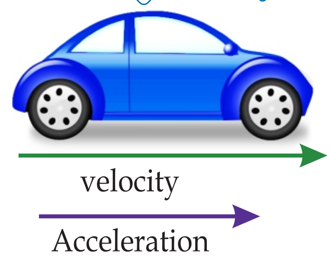


Fig 2.12 (a)
Velocity of this car is increasing

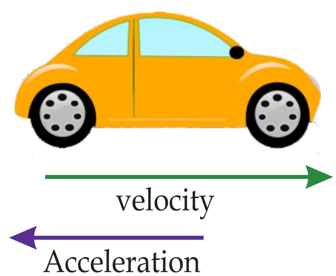


Fig 2.12 (b)
Velocity of this car is decreasing

Uniform Acceleration

A body has uniform acceleration, if the velocity of body changes by an equal amount in every equal time period.

When the change i.e., increase or decrease in the velocity of an object is same for every second then its acceleration is uniform. when velocity of an object is increasing by 10 ms^{-1} every second ,the acceleration is 10ms^{-2}.When the velocity of the object is decreasing by 10ms^{-1} every second, the deceleration is 10 ms^{-2}. Thus, uniform acceleration can be defined as:

A constant rate of change of velocity is called uniform acceleration.

The uniform acceleration can be calculated by using following formula :

$$\vec{a} = \frac{\Delta\vec{V}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t_2 - t_1}$$

Where **v_f**= initial velocity (in ms^{-1});
v_i= final velocity (in ms^{-1});
t_1= time at which an object is at initial velocity u (in s);
t_2 = time at which an object is at final velocity v (in s);
Δv= change in velocity (in ms^{-1})
Δt= time interval between t_1 and t_2(in s)

Worked Example 3

A bus start from rest and travels along a straight path its velocity become 15ms^{-1} in 5 seconds. Calculate acceleration of the bus?

Solution:

Step 1. Write the known quantities and point out quantities to found.

$v_i = 0\ ms^{-1}$
$v_f = 15\ ms^{-1}$
t = 5 second
a = ?

Step 2: Write the formula and rearrange if necessary

$$a = \frac{v_f - v_i}{t}$$

Step 3: Put the value in formula and calculate.

$$a = \frac{15 - 0}{5} = \frac{15}{5} = 3ms^{-2}$$

Acceleration of bus is $3ms^{-2}$.

Worked Example 4

A motorcyclist moving along a straight path applies breakes to slow down from $10ms^{-1}$ to $3ms^{-1}$ in 5 seconds. Calculate its acceleration.

Solution

Step 1. Write the known quantities and point out quantities to be found.

$v_i = 10ms^{-1}$

$v_f = 3ms^{-1}$

$t = 5$ second

$a = ?$

Step 2. Write the formula and rearrange if necessary.

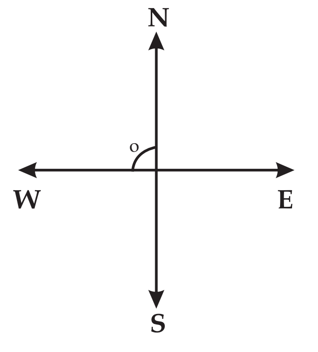
$$a = \frac{v_f - v_i}{t}$$

Step 3: Put the value in formula and calculate.

$$a = \frac{3 - 10}{5} = \frac{-7}{5} = -1.4\ ms^{-2}$$

Deceleration of motorcycle is $-1.4\ ms^{-2}$.

The negative sign shows the retardation in opposite direction of velocity.



Self Assessment Questions:

Q 7. Define Speed.

Q 8. What is velocity?

Q 9. Define acceleration.

2.4 SCALARS AND VECTORS

All physical quantities are divided into two types on the bases of information required to describe them completely.

- Scalars
- Vectors

Scalars

There are certain physical quantities that can be described through their magnitude and a suitable unit. This information is enough to describe them, For example the mass of a watermelon is 3kg, where 3 is the magnitude and kg is a suitable unit such quantities are called scalar quantities. Thus we can define **scalar** quantities as:

The physical quantities that have magnitude and a suitable unit are called scalar quantities.

The other examples of scalar quantities are speed, temperature, mass, density etc.

Vectors

Some physical quantities need direction along with their magnitude and unit for their complete description. For example, a bus traveling with a velocity of $50ms^{-1}$ in the direction of North. The vector quantities can be defined as:

The physical quantities which are completely specified by magnitude with suitable unit and particular direction are called as "Vector" quantities.

Force ,acceleration , momentum, torque and magnetic field are the examples of vector quantities

SELF ASSESSMENT QUESTIONS:

Q10. Define Vector.

Q11. Differentiate between vector and scalar quantities.

Representation of vector:

Vector diagram is an easy way to represent a vector quantity. The directed line segment can be used to represent a vector. The length of the line segment gives the magnitude of the vector and arrow head gives its direction. For example, Fig 2.14 represents velocity of a car travailing at $50ms^{-1}$ in the direction of 30° North of East.

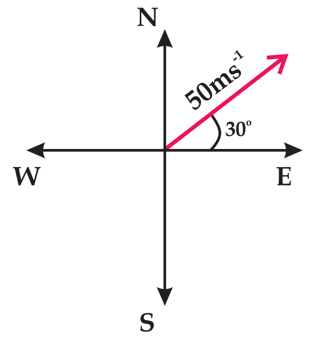


Fig. 2.14

2.5 GRAPHICAL ANALYSIS OF MOTION

Graph gives the complete information about the motion of the object based on the measured physical quantities such as distance, speed, time etc.

Distance - Time Graphs

A bus travels along a straight road from one bus stop to another bus stop. The distance of the bus from first bus stop is measured every second. The possible motion of the bus is shown by three examples.

The vertical axis gives rise of the graph while horizontal axis shows its run. The rise divided by run is called **gradient.**

The gradient on the distance time graph is numerically equal to the speed.

When bus travels with uniform speed, the distance time graph is a straight line. Fig 2.15(a) shows graph of the motion of bus with steady speed, the line rises 5 m on the distance scale for every 1 seconds on the time scale.

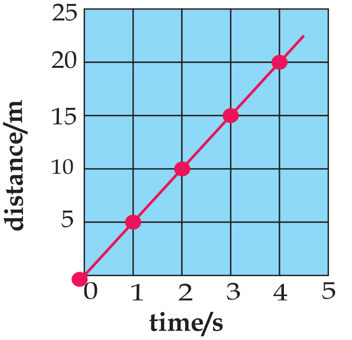


Fig. 2.15 (a)
Uniform speed

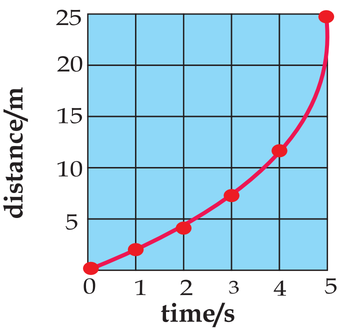


Fig.2.15 (b)
Non-uniform speed

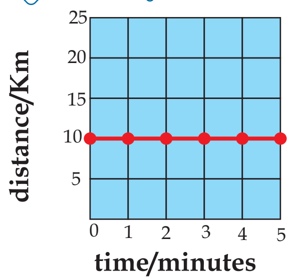


Fig.2.15 (c)
Objective at rest

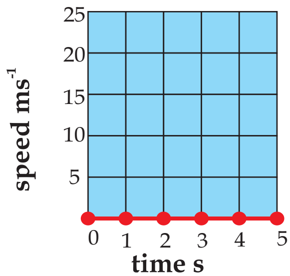


Fig. 2.16 (a)

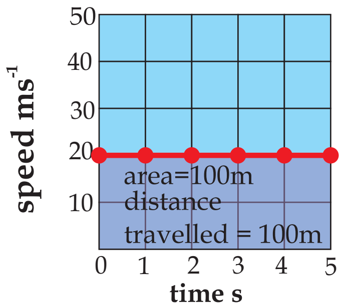


Fig.2.16 (b)

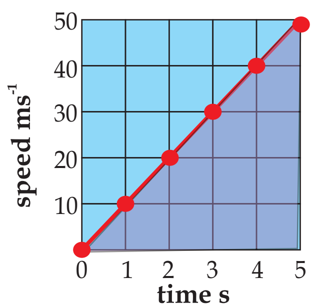


Fig 2.16 (c)

$$\text{Gradient} = \frac{20}{4} = 5$$

Thus speed = 5 ms^{-1}.

when bus travels with non-uniform speed, the distance time graph is a curve. Fig 2.15(b) shows motion of the bus, for this case the speed rises every second. So the bus covers more distance each second than the one before.

When the bus stops on the next bus stop to drop or pick the passengers the time continues running but the distance stays same. The graph line is now parallel to the time axis which shows the bus does not change its position Fig. 2.15(c).

Speed -Time Graph

Speed -time graph tells us that how much speed is increasing or decreasing in every second. Thus,

The gradient on speed - time graph gives the acceleration of the moving object.

If the gradient is positive then acceleration is also positive. On the other hand, if gradient is negative then acceleration will be negative which is known as deceleration or retardation.

In graph Fig.2.16(a), the bus is at rest for an interval of 5 seconds. Therefore, speed of bus remains zero for entire interval of time.

Fig.2.16(b), the bus moves at steady speed 20 ms^{-1} for 5 second, so the distance covered is 100 m. The distance is always product of speed and time, therefore two magnitudes on speed-time graph ($20 \times 5 = 100$) determine the distance represented through shaded rectangle on the graph Fig 2.16 (b).

Now suppose that once again bus is accelerated as the speed of bus increases at the rate of 5 m every second, the distance covered in next 5 seconds is determined by shaded triangle on the graph Fig 2.16 (c).

The area of shaded triangle, $\frac{1}{2}$ (base × height). So the distance travelled is 75 meters.

On a speed -time graph, the area under the line is numerically equal to the distance travelled.

2.6 EQUATIONS OF MOTION

There are three basic equations of motion for bodies moving with uniform acceleration. These equations are used to calculate the displacement (s), velocity, Time (t) and acceleration (a) of a moving body.

Suppose a body is moving with uniform acceleration "a" during some time interval "t" its initial velocity "v_i" changes and denoted as final velocity "v_f". The covers a distance "s" in this duration of time.

First Equation of Motion

In First equation determine the final velocity of a uniformly accelerated body.

where v_f = Final Velocity
v_i = Initial Velocity
a = acceleration
t = time

The average acceleration is the change in velocity over a time interval

$$a = \frac{\text{change in velocity}}{\text{time}}$$

$$a = \frac{v_f - v_i}{t}$$

$$at = v_f - v_i$$

$$\therefore \quad v_f = v_i + at \quad \cdots\cdots\cdots\cdots(2.5)$$

This is known as the first equation of motion.

Second Equation of Motion

The second equation of motion determines the distance covered during some time internal "t", while a body is accelerating from a known initial velocity.

As we know the average velocity $= \dfrac{v_f + v_i}{2}$

Putting value of v_f from equation 2.5 we get

$$\text{Average velocity} = \frac{(v_i + at) + v_i}{2}$$
$$= \frac{v_i + v_i + at}{2}$$
$$= \frac{2v_i + at}{2}$$
$$= \frac{2v_i}{2} + \frac{at}{2}$$
$$= v_i + \frac{1}{2}at$$

As the $s = vt$ or $v = \dfrac{s}{t}$

$$\frac{s}{t} = v_i + \frac{1}{2}at$$
$$\therefore s = v_i t + \frac{1}{2}at^2$$

This equation is known as second equation of motion

$$S = v_i t + \frac{1}{2}at^2 \cdots\cdots\cdots\cdots(2.6)$$

Third Equation of Motion

Third equation of motion determines relationship among the velocity and the distance covered by a uniformly accelerated body, where time interval is not mentioned.

Let us take the first equation of motion.

$$v_f = v_i + at$$

By squaring the both sides of equation we get:

$$v_f^2 = (v_i + at)^2$$

or $$v_f^2 = v_i^2 + 2v_i at + a^2t^2$$

or $$v_f^2 = v_i^2 + 2a(v_i t + \frac{1}{2}at^2)$$

According to second equation of motion $S = v_i t + \frac{1}{2}at^2$

Therefore $$v_f^2 = v_i^2 + 2a(S)$$

$$2aS = v_f^2 - v_i^2 \text{..............}(2.7)$$

This is known as third equation of motion for bodies moving with uniform acceleration.

Worked Example 5

A car moving on a road with velocity 30 ms^{-1}, when brakes are applied its velocity decreases at a rate of 6 meter per second.

Find the distance it will cover before coming to rest.

Solution

Step 1: Write the known quantities and point out quantities to found.

$a = -6\ ms^{-2}$

$v_i = 30\ ms^{-1}$

$v_f = 0$

$S = ?$

Step 2: Write the formula and rearrange if necessary.

$$2aS = \frac{v_f^2 - v_i^2}{2a}$$

$$S = \frac{v_f^2 - v_i^2}{2a}$$

Step 3: Put value in formula and calculate

$$S = \frac{(0)^2 - (30)^2}{2 \times (-6)}$$

$$S = \frac{-900}{-12} = 75m$$

Thus the car will stop after covering 75m distance.

Worked Example 6

A motor cycle moving with velocity of 40 ms^{-1}. It gets accelerating at a rate of 8 ms^{-2}. How much distance will it cover in the next 10 seconds.

Solution

Step 1: Write the known quantities and point out quantities to found.

$v_i = 40\ ms^{-1}$

$a = 8\ ms^{-2}$

$t = 10s$

$S = ?$

Step 2: Write the formula and rearrange if necessary

$$S = vit + \frac{1}{2}at^2$$

Step 3: Put value in formula and calculate

$$S = 40 \times 10 + \frac{1}{2} \times 8 \times (10)^2$$

$$S = 400 + \frac{1}{2} \times 8 \times 100$$

$$S = 400 + \frac{800}{2}$$

$$S = 400 + 400m$$

$$S = 800m$$

Thus motor cycle covers 800 m in next 10 seconds.

2.7 MOTION DUE TO GRAVITY :

If two stones of different sizes are dropped from same height simultaneously, which of them will hit the ground first? You can observe that lighter and lighter stone catch the same accelerated and hit the ground at same time.

To discover this Galileo Galilei carried out a series of experiments from at leaning tower Pisa and carefully observed that all objects catch the same acceleration due to gravity of earth. The mass or size of object has no effect. It was against the widely accepted claim of Aristotile that heavier objects would fall faster than lighter one. A small feather and a stone are dropped in an air filled tube. Since air resistance greatly affects the feather, so the stone falls faster; Fig 2.18. On the other hand, when feather and stone are dropped in absence of air resistance, they acquire the same acceleration and reach the bottom at same time..

Acceleration due to gravity 'g' is a constant. Its value near the surface of earth is found to be 9.81 ms^{-2}. However for ease of calculation value of 'g' is approximated to 10 ms^{-2} .

Gravitational acceleration is taken negative for objects moving downward and positive for objects moving upward.

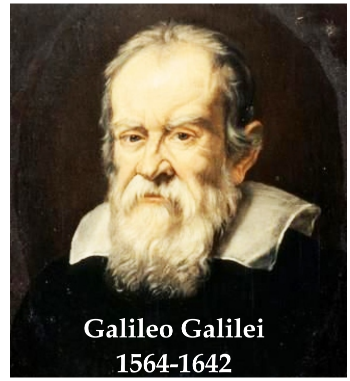


Fig 2.17

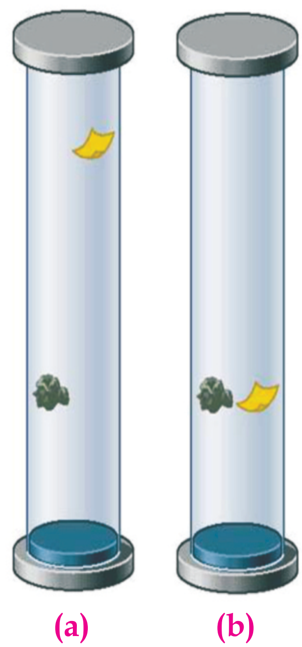


Fig 2.18

A piece of feather and a piece of stone dropped together in an air filled glass tube (a) and an evacuated air free glass tube (b)

For the motion of bodies under the influence of gravity the equation of motion are slightly modified. Where distance is taken as (S=h) and acceleration is taken as g (a=g).

There fore equation of motion are taken as.

(i) $v_f = v_i + gt$

(ii) $S = v_i t - \frac{1}{2} gt^2$

(iii) $2gh = v_f^{\,2} - v_i^{\,2}$

Worked Example 7

A ball is thrown vertically upward with velocity of 12 ms^{-1}. The ball will be slowing down due to pull of Earth's gravity on it, and will return back to Earth.

Find out the time the ball will take to reach the maximum height.

Solution

Step 1: Write the known quantities and point out quantities to be found.

$$v_i = 12\ ms^{-1}$$
$$v_f = 0\ ms^{-1}$$
$$g = -10\ ms^{-2}$$
$$t = ?$$

Step 2: Write the formula and rearrange if necessary.

$$v_f = v_i + gt$$
$$t = \frac{v_f - v_i}{g}$$

Step 3: Put the value in formula and of calculate.

$$t = \frac{0-12}{-10}$$
$$t = 1.2\ s$$

The ball will reach maximum height in 1.2 seconds.

SUMMARY

- A body is said to be at rest if it does not change its position with respect to its surroundings.
- A body is said to be in motion if it changes its position with respect to its surroundings.
- When all points of moving body move uniformly along the same straight line the motion is called translatory motion.
- Motion of a body along straight line is called linear motion.
- Motion of a body along a circular path is called circular motion.
- Irregular motion of an object is called random motion.
- The motion of the body around a fixed axis which passes through body itself is called spin motion.
- Back and forth motion of a body about its mean position is called vibratory of oscillatory motion.
- The total length covered by moving body without mentioning direction of motion is called distance.
- The distance measured in straight line in a particular direction is called displacement.
- Distance covered by an object in a unit time is called speed.
- An object covers an equal distance in equal interval of time is called uniform speed.
- Rate of change of displacement with respect to time is called velocity
- Rate of change of velocity of an object with respect to time is called acceleration.