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Catalog

MEASUREMENTS

SYNOPSIS - 1

MEASUREMENTS AND EXPERIMENTATION

IMPORTANCE OF MEASUREMENTS IN PHYSICS

Everything we know about our physical world and the principles that govern its behaviour, has been learned through **careful observations** of phenomena of nature. The ultimate test of physical theory is its agreement with observations and measurements of physical phenomena.

Physics is an exact science. The most basic aspect of the study of physics is the measurment of physical quantities. It is because, in order to establish and verify a physical law, we have to make observations and take measurements.

Physics is basically a science of measurments. **Lord Kelvin** (1824-1907) stated as under.

"I often say when you can measure what you are speaking about, and express it in numbers, you know something about it; but if you can not ex press it in numbers, your knowledge is meagre and of unsafisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to a stage of science."

For the measurement of any physical quantity, we choose a constant quantity as a standard.

We compare this standard quantity with the given physical quantity to find the number, which expresses how many times a standard quantity is contained in a physical quantity.

The standard quantity (constant quantity), used for comparison is called unit.

Measurement is the comparison of an unknown quantity with a known standard quantity (constant quantity) or unit.

In order to express the result of measurement, we must know :

1. The unit in which a quantity is measured.
2. The numerical value which expresses how many times a standard quantity or unit is contained in a given physical quantity.

Example : If we have to measure length, we use a metre-scale as a standard. On measurement, if we find that length is 10 times the standard meter scale, then the length is 10 metres. In the above statement 10 is the magnitude of length and metre is the unit of the physical quantity.

Magnitude of physical quantity : *The number of times a standard quantity is present in a given physical quantity, is called* **magnitude of physical quantity.**

$$\textbf{Physical quantity} = (\textbf{magnitude}) \times (\textbf{unit})$$

NEED FOR THE INTRODUCTION OF STANDARD QUANTITY

From the times immemorial, man has been facing the necessity of measuring and estimating various quantities. For measuring mass, he used various kinds of standards. For measuring length, he used foot length or arm length, etc. However, parts of human body differ in lengths of different people. This led to a lot of confusion.

Grandually with the passage of time, people accepted certain norms of measurements. For example, in India the mass was measured in seers and maunds, whereas in Europe it was measured in pounds and stones.

However, with developments in science, the world trade opened. It was felt that same standards of measurement should be adopted all over the world, so as to avoid any confusion. Thus, there was a need for the introduction of standard units.

The first serious attempt to standardise the units was made in 1889 in Paris. However, some anomalies were left. In October 1960, another conference was held and the standard units were revised.

Characteristics of standard unit :

1. It should be of convenient size.
2. It should not change with respect to space and time.
3. It should be possible to define, without any doubt or ambiguity.
4. It should not be perishable
5. It should be easily reproduced.

FUNDAMENTAL UNITS

The units, which can be neither derived from one another nor resolved (broken) into any thing more basic are called fundamental units.

(or)

A unit, which is independent of any other unit, or which can neither be changed nor related to any other fundamental unit, is a fundamental unit.

Examples of fundamental units : Mass; length; time; temperature; luminous intensity; electric charge and electric current are fundamental units.

Quantity	Unit	Symbol
Fundamental Quantities		
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Temperature	Kelvin	K
Luminous Intensity	Candela	cd
Electric Current	Ampere	A
Amount of substance	Mole	mol
Supplementary Quantities		
Angle	Radian	rd
Solid Angle	Steradian	sr

DERIVED UNITS

Any unit which can be obtained by the combination of one or more fundamental units, is called derived unit.

In mechanics, derived units can be obtained from fundamental units of mass, length and time.

Physical quantity	Derived unit	Symbol
Area	square metre	m^2
Volume	cubic metre	m^3
Density	kilogram per cubic metre	kg/m^3 or $kg\,m^{-3}$
Velocity	metre per second	m/s or ms^{-1}
Acceleration	metre per square second	m/s^2 or ms^{-2}
Momentum	kilogram metre per second	$kg\,m/s$ or $kg\,ms^{-1}$
Force	kilogram metre per square second	$kg\,m/s^2$ or $kg\,ms^{-2}$

WORK SHEET - 1

Single Answer Type

1. Choose the correct ?
   1) Physical quantity = Magnitude + Unit
   2) Physical quantity = Magnitude $\times$ Unit
   3) Physical quantity $\times$ Magnitude = Unit
   4) Physical quantity = $\dfrac{magnitude}{Unit}$
2. The Standard quantity, used for comparision is called
   1) Physical quantity 2) Numerical value
   3) Derived quantity 4) Unit
3. On measurement, if we find that the radius of earth is 64,00,000 times the standard meter scale, then 64,00,000 is called
   1) Physical quantity 2) Magnitude of physical quantity
   3) Unit 4) Mass
4. A unit which is independent of any other unit, is called
   1) Fundamental quantity 2) Fundamental Unit
   3) Derived quantity 4) Derived Unit
5. A unit which can be obtained by the combination of one or more fundamen tal units is called
   1) Fundamental Unit 2) Fundamental quantity
   3) Derived quantity 4) Derived Unit
6. A physical quantity is given by 14 days. Here 14 is called
   1) Physical quantity 2) Unit
   3) Magnitude 4) None

Multi Answer Type

7. The characteristies of standard unit is/are
   1) It should be of convenient size
   2) It should not be perishable
   3) It should not be easily reproduced
   4) it should be possible to define, without any doubt.
8. Among the following, the fundamental Units is/are.
   1) m 2) kg 3) m/s 4) $kg-m/s$
9. Choose the Derived quantities.
   1) Mass 2) Area 3) Force 4) Length
10. Choose the fundamental quantities.
   1) Velocity 2) Luminous intensity 3) Time 4) Temperature

Comprehension Type

11. Length of a table = 8 m. Here physical quantity is ?
   1) 15 2) m 3) Length of table 4) Mass
12. Mass of electron is given by $9.109\times10^{-31}kg$. Here the unit is ?
   1) 9.109×10^{-3} 2) kg 3) Mass 4) Time
13. Velocity of a car is given by $18m/s$. Here the magnitude of velocity is ?
   1) 18 2) m/s 3) Velocity 4) Length

Matrix Matching Type

14.

Column - I	Column - II
a) 10 kg	1) Physical Quantity
b) 10 m	2) Numerical Value
c) 10	3) Unit
d) kg	4) None.

Integer Answer Type

15. The number of Fundamental physical quantities are

SYNOPSIS - 2

GUIDELINES FOR WRITING UNITS

Following rules are observed while writing the unit of a physical quantity.

(i) The symbol for a unit which is not named in the honour of some scientist is written in lower letter.

Examples : The symbol for metre is 'm', for kilogram is 'kg' and for second is 's'.

(ii) The symbol for a unit which is named in the honour of some scientist is written with initial capital letter.

Example :

1. The symbol for unit of force (newton) is N.
2. The symbol for unit of temperature (celcius) is ^0C.
3. The symbol for unit of work (joule) is J.
4. The symbol for unit of power (watt) is W.

(iii) Full name of the unit named in the honour of a scientist is written with lower intial letter.

Examples :

1. The full name for the unit of force is newton and not Newton.
2. The full name for the unit of power is watt and not Watt.
3. The full name for the unit of work is joule and not Joule.

(iv) A compound unit obtained by multiplying two or more units is written after putting a dot between the individual units or leaving space between the individual units.

Examples :

1. Unit of momentum is written as N. s or N-s .
2. Unit of couple is written as N. m or N-m.

(v) Negative powers are used for compound units obtained by dividing one unit with another unit.

Examples :

1. The unit of velocity is $\frac{m}{s}$. It is expressed as ms^{-1}.
2. The unit of acceleration is $\frac{m}{s^2}$. It is expressed as ms^{-2}.
3. The unit of pressure is $\frac{N}{m^2}$. It is expressed as Nm^{-2}.

(vi) A unit in short form is never written in plural.

Examples :

1. 30 kilograms in short form is written as 30 kg and not 30 kgs.
2. 200 kilometres in short form is written as 200 km and not 200 kms.

SYSTEM OF UNITS

The fundamental units of length, mass and time taken together form a system of units. For measuring various physical quantities following systems are commonly adopted.

1. **C.G.S. system:** In this system C stands for centimetre (length); G stands for gram (mass) and S stands for seconds (time).
   This system is generally adopted for smaller measurements of mass length, and time.
2. **M.K.S. system :** In this system M stands for metre (length); K stands for kilogram (mass) and S stands for seconds (time). This system is generally adopted for larger measurements.
3. **S.I. system (Standard International System) :**
   In this system the units of mass, length and time are same, as that of M.K.S system. However, it is an enlarged system encompassing all fundamental units.

DEFINITIONS OF MKS UNITS:

1. **Metre:** In 1971, the **Paris Academy of Sciences** defined metre as under. One ten millionth part of distance from the pole to the equator is called **metre**.

   Multiples of Metre

   1. decametre (dam) = $10^1 m = 10\ m$
   2. hectometre (hm) = $10^2 m = 100\ m$
   3. kilometre (km) = $10^3 m = 1000\ m$

   Sub-multiples of Metre

   1. decimetre (dm) = $10^{-1} m = 10\ cm$
   2. centimetre (cm) = $10^{-2} m = 1\ cm$
   3. millimetre (mm) = $10^{-3} m = 0.1\ cm$
   4. micrometre (μm) = $10^{-6} m = 10^{-4}\ cm$
   5. nanometre (nm) = $10^{-9} m = 10^{-7}\ cm$
   6. picometre (pm) = $10^{-12} m = 10^{-10}\ cm$

2. Kilogram: The standard kilogram is the mass of a cylinder, made from platinum-iridium alloy at $0^0 C$ kept at Sevres, in International Bureau of Weights and Measures near Paris.

   Multiples of Kilogram

   1. Quintal (qt) = $10^2\ kg = 100\ kg$
   2. Tonne (t) = $10^3\ kg = 1000\ kg$

Sub-multiples of Kilogram

1. Hectogram (hg) = $10^{-1}\ kg$ = $100g$.
2. Decagram (dag) = $10^{-2}\ kg$ = $10g$.
3. Gram (g) = $10^{-3}\ kg$ = $1\ g$.
4. Milligram (mg) = $10^{-6}\ kg$ = $10^{-3}\ g$.
5. Microgram (μ g) = $10^{-9}\ kg$ = $10^{-6} g$.

3. **Time :** The interval between two events in called **time**.

Units of time :

(a) **Solar Day:** The time taken by the earth to complete one rotation about its own axis is called solar day. It has been found that the distance of the earth from the sun changes, as it revolves around the sun. This, in turn, changes the length of solar day slightly.

(b) **Mean Solar Day:** The average of the varying solar days, when the earth completes one resolution around sun is called mean solar day.

(c) **Hour :** 1/24th part of the mean solar day is called an hour.
Minute: 1/1440 part of the mean solar day is called one minute.
Second: 1/86400 part of the mean solar day is called one second.
Year: Time in which earth completes one complete revolution around the sun is called one year.

One year is equal to $365\frac{1}{4}$ days.

1 Mean Solar Day = 24 hours
= 24×60 minutes
= 1440 minutes
= 1440×60 seconds
= 86400 seconds

1 second = 1/86400 of mean solar day

Hence we can have the completion of prefixes as given below.

Multiple	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	K
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

WORK SHEET - 2

Single Answer Type

1. The force applied by a boy on the table is of magnitude 50 units in S.I system. Which is represented by
   1) 50 Newtons 2) 50 Ns 3) 50 N 4) 50 n
2. One Qnintal is ______ kg
   1) 1000 2) 10,000 3) 10 4) 100
3. 100 picometres is ______ m
   1) $10^{-12}m$ 2) $10^{-10}m$ 3) $10^{-9}m$ 4) $10^{-6}m$
4. 42 metres in short form is written as ______
   1) 42 mc 2) 42 metre 3) 42 m 4) 42 M
5. The S.I. unit of eletric current is _______
   1) A 2) K 3) ed 4) mol
6. One second is defined as ________
   1) $\frac{1}{1440^{th}}$ part of mean solar day 2) $\frac{1}{86,400^{th}}$ part of mean solar day
   3) $\frac{1}{24^{th}}$ part of mean solar day 4) $\frac{1}{8640^{th}}$ part of mean solar day
7. One femto metre is ________ m
   1) 10^{-9} 2) 10^{-12} 3) 10^{-15} 4) 10^{-18}

Multi Answer Type

8. Choose the supplementary quantity
   1) Angle 2) Temperature 3) Solid angle 4) Current
9. One hectometre is _______
   1) 10^{2} 2) $10^{-2}m$ 3) $10^{-4}cm$ 4) $10^{4}cm$

Comprehension Type

Table from pg no : 5, I.C.S.E. part - I

10. $1\ \text{pm} \times 100\ \mu\text{m} =$
    1) $10^{-16}m^2$ 2) $10^{-12}m^2$ 3) $10^{-18}m^2$ 4) $10^{-10}m^2$
11. $\frac{\text{xkg} \times 10\ \mu\text{s}}{5\ \text{ns}} = 10^4$ kg, then x =
    1) 10^{2} 2) 10^{3} 3) 10 4) 5
12. One mega metre is ________ cm
    1) 10^{6} 2) 10^{-6} 3) 10^{8} 4) 10^{-8}

Matrix Matching Type

13. **Column - I** **Column - II**

Column - I	Column - II
a) 10^{-12}	1) Kilo
b) 10^{-15}	2) Femto
c) 10^{6}	3) Pico
d) 10^{3}	4) Mega

Integer Answer Type

14. 2×10^{9} grams is equal to ______ giga grams

Subjective Answer Type

15. What are the characteristics of standard Unit ?
16. What is Unit ?
17. Give any five examples for Derived quantities ?

Competitive Galaxy

1. Select the correct equality from the following **[Dr. A.S.Rao Awards Council - 2009]**

   1) $1\,gm/cm^{3}=1000kg/m^{3}$ 2) $1\,gm/cm^{3}=1kg/m^{3}$

   3) $100\,gm/cm^{3}=1kg/m^{3}$ 4) $100\,kg/m^{3}=100gm/cm^{3}$

KEY & HINTS

WORK SHEET – 1 (KEY)

1) 2	**2)** 4	**3)** 2	**4)** 2	**5)** 4
6) 3	**7)** 1,2,4	**8)** 1,2	**9)** 2,3	**10)** 2,3,4
11) 3	**12)** 2	**13)** 1	**14)** A-1 B-1 C-2 D-3	**15)** 2

WORK SHEET – 2 (KEY)

1) 3	**2)** 4	**3)** 2	**4)** 3	**5)** 1
6) 2	**7)** 3	**8)** 1,3	**9)** 1,4	**10)** 1
11) 4	**12)** 3	**13)** A-3 B-2 C-4 D-1	**14)** 2	

1. Name of Scientist

6. 1 Second = $\frac{1}{24\times60\times60} = \frac{1}{86400^{th}}$ part of mean solar day

10. $1\,pm \times 100\,\mu m = 1\times10^{-12}\,m \times 100\times10^{-6}\,m = 10^{-16}\,m^2$

11. $\frac{x \text{ kg} \times 10\ \mu\text{s}}{5 \text{ ns}} = 10^4 \text{ kg}$

$\Rightarrow x = \frac{10^4 \times 5ns}{10\mu s}$

$= \frac{10^4 \times 5\times10^{-9}}{10\times10^{-6}}$

= 5

12. 1Mm = $10^6 m$

$= 10^6 \times 10^2 cm$

$= 10^8 cm$

13. key : a - 3, b - 2, c - 4, d - 1

Competitive Galaxy

Sol. Key - 1

$$\frac{1gm}{cm^3} = \frac{10^{-3}kg}{(10^{-2}m)^3} = \frac{10^{-3}kg}{10^{-6}m^3} = 10^3 kg/m^3$$

KINEMATICS

SYNOPSIS - 1

INTRODUCTION:

Kinematics is the branch of mechanics, which deals about the motion of a body without considering the cause for its motion.

REST

Kinematics is when a body does not change its position with respect to its surroundings, the body is said to be at rest.

Example : A chair lying in a room is in the state of rest, because it does not change its position with respect to (w.r.t) the surroundings of the room.

MOTION

When a body changes its position with respect to its surroundings, it is said to be in motion.

Example : A car changing its position w.r.t. trees, houses, etc., is in the state of motion.

REST AND MOTION AS RELATIVE TERMS

Seemingly, rest and motion are opposed to each other, yet there is a close relation between them, and it is very difficult to say, whether a body is in a state of rest or in a state of motion.

Example : A person sitting in the compartment of a moving train is in the state of rest, with respect to the surroundings of compartment. Yet he is in the state of motion, if he compares himself with the surroundings outsidethe compartment.

SCALAR AND VECTOR QUANTITIES

(a) Scalar Quantities : The physical quantities which are expressed in magnitude only are called scalar quantities. They do not have any direction.

Examples of scalar quantities :

2 kg sugar tells about the magnitude of its mass, but has no direction.

Mass, length, time, area, volume, density, energy, power, temperature, current, etc., are scalar quantities.

(b) Vector Quantities : The physical quantities which are expressed in magnitude as well as direction are called vector quantities.

Examples of vector quantities :

60 m towards east is a vector quantity, as it tells about magnitude as well as direction.

Displacement, velocity, acceleration, retardation, momentum, impulse, force are the example of vectors.

Scalar Quantities	Vector Quantities
1. They are expressed in magnitude only.	1. They are expressed in magnitude as well as direction.
2. They can be added by simple arithmetic means.	2. They cannot be added by simple arithmetic means.
3. They cannot be easily plotted on graph paper.	3. They can be easily plotted on graph paper.
Example: Speed, Mass, Time, etc.	**Example:** Velocity, Acceleration, etc.

BASIC TERMS IN KINETICS:

1. Distance : the length of the path travelled by a body in certain interval of time is called distance.

DISTANCE IS A SCALAR QUANTITY

Units of distance : In C.G.S. system, distance is measured in centimetres and in S.I. system it is measured in metres. It is denoted by the letter ‘S’.

2. Displacement : The shortest distance between the initial position and the final position of a body is called displacement.

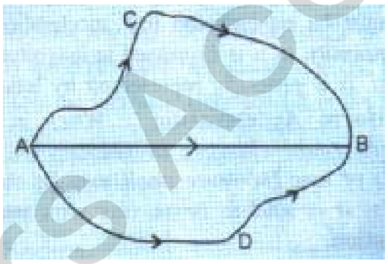


Fig. 2.1 shows two points A and B which can be reached by the paths AB, ACB or ADB or any other supposed path. However, the shortest distance between points A and B is AB. Thus AB is the displacement of a body.

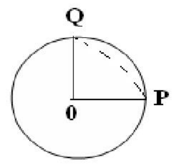
Displacement is a vector quantity and, hence is directional. Without direction, displacement has no meaning. For example, if a body moves 10 m, it means the body has covered a distance of 10 m in any direction. However, if a body moves 10 m towards west, then displacement of the body is 10 m (west).

Is it possible to have a moving body with zero displacement, but covering a large distance ?

Yes, it is possible. For example, if a body completes one revolution along a circular path, distance covered by the body will be $2\pi r$, whereas its displacement will be zero. Similarly, earth has a zero displacement about its own axis after 24 hours, whereas it covers a very large distance.

WORK SHEET - 1

1. Out of the following physical quantities, vector is
   1) Displacement 2) Mass 3) Time 4) Density
2. A toy car is moving on a circular path of radi 21 m. it statrts from P and reaches Q. Calculate distance covered by car.



   1) 21 m 2) 33 m 3) 32 m 4) $21\sqrt{2}$ m
3. In above question, calculate the displacement ?
   1) 21 m 2) 33 m 3) 32 m 4) $21\sqrt{2}$ m
4. The ratio of Diplacement to distance is
   1) Always = 1 2) Always, < 1 3) Always, ≥ 1 4) Always ≤ 1
5. If a body completes half revolution along a circular path. The ratio of distance by displacement is
   1) π 2) $\frac{\pi}{2}$ 3) 2π 4) None of these
6. A boy travels distance of 3 km east, these 6 km towards north and finally 5 km towards east find total distance ?
   1) 10 km 2) 14 km 3) 24 km 4) $10\sqrt{2}$ km
7. In above question find displacement.
   1) 10 km 2) 14 km 3) 24 km 4) $2\sqrt{10}$ km

Reasoning Answer Type

8. Statement - I :In Circular motion the displacement of a body at any time is zero.
   Statement - II : Displacement is length between initial and final point.
   1) Both Statement - I and Statement - II are true
   2) Both Statement - I and Statement - II are false
   3) Only Statement - I is true 4) Only Statement - II is true

Multi Answer Type

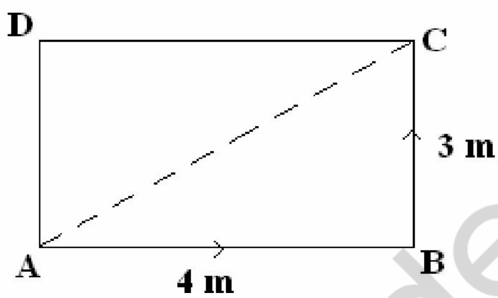
9. The characteristice is vector quantity ?
   1) It has magnitude 2) It has direction
   3) It has magnitude but not direction
   4) It has direction but not magnitude

10. Choose the scalar quantities ?
    1) Velocity 2) Mass 3) Displacement 4) Time

Comprehension Type

Writeup-1

In a field of Dinensions $3\text{ m} \times 4\text{ m}$, the dog walks from A to B and then from B to C.



11. What is the total distance covered by dog
    1) 4 m 2) 3 m 3) 7 m 4) 5 m
12. What is the displacement of the dog ?
    1) 4 m 2) 3 m 3) 7 m 4) 5 m
13. In above discusion, if dog again comes back to A, then find displacement.
    1) 5 m 2) 10 m 3) 0 m 4) 14 m

Writeup-2

An insect moves 3 m east, 4 m north and 12 m Vertically up. Then

14. What is the total distance covered by insect ?
    1) 18 m 2) 19 m 3) 20 m 4) 21 m
15. What is the displacement covered by insect ?
    1) 12 m 2) 13 m 3) 14 m 4) 15 m
16. If insect fly again to initial position, along the same path, find total distance covered ?
    1) 18 m 2) 19 m 3) 0 m 4) 38 m

Subjective Answer Type

17. Define (i) Scalar quantity (ii) Vector quantity.
18. Difine (i) Distance (ii) Displacement.

SYNOPSIS - 2

BASIC TERMS IN KINETICS:

3) **Speed :** Rate of change of motion is called speed.

Or

Distance covered by a moving body per unit time is called speed.
Thus, if S is the distance covered by a body in time t then :

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{S}{t}$$

Speed is a scalar quantity as it has magnitude, but not direction.

Units of Speed : In C.G.S. system, unit of speed is cm/s or cms^{-1}.

In S.I. system, unit of speed is m/s or ms^{-1}.

Uniform Speed : If a body covers equal distances in equal intervals of time (however small may be the time intervals). it is said to be moving with uniform speed.

Example : A rotating fan, a rocket moving in space, etc., have uniform speeds.

Variable Speed : If a body covers unequal distances in equal intervals of time, it is said to be moving with a variable speed.

Example : A train starting from a station, a dog chasing a cat, etc., have variable speed.

Average speed: The ratio of the total distance travelled by the body to the total time taken by the body to cover the distance is called average speed..
Thus :

$$\text{Average Speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

Instantaneous Speed : If the speed of a body is continuously changing with time, then the speed at some particular instant during the motion is called
instantaneous speed.

For example, speedometer of a moving automobile measures ***instantaneous speed.***

4) **Velocity :** The rate of change of motion in a specified direction is called ***velocity.***

Or

Rate of change of displacement is called ***velocity.***

It is a **vector quantity**, as it is expressed in magnitude as well as direc tion.

Units of Velocity : It has same units as speed except that the direction is specified.

For example, 36 km/h towards east is the velocity of a body, whereas 36 km/h only is the speed of a body.

Uniform Velocity : When a body covers equal distances in equal intervals of time (however small may be the time interval) in a specified direction, the body is said to be moving with ***uniform velocity.***

Veriable Velocity : When a body covers unequal distances in equal intervals of time in a specified direction, the body is said to be moving with a ***variable velocity.***

The velocity of a body becomes variable when

(i) the magnitude changes (ii) the direction changes. For example, a rotating fan at a constant speed has variable velocity, because of continuous change in direction.

Average Velocity : The ratio of the total distance travelled in a specified direction to the total time taken by the body to travel that distance is called average velocity. Thus, average velocity :

$$\text{A.V.} = \frac{\text{Total distance travelled in specified direction}}{\text{Total time taken}}$$

It is possibe to have a moving body with ***an average velocity zero, but its average speed is not zero.*** For example, when a body moves in a circle, the displacement after one complete rotation is zero, therefore, its average velocity is zero. However, as it covers a certain distance in a certain time interval, its speed is not zero.

5. Acceleration : In general the moving bodies do not have uniform velocity. For example, a cyclist moving through a busy street does not have a uniform velocity. The velocity of the cyclist may change in magnitude or direction or both. In such a case the cyclist is said to have an accelerated motion.

The rate of change of velocity of a body is called **acceleration.**

Positive Acceleration : If the velocity of a body is increasing with respect to time, the acceleration is said to be positive.

Negative Acceleration : If the velocity of a body is decreasing with respect to time, the acceleration is said to be negative. The negative acceleration is sometimes called de-acceleration or retardation.

$$\text{Thus, acceleration} = \frac{\text{Change in velocity}}{\text{Time}}$$

$$= \frac{\text{Displacement}}{\text{Time}} \times \frac{1}{\text{Time}}$$

$$= \frac{\text{Displacement}}{(\text{Time})^2}$$

$$= \frac{L}{T^2} \text{ or } LT^{-2}$$

where (L) stands for length and (T) for time.

Unit of Acceleration : We have already proved that

$$\text{acceleration} = \frac{\text{Displacement}}{(\text{Time})^2}$$

Thus, unit of acceleration is a derived unit and has unit of length and unit of time.

Thus, in C.G.S. system, acceleration is

expressed in $\frac{\text{cm}}{S^2}$ or cms^{-2}. Similarly, in S.I.

system, it is expressed in $\frac{m}{S^2}$ or ms^{-2}.

It must be remembered that acceleration is a vector quantity, as it is expressed in magnitude and direction . It is generally represented by letter 'a'.

Uniform Acceleration : When a body describes equal changes in velocity in equal intervals of time (however small may be the time intervals) it is said to be moving with uniform acceleration.

6. **Acceleration due to gravity :** When a body falls freely, its velocity constantly increases with respect to time and, hence is acted upon by a uniform acceleration.

The acceleration of a freely falling body, under the action of gravity of earth, is called acceleration due to gravity.

The value of acceleration due to gravity is constant at a given place. However, its value changes from place to place.

For example, acceleration due to gravity is maximum at poles. Its value with respect to poles decreases, if the body is taken towards equator, or to a high altitude, or deep inside a mine.

Magnitude of acceleration due to gravity

The average value of acceleration due to gravity (denoted as 'g') is taken as $\mathbf{9.8\ m/s^2}$ in S.I. system and $\mathbf{980\ cm/s^2}$ in C.G.S. system. The value of 'g' is $+\mathbf{9.8\ m/s^2}$, if a body falls towards earth and $-\mathbf{9.8\ m/s^2}$, if the body rises vertically upward.

WORK SHEET - 2

Single Answer Type

1. $1\,km\,h^{-1}$ = ______ ms^{-1}

1) $\frac{18}{5}ms^{-1}$ 2) $\frac{11}{5}ms^{-1}$ 3) $\frac{5}{13}ms^{-1}$ 4) $\frac{5}{18}ms^{-1}$

2. A train starting from rest, picks up a speed of $20ms^{-1}$ in 200 s. Calculate uniform rate of acceleration

1) $1\,ms^{-2}$ 2) $1.5\,ms^{-2}$ 3) $0.1\,ms^{-2}$ 4) $0.5\,ms^{-2}$

3. A ball is thrown up vertically and returns back to thrower in 6s. Assuming there is no air friction, calculate the acceleration while ball is returning

1) $6\,ms^{-2}$ 2) $12\,ms^{-2}$ 3) $0\,ms^{-2}$ 4) $10\,ms^{-2}$

4. A speeding car changes its velocity from $109\,km\,h^{-1}$ to $36\,km\,h^{-1}$ in 4s. Calculate its de-acceleration in $km\,h^{-2}$

1) $5\,km\,h^{-2}$ 2) $6480\,km\,h^{-2}$ 3) $64800\,km\,h^{-2}$ 4) $61800\,km\,h^{-2}$

5. In above question calculate the acceleration in ms^{-2}

1) $4\,ms^{-2}$ 2) $5\,ms^{-2}$ 3) $3.8\,ms^{-2}$ 4) $0\,ms^{-2}$

6. The change in velocity of motor bike is $54\,km\,h^{-1}$ in one minute. Calculate its acceleration in ms^{-2}

1) $0.35\,ms^{-2}$ 2) $0.25\,ms^{-2}$ 3) $0.33\,ms^{-2}$ 4) $0.32\,ms^{-2}$

7. In above question, calculate the acceleration in $km\,h^{-2}$

1) $3240\,km\,h^{-2}$ 2) $3124\,km\,h^{-2}$ 3) $3140\,km\,h^{-2}$ 4) $4123\,km\,h^{-2}$

Multi Answer Type

8. Choose the unit(s) of acceleration

1) ms^{-1} 2) ms^{-2} 3) $cm\,s^{-1}$ 4) $cm\,s^{-2}$

Comprehension Type

A car covers 90 km in $1\frac{1}{2}$ hours towards east.

9. Calculate the displacement of car
   1) 90 km 2) 90 km - east 3) 90 km - west 4) 90 m
10. The velocity of car in $km\,h^{-1}$ is
    1) $180\,km\,h^{-1}$ 2) $90\,km\,h^{-1}$ 3) $60\,km\,h^{-1}$ 4) $30\,km\,h^{-1}$
11. The velocity of car in ms^{-1}, is
    1) $13.47\,ms^{-1}$ 2) $10.47\,ms^{-1}$ 3) $12.67\,ms^{-1}$ 4) $16.67\,ms^{-1}$

Integer Answer Type

12. A race horse runs straight towards north and covers 540 m in one minute. Then its velocity is ____ ms^{-1}

Subjective Answer Type

13. An aeroplane flies towards south and covers 324 km in 20 minutes. Calculate (i) Displacement of aeroplane (ii) Its velocity in (a) kmh^{-1} (b) ms^{-1}.
14. The velocity of a car changes from $\mathbf{18kmh^{-1}}$ to $72\,\mathbf{kmh^{-1}}$ in 30 s. Calculate (i) change in velocity in ms^{-1}. (ii) Acceleration in (a) kmh^{-2} (b) ms^{-2}

Competitive Galaxy

1. Sunitha types 1800 words in half an hour. What is her typing speed in words per minute? **[NSTSE-2012]**
   1) 60 2) 600 3) 750 4) 3000
2. In a marathon, Varun runs 800 metres in 2 minutes 40 seconds. What is his speed in metres per second? **[NSTSE-2012]**
   1) $4\,ms^{-1}$ 2) $5\,ms^{-1}$ 3) $200ms^{-1}$ 4) $1600ms^{-1}$
3. Which of the following physical quantities is constant for a falling object? **[SLSTSE,AP-2012]**
   1) Speed 2) Velocity 3) Acceleration 4) Displacement

KEY & HINTS

W0RK SHEET – 1 (KEY)

1) 1	**2)** 2	**3)** 4	**4)** 4	**5)** 2
6) 2	**7)** 1	**8)** 1	**9)** 1,2	**10)** 2,4
11) 3	**12)** 4	**13)** 3	**14)** 2	**15)** 2
16) 4				

2. Distance = $\frac{1}{4}\times 2\pi r$

$= \frac{1}{4}\times 2\times\frac{22}{7}\times 21$

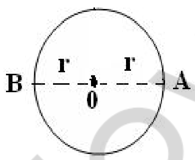
= 33 m

3. For displacement join PQ and from triangle PQ is the displacement

$\therefore PQ=\sqrt{(OP)^2+(OQ)^2}$

$=\sqrt{(21)^2+(21)^2}$

$=21\sqrt{2}$ m.

5. 

distance = $\frac{1}{2}(2\pi r)=\pi r$

displacement = $r+r$

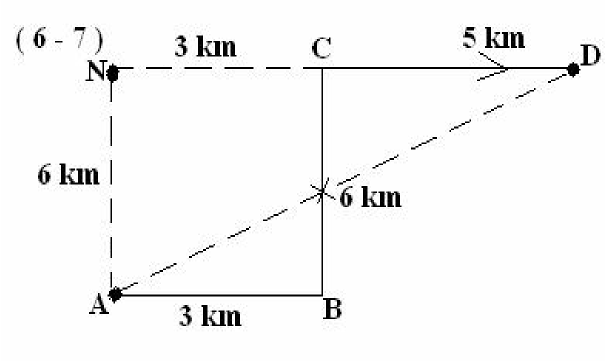
= 2r

$\therefore \frac{\text{Distance}}{\text{Displacement}}=\frac{\pi r}{2r}=\frac{\pi}{2}$

6. Distance = $3\text{ km}+6\text{ km}+5\text{ km}$

= 14 km

7.



Displacement AD $=\sqrt{(AN)^2+(ND)^2}$

$=\sqrt{(6)^2+(3+5)^2}$

$=\sqrt{36+64}$

$=\sqrt{100}=10$ km

11. Distance = $AB+BC$ (path length)

= 4 m+3 m

= 7 m.

12. Displacement = AC (shortest path)

$\therefore AC=\sqrt{(AB)^2+(BC)^2}$

$=\sqrt{(4)^2+(3)^2}$

$=\sqrt{16+9}$

$=\sqrt{25}$

= 5 m.

13. Since initial and find positions are same.

14. Distance = $3\text{ m}+4\text{ m}+12\text{ m}$

= 19 m

15. Displacement = $\sqrt{3^2+4^2+12^2}$

= $\sqrt{9+16+144}$

= $\sqrt{169}$

= 13 m.

W0RK SHEET – 2 (KEY)

1) 4	**2)** 3	**3)** 4	**4)** 3	**5)** 2
6) 2	**7)** 1	**8)** 2,4	**9)** 2	**10)** 3
11) 4	**12)** 9			

1. $1\,km\,h^{-1} = \dfrac{1\,km}{1\,h}$

$= \dfrac{1000m}{60 \times 60s}$

$= \dfrac{5}{18} ms^{-1}$

2. Acceleration $a = \dfrac{V-u}{t}$

$\therefore a = \dfrac{20-0}{200} ms^{-2}$

$\therefore a = \dfrac{20}{200} ms^{-2} = 0.1ms^{-2}$

3. Here the ball is falling under gravitational force.
So acceleration is due to gravity.
$\therefore a = 10\,ms^{-2}$ (or) $9.8\,ms^{-2}$

4. Acceleration $= \dfrac{v-u}{t}$

$a = \dfrac{(36-108)\,km\,h^{-1}}{\dfrac{4}{60 \times 60} h}$

$= \dfrac{-72 \times 60 \times 60}{4} km\,h^{-2}$

$= -64800\,km\,h^{-2}$

5. $a = \dfrac{v-u}{t}$

$$=(36-108)\times\frac{1000m}{60\times60s}\times\frac{1}{4s}$$

$$=-\frac{72\times1000}{60\times60\times4}ms^{-2}$$

$$=-5ms^{-2}$$

6. acceleration $(a)=\frac{\text{change in velocity}}{\text{time}}$

$$\therefore=\frac{\left(54\times\frac{5}{18}\right)ms^{-1}}{60s}$$

$$=\frac{15}{60}ms^{-2}=0.25ms^{-2}$$

7. $a=\frac{54kmh^{-1}}{\frac{1}{60}h^{-1}}$

$$=54\times60\,kmh^{-2}$$

$$=3240\,kmh^{-2}$$

9. Displacement is the directed line segment

10. Velocity$=\frac{\text{displacement}}{\text{time}}$

$$=\frac{90\text{km}}{\frac{3}{2}hr}$$

$$=\frac{90}{3}\times2\,km\,h^{-1}$$

$$=60\,km\,h^{-1}$$

11. Velocity$=\frac{\text{displacement}}{\text{time}}$

$$=\frac{90\times1000\text{m}}{\frac{3}{2}\times60\times60s}$$

$$=\frac{90\times1000\times2}{3\times60\times60}ms^{-1}$$

$=16.67\,ms^{-1}$

12. Velocity$=\dfrac{\text{displacement}}{\text{time}}$

$=\dfrac{540\text{m}}{60\text{s}}=9\,ms^{-1}$

13. (i) Displacement = $324\text{km}-$ south.

(ii) (a) Velocity = $\dfrac{\text{Displacement}}{\text{Time}}=\dfrac{324\text{km}}{\frac{1}{3}\text{h}}=972\text{kmh}^{-1}$

(b) $\therefore$ velocity in $ms^{-1}=972\times\dfrac{5}{18}ms^{-1}=\mathbf{270\ ms^{-1}}$ $\left[\because \mathbf{1\ kmh^{-1}=\dfrac{5}{18}ms^{-1}}\right]$

14. (i) Change in velocity = $(72\text{-}18)\text{kmh}^{-1}=54\text{kmh}^{-1}$

$\therefore$ Change in velocity in $\text{ms}^{-1}=54\times\dfrac{5}{18}\text{ms}^{-1}=15\text{ms}^{-1}$

(ii) (a) Acceleration in $\text{kmh}^{-2}=\dfrac{\text{Change in velocity}}{\text{Time}}=\dfrac{54\text{kmh}^{-1}}{\frac{30}{3600}\text{h}}$

$=54\times120\text{kmh}^{-2}=\mathbf{6480kmh^{-2}}$

(b) Acceleration in $\text{ms}^{-2}=\dfrac{\text{Change in velocity}}{\text{Time}}=\dfrac{15\ \text{ms}^{-1}}{30\ \text{s}}=\mathbf{0.5\ ms^{-2}}$

Competitive Galaxy

1. Key - 1

Typing speed $=\dfrac{\text{Number of words typed}}{\text{Time taken}}$

$=\dfrac{1800\text{ words}}{\frac{1}{2}\times60m}=60$ words per minute

2. Key - 2

Given distance $=800$ m

time $=2$ min 40s

$=2(60)+40=160s$

$\therefore$ speed$=\dfrac{\text{distance}}{\text{time taken}}$

$= \frac{800m}{160s} = 5m/s$

3. Key - 3

Here the acceleration is due to gravitational force which is constant.

$\therefore a = \frac{F}{m} =$ Constant.

$(\because$ mass of falling body is constant$)$

NEWTON'S LAWS OF MOTION

SYNOPSIS - 1

FORCE IN OUR LIFE

The use of word, 'force' in our daily life is very common. We use force to walk on the ground, to lift the objects, to throw a cricket ball, or to move a given body.

There are different types of forces, but the word 'force' generally denotes a push or a pull.

When a force acts upon a body, it begins to move. When we want to change the motion of an object, we apply force. We see that force can make a body move, or make a moving body stop, or make it move slower or faster, or change the direction of motion, of the moving body.

Thus, a force may be defined as an external cause which changes or tends to change the state of rest or uniform motion of a body in a straightline.

We are familiar with various effects of force. We can exert pushes and pulls.

We must apply a push through something rigid, while a pull can act through a non-rigid connector such as a rope or a wire. Forces which are applied through something rigid or non-rigid are called contact forces.

In physics, we come across forces which do not make contact and act through space. These are called forces at distance.

Gravity is an invisible force, with which a body is attracted or pulled towards the earth. There is nothing attached to the body, by which the force is applied. When a magnet attracts another magnet or a magnetic substance, there is nothing visible, which is pulling them together or separating them.

This ability of a force is due to the body creating a sphere of influence around itself which we call force field.

Thus, around a magnet there is a magnetic field, around a material body there is a gravitational field. A body on the earth's sufrace is in a very strong gravitational field of the earth, and hence, the body experience a force of attraction due to earth's gravity.

We have seen that a body needs a force to move it from rest, or to change its motion. To move a body from rest or to bring it to rest or to change its speed, all require force.

Force can also change the shape of an object.

When an object is not free to more, the applied force deforms it, that is , it changes the shape of the object. If the object is soft, we can see the deformation easily. When we squeeze a balloon or a lump of wax, we can deform it easily.

Let us take a special case of deformation, i.e., the stretching of a spring. The spring stretches moer with a greater pull and less with a lesser pull. In the like manner, a spring can be compressed by applying force.

EFFECTS OF FORCE

A force can bring about following effects as illustrated by the examples below :

1. To set a stationary body into motion.
   (a) A horse can make a carriage move by applying the force in the forward direction.
   (b) A player can set a ball in motion by hitting it with some suitable material.
   (c) The railway engine can move a stationary train by applying a force of pull or push.
   (d) A magnet can move an iron nail.
2. To stop the moving bodies.
   (a) A speeding car is stopped by the force of friction of brakes.
   (b) A rolling football stops because of friction from the ground.
   (c) A stone thrown vertically upward slows down and finally stops because of the force of gravity of the earth.
   (d) A freely oscillating pendulum stops because of the friction of air.
3. To change the speed or direction of a moving body.
   (a) A stone projected vertically upward changes its speed as well as direction because of the force due to gravity.
   (b) A moving car changes its direction, when a force is applied on its steering-wheel.
   (c) A moving bicycle starts runningfaster, when more force is applied on its paddles.
   (d) The direction and speed of a football changes, when a player heads it.
   (e) Satellites move around the earth at a constant speed, but continuously change their direction due to the force of gravity.
4. To bring about change in dimensions.
   (a) Length of a rubber band increases, when a stretching force is applied.
   (b) A spring shortens in length on the application of a compressive force.
   (c) Gold on hammering flattens to form a thin leaf.
   (d) Wet clay can be moulded in any shape by applying a force with hands.
   (e) A rubber balloon expands when the molecules of air exert force on its walls.

NEWTON'S FIRST LAW OF MOTION

It states that every object in this universe will continue its state of rest or uniform motion in a straight line, unless acted upon by some external force.

Explanation

The above law can be sub-divided into two sub-laws.

(i) Every object in this universe will continue in its state of rest, in a straight line, unless acted upon by some external force.

This part of the law is self-explanatory, as we know from our everyday experience that an object in its state of rest and pointing in some particular direction will remain in the same state of rest and in same direction, unless some force acts on the body. If this were not so, then the objects would have changed their position on their own, thereby causing confusion in the world.

(ii) Every object in this universe will continue in its state of uniform motion, in a straight line, unless acted upon by some external force.

This part of the law may appear wrong as we see in our everyday life that a moving object always comes to rest and does not move forever. However, if the problem is analysed closely, we come to the conclusion that moving objects on the surface of earth come to rest on account of force of friction, apolied by air or earth or both, and due to the acceleration due to gravity. The present-day space probes have proved beyond doubt that an object will continue moving forever in a straight line, when the above mentioned forces are absent. A recent example of this is the launching of Pioneer I and II, which will ultimaltely move out of our solar system.

INERTIA

From Newton's first law of motion, it can be safely concluded that a body will change its state of rest or unifrom motion only, "if some external force acts on it." In other words, any thing or material is incapable of changing its state of rest or uniform motion, and hence is in the state of inertness or inertia.

Law of Inertia : The tendency of a body to continue in its state of rest or uniform motion, in a straight line, even when some external force acts on it is called inertia.

Inertia can be further divided into two types.

(1) **Inertia of Rest :** The tendency of a body to continue in its state of rest, even when some external force is applied on it, is called **inertia of rest**.

Examples of Inertia of Rest :

(a) Imagine a pile of books placed on a sheet of paper. If the paper is suddenly pulled with a jerk, the books are left behind, because of the inertia of rest.

(b) The passengers sitting in a bus fall backwards, when the bus suddenly starts. The reason is that when the bus moves, the passengers, due to the property of the inertia of rest, are left behind, and hence, fall backwards.

(c) When a carpet is suddenly jerked, the dust flies off. Because on the sudden movement, the carpet moves, but dust on account of the inertia of rest, is left behind.

(d) When the branches of a tree, laden with fruits, are shaken, the fruits fall down. The reason is that when branches move suddenly, the fruits, on account of the inertia of rest, are left behind and fall.

2. **Inertia of Motion:** The tendency of a body to continue in its state of motion, in a straight line, even when some external force acts on it, is called inertia of motion.

Examples of Inertia of Motion:

(a) A rider falls forwards, when a galloping horse stops suddenly. When the hborse stops, the rider, on account of the inertia of motion, continues moving, and hence, falls in the forward direction,

(b) A running boy falls in the forward direction if he is tripped by a stone, etc., because the stone stops his foot, whereas rest of the body continues moving forwards, and hence, the boy falls in the forward direction.

(c) Before taking a long jump, a boy runs a certain distance, because in doing so he picks up the inertia of motion, which helps him in taking a longer leap.

(d) It is very important to run along with moving bus, and in the same direction in which the bus is moving , while jumping out of it. Otherwise, the feet will suddenly come to rest, while the rest of the body will be in the state of motion, and hence, one can fall down and get seriously injured.

WORK SHEET - 1

Single Answer Type

1. Push (or) Pull is called ________

   1) Force 2) Motion 3) Speed 4) Velocity

2. Newtons first law states that every object in this universe will continue its state of rest (or) uniform motion in a straight line unless________ acts on it.

   1) Internal force 2) External force 3) Either (1) or (2) 4) None

3. The passengers sitting in a bus fall back wards, when the bus suddenly starts, it is due to _________

   1) Gravity 2) Inertia of Rest 3) Inertia of motion 4) None

4. When a carpet is suddenly jerked, the dust flies off, due to ________

   1) Gravity 2) Inertia of Rest 3) Inertia of motion 4) None

5. The tendency of a body to continue in its state of motion, in a straight line, even when some external force acts on it, is called _______

   1) Gravity 2) Inertia of Rest 3) Inertia of motion 4) None

6. Before taking a long jump, a boy runs a certain distance, to get ________

   1) Free from leg pains 2) Concentration
   3) Inertia of Rest 4) Inertia of motion

Multi Answer Type

7. Choose the correct regarding effects of force

   1) If can stop the moving body
   2) If can increase the mass of body
   3) If cannot change the speed
   4) If can bring the change in dimensions

Subjective Answer Type

8. What is inertia, explain with example ?
9. Give some example for effects of force in daily life ?

SYNOPSIS - 2

LINEAR MOMENTUM

Let us perform the following activities :

1. Place a thin glass plate on a table and let a small metallic ball (say, mass 20 g) fall from a height of 10 cm. What happens ? Does the glass plate break ? No, it does not.
2. Now let a metallic ball of mass 500 g fall on the plate from the same height. Does the glass plate break ? Yes, it does.
3. Take another similar glass plate and let the metallic ball of mass 20 g fall on it from a height of 5 m. Does the glass plate break ? Yes, it does.

Let us consider the reasons. Why does the glass plate break in the second and the third case, but not in the first case?

In the first case, the mass of metallic ball is very small (20 g) and the height through which the ball falls is very small. Due to this small height, the ball is unable to generate sufficient velocity. The overall force generated by the ball due to the combined effect of mass and velocity is not sufficient to break the glass plate.

In the second case, the height through which metallic ball falls remains the same, but mass increases by 25 times. It is this increase in the mass which generates more force and hence, the glass plate breaks. Thus, we can say that more the mass of a moving body, more is the force possessed by it.

In the third case, tha mass of the ball remains same as in first case, but the height through which the ball falls increases by 50 times. This in turn increases the velocity of the falling ball. It is this increase in the velocity which generates more force and hence, the glass plate breaks, Thus, we can say, that more the velocity of a moving body, more is the force possessed by it.

From the above activities the linear momentum can be defined as under :

The instantaneous force which a body possesses due to combined effect of mass and velocity is called linear momentum.

Mathematically,

Linear Momentum is the product of mass and velocity.

If ***m*** is the mass of the body, ***v*** the velocity and ***p*** the linear momentum then :

Linear momentum = Mass $\times$ Velocity

or $p = \mathbf{m} \times \mathbf{v}$.

Linear momentum is vector quantity and acts in the direction of velocity of the body.

Units of linear momentum

In SI system its unit is newton second (Ns); mathematically, $1Ns = 1\ kg\ \ ms^{-1}$.

In CGS system its unit is dyne second; mathematically,

1 dyne second $= 1\ g\ cms^{-1}$.

It has been found that if same force is applied on two bodies of different masses for the same time interval, the lighter body moves with a greater velocity, as compared to the heavier body. However, the linear momentum of both the bodies remains same. From the above statement it implies that force applied is related to the change in the linear momentum of the body.

Change in linear Momentum $(\Delta p = m\ \Delta v)$

From the equation :

$p = mv$, we have

$\Delta p = \Delta(mv)$.

In the above equation symbol Δ before the quantity denotes a small change in quantity.

Now, if the mass of the body (m) remains constant, then linear change in momentum.

$\Delta p = m\ \Delta\ v$.

It has been observed that in case of sub-atomic particles moving with very, very high velocities which are comparable to the velocity of light $(c = 3\times 10^8\ ms^{-1})$, the mass of particles does not remain constant. The mass increases with the velocity of light.

Thus, we cannot say $\Delta(mv) = m\times\Delta v$.

The relation of $\Delta p = m\ \Delta v$ is valid only, if $v << c$, i.e., the velocity of particle or body is very, very small as compared to the velocity of light, particle should be of the $10^6 ms^{-1}$ or less. It is because at the variation of mass is not perceptible.

However, the relation $\Delta p = \Delta(mv)$ is always true for all the velocities.

NEWTON'S SECOND LAW OF MOTION

"The rate of change of the linear momentum is directly proportional to the applied force, and takes the direction in which the force acts."

Consider a body of mass 'm', moving with an initial velocity 'u'. Let a uniform force 'F' acts on the body for 't' seconds, such that 'v' is its final velocity. Then :

Initial linear momentum of the body

= Mass $\times$ Initial velocity

= mu

Final linear momentum of the body

= Mass $\times$ Final velocity

= mv

$\therefore$ Change in linear momentum in t seconds

= $mv - mu$

$\therefore$ Change in linear momentum in 1 second

$$= \frac{m(v-u)}{t}$$

But, change in linear momentum in one second = Rate of change of momentum

$\therefore$ Rate of change of linear momentum

$$= \frac{m(v-u)}{t} \qquad \text{..........(1)}$$

Also, we know $v = u + at$

$$a = \frac{v-u}{t} \qquad \text{..........(2)}$$

Substituting the value of (2) in (1)

Rate of change of linear momentum $= ma$ .... (3)

Also, according to Newton's second law of motion :

Rate of change of linear momentum α applied force (F) .... (4)

$\therefore$ Combining (3) and (4)

$F \ \alpha \ ma$

$F = \text{K}ma$ .... (5)

[Where K is the constant of proportionality]

Now, if there be a body with unit mass, moving with unit acceleration, such that force possessed by it is one unit, then :

$1 = K \times 1 \times 1$ or $K = 1$

Substituting the value of K in (5) , we get

$F = ma$

Mathematically, *force is the product of mass and acceleration.*

(B) UNITS OF FORCE

Absolute Units of Force

A force which produces unit acceleration in a body of unit mass is called absolute unit of force.

In CGS system, absolute unit of force is called dyne.

Definition : When a body of mass 1 g, moves with an acceleration of $1\ \text{cms}^{-2}$, then force acting on the body is called one dyne.

Thus, 1 dyne = $1\ g \times 1\ cms^{-2}$

$= 1\ g\ cms^{-2}$

In SI system, the absolute unit of force is called newton (N).

Definition : When a body of mass 1 kg, moves with an acceleration of $1\ ms^{-2}$, then the force acting on the body is called one newton.

Thus, 1 newton (N) = $1\ kg \times 1\ ms^{-2}$

$= 1\ kg\ m\ s^{-2}$

Relation between newton and dyne

1 N = $1\ g \times 1 m s^{-2}$

$= 1000\ g\ \times 100\ cm\ s^{-2}$

$= 100000\ g\ cm\ s^{-2}$

$\therefore \mathbf{1\,N = 10^5 dynes.} \left[1\ \text{dyne} = 1\ \text{gcm s}^{-2}\right]$

Gravitational Units of Force

A force which produces an acceleration in a body equal to acceleration due to gravity of Earth, when the body has a unit mass is called gravitational unit of force.

In CGS system, gravitational unit of force is called gram-force (gf).

Definition : A force required to produce an acceleration due to gravity of Earth in a body of mass 1 g, is called gram-force.

$$1\ \text{gf} = 1\ \text{kg} \times 980\ \text{cm s}^{-2}$$

= 980 dynes.

In SI system gravitational unit of force is called kilogram-force (kgf).

Definition : A force required to produce acceleration due to gravity of Earth in a body of mass 1 kg, is called kilogram-force.

$$1\ \text{kgf} = 1\ \text{kg} \times 9.8\ \text{ms}^{-2} = 9.8\ \text{N}.$$

WORK SHEET - 2

Single Answer Type

1. The S.I unit of force is ________

   1) $kg\ ms^{-1}$ 2) $kg\ ms^{-2}$ 3) $kg\ m^{-1}s$ 4) $kg\ m^{-2}s$

2. One newton = __________ dynes

   1) 10^2 2) 10^3 3) 10^4 4) 10^5

3. Mathematically linear momentum is expressed as

   1) Mass $\times$ Velocity 2) Mass $\div$ Velocity
   3) Mass $+$ Velocity 4) Mass $-$ Velocity

4. Calculate the velocity of a body of mass 0.5 kg, when it has a linear momentum of 5 Ns.

   1) 5 m/s 2) 10 m/s 3) 15 m/s 4) 5.5 m/s

5. A car initially at rest, picks up a velocity of 72 km/h in 20 seconds. If the mass of the car is 1000 kg, find the force developed by its engine.

   1) 20 N 2) 40 N 3) 100 N 4) 1000 N

6. In the above question find the distance covered by the engine.

   1) 20 m 2) 40 m 200 m 4) 400 m

7. What is the S.I unit of momentum ?

   1) $kgms^{-1}$ 2) $kgms^{2}$ 3) $kgm^{-1}s$ 4) $kgm^{-2}s$

Multi Answer Type

8. Choose the unit of force

   1) kgf 2) N 3) dyne 4) None

Integer Answer Type

9. A cricket player holds a cricket ball of mass 100 g by moving his hands backward by 0.75 m. If the initial Velocity of the ball is $1084\ mh^{-1}$, find the retarding force opplied by the player is ________$\times 10^1\ N$

Comprehension Type

The linear momentum of a body is given by $\overline{P} = m\overline{V}$ mathematically,
linear momentum = mass $\times$ velocity

10. An electron of mass 9×10^{-31} kg is moving with a linear velocity of 6×10^7 m/s. Calculate the linear momentum of electron

    1) 54 kg m/s 2) 54×10^{-31} kg m/s 3) 54×10^{-24} kg m/s 4) 45 kg m/s

11. A body of mass 200g is moving with a velocity of 5 m/s. If the velocity of the body changes to 17 m/s, calculate the change in linear momentum of the body.
    1) 24 Ns 2) 14 Ns 3) 42 Ns 4) 2.4 Ns
12. A motorcycle of mass 100 kg is running at $10\ ms^{-1}$. If its engine develops on extra linear momentum of 2000 N-s, calculate the new velocity of motorcycle
    1) $30\ ms^{-1}$ 2) 20 m/s 3) $10\ ms^{-1}$ 4) $15\ ms^{-1}$

Subjective Answer Type

13. A body has a linear momentum of 5 Ns. If the velocity of the body is $200\ ms^{-1}$, find the mass of the body.
14. A motor cyclist along with the machine weighs 160 kg. While driving at $72\, kmh^{-1}$, he stops his machine over a distance of 8m. Find the retarding force of the brakes.
15. A force of 500 dynes acts on a mass of 0.05 kg over distance of 20m. Assuming that the mass is initially at rest, find the final velocity and time for which the force acts.
16. A force of 600 dynes acts on a glass ball of mass 200 g for 12 s. If initially the ball is at rest, find (i) Final velocity (ii) Distance covered.

Additional Questions

17. A car of mass 800 kg, moving at $54 kmh^{-1}$ is brought to rest over a distance of 15m. Find the retarding force developed by the brakes of the car.
18. A bullet of mass 30 g, and moving with a velocity x hits a wooden target with a force of 187.5N. If the bullet penetrates 80 cm, find the value of x.

Competitive Type

1. A person runs a very long distance before taking a long jump just to **[Dr. A.S.Rao Awards Council - 2009]**
   1) increase kinetic energy 2) train up muscles
   3) to attain inertia of motion 4) show power of running

2. Which of the following uses Newton's third law? **[Dr. A.S.Rao Awards Council - 2009]**
   1) Motor 2) Lift 3) Rocket 4) Weighing machine

WORK SHEET – 1 (KEY)				
1) 1	**2)** 2	**3)** 2	**4)** 2	**5)** 3
6) 4	**7)** 1,4			

WORK SHEET – 2 (KEY)				
1) 2	**2)** 4	**3)** 1	**4)** 2	**5)** 4
6) 3	**7)** 1	**8)** 1,2,3	**9)** 6	**10)** 3
11) 4	**12)** 1			

2. $1N = 1kg \times \frac{1m}{5^2}$

$= 1000g \frac{100cm}{5^2}$

$= 100000 \frac{gcm}{5^2}$

$\therefore 1N = 10^5 dyn$

4. $P = m \times V$

$5 = (0.5) \times V$

$\Rightarrow V = \frac{5}{0.5}$

$= \frac{5 \times 10}{5} = 10 \text{ m/s}$

5. Given $u = 0$, $V = 72 \text{ km/h}$, $t = 20s$, $m = 1000 \text{ kg}$

$= 72 \times \frac{5}{18} \text{ m/s}$

$= 20 \text{ m/s}$

$F = ma$

$\therefore F = m\left(\frac{V-u}{t}\right)$

$= 1000\left(\frac{20-0}{20}\right)$

$= 1000 \text{ N}$

6. $V^2 - u^2 = 2as$

$(20)^2 - 0^2 = 2\times\left(\frac{V-u}{t}\right)\times s$

$400 = 2\left(\frac{20-0}{20}\right)\times s$

$400 = 2\times s$

$\therefore s = 200 \text{ m}$

9. Here $V = 0$, $u = 108 \text{ kmh}^{-1}$, $s = 0.75 \text{ m}$

$= 108\times\frac{5}{18} m/s = 300\ m/s$

and $m = 100 \text{ g} = \frac{100}{1000}\ kg$

Now $V^2 - u^2 = 2as$

$0^2 - (30)^2\ 2\times a\times\frac{75}{100}$

$-900 = 2\times a\times\frac{3}{4}$

$\therefore a = 600 \text{ m/s}^2$

$\therefore F = ma = \frac{100}{1000}\times 600 = 60 \text{ N} \Rightarrow 6\times10^1 N$ = 6

10. $P = m\times V$

$\therefore P = \left(9\times10^{-31}\text{ kg}\right)\times\left(6\times10^7\text{ m/s}\right)$

$= 54\times10^{-24}$ kg. m/s

11. Change in linear momentum $= P_f - P_i$

$=$ mV-mu

$=$ m(V-u)

$\therefore\ \Delta P = \frac{200}{1000}\ kg[17\ m/s - 5\ m/s]$

$= \frac{1}{5}\ kg \times 12\ m/s$

2.4 kg m/s (or) 2.4 kg N-s

12. Given,

Change in linear momentum $= 2000$ N-s

$m = 100$ kg

$V = ?$

$\therefore \Delta P = P_f - P_i$

$\Delta P = mV - mu$

$2000 = 100(V - 10)$

$20 = V - 10$

$\therefore V = 30\ ms^{-1}$

13. Mass $(m) = ?$, velocity $(v) = 200\ ms^{-1}$ and linear momentum $(p) = 5\ Ns$

Now, $p = m \times v$

$$m = \frac{p}{v} = \frac{5Ns}{200\ ms^{-1}} = \frac{5\ kgms^{-1}}{200\ ms^{-1}} = 0.025\ kg.$$

14. $u = 72\,kmh^{-1} = 20ms^{-1}; v = 0; S = 8m$

Applying, $v^2 - u^2 = 2aS$

$(0)^2 - (20)^2 = 2 \times a \times 8$

$\therefore a = -\frac{400}{16} = -25ms^{-2}$

$\therefore$ Retardation = $25ms^{-2}$

$\therefore$ Retarding force = Mass $\times$ Retardation = 160 kg $\times$ 25 $ms^{-2} = 4000N$

15. $F = 500$ dynes $= 500$ gcm s^{-2}

$m = 0.05\,kg = 50g$

Now, $a = \frac{F}{m} = \frac{500\,gcms^{-2}}{50g} = 10cms^{-2}$

Also, $S = 20m = 2000cm$

Applying, $v^2 - u^2 = 2aS$

$v^2 - (0)^2 = 2\times 10\,cm\,s^{-2} \times 2000cm$

$\therefore v^2 = 40000cm^2 s^{-2}$

or $v = 200\,cm\,s^{-1}$

Applying, $v = u + at$

$\therefore\ 200cm\,s^{-1} = 0 + 10cm\,s^{-2} \times t$

or $t = 20s$

16. Given $F = 600$ dyn, $\quad$ m = 200 g, $\quad$ t = 12 s, $\quad$ u = 0

i) $F = ma$

$600 = 200\times a \quad \Rightarrow \quad a = 3\ \text{cm/s}^2$

$V = u + at$

$V = 0 + 3\times 12$

$\therefore V = 36\ \text{cm/s}$

ii) $V^2 - u^2 = 2as$

$(36)^2 - 0^2 = 2\times 3\times s$

$\therefore 36\times 36 = 6\times s$

$\Rightarrow s = \dfrac{36\times 36}{6} = 216\ \text{cm}$

17. Given $m = 800$ kg

$u = 54\ \text{km/h} = 54\times\dfrac{5}{18}\ \text{m/s}$

$= 15\ \text{m/s}$

$V = 0$

$s = 15\ \text{m}$

$V^2 - u^2 = 2as$

$0^2 - (15)^2 = 2\times a\times 15$

$\therefore\ a = -\dfrac{15}{2}\ \text{m/s}^2$

Now $F = ma$

$= 800\left(-\dfrac{15}{2}\right) = -6000\ \text{N}$

18. Given $m = 30$ g , $u = x$, $V = 0$, $F = 1875N$, $s = 80$ cm

$$= \frac{30}{1000} \text{ kg} = \frac{80}{100} \text{ m}$$

Now $F = ma$

$$187.5 = \frac{30}{1000} \times 9$$

$$\therefore a = 6250 \text{ m/s}^2$$

$$V^2 - u^2 = 2as$$

$$0^2 - x^2 = -2 \times 6250 \times \frac{80}{100} \Rightarrow x^2 = 625 \times 16$$

$$\therefore x = 100 \text{ ms}^{-1}$$

Competitive Type

1. Key - 3
2. Key - 4

WORK POWER ENERGY & MACHINES

SYNOPSIS - 1

Definition :

Work is said to be done when a force produces motion.

Examples : A man climbing the stairs of a house is also doing work in moving himself against the force of gravity.

Mathematical Expression for work :

work = Force × Distance moved in the direction of force

The work done by a force on a body depends on two factors.

i) Magnitude of the force.

ii) Distance through which the body moves (in the direction of force)

Units of work : The unit of work in C.G.S. system is 'erg'.

$W = F \,.\, S = 1\text{dyne} \times 1\text{cm} = 1\text{erg}$

erg : Work done is said to be one 'erg' if a force of one dyne displaces the body through a distance of 1 cm along the direction of force.

$1 \text{ erg} = 1 \text{ dyne} \times 1 \text{ cm}$

$= 1 \text{ g cm s}^{-2} \times \text{cm}$ or $1 \text{ erg} = 1 \text{ g cm}^2 \text{ s}^{-2}$

The unit of work in S.I. system is joule (J)

$W = F \,.\, S = 1\text{N} \times 1\text{m} = 1 \text{ joule}$

Joule : Work is said to be one joule, if a force 1 newton displaces a body through a distance of 1 m along the direction of force.

$$1 \text{ J} = 1 \text{ N} \times 1 \text{ m} = 1 \text{ kg}.\frac{\text{m}}{\text{s}^2}.\text{ m} \quad 1 \text{ J} = 1 \text{ kg m}^2 \text{ s}^{-2}$$

Relation between Joule and erg :

$1 \text{ J} = 1 \text{ N} \times 1 \text{ m}$

$= 10^5 \text{ dyn} \times 100 \text{ cm}$

$= 10^7 \text{ dyn cm}$ or $1 \text{ J} = 10^7 \text{ erg}$.

Work done can be positive, negative or zero depending upon the directrion of force and direction of motion. (displacement)

Work done by a force on a body (or an object) is said to be positive work done when the body is displaced in the direction of applied force.

Types of work done:

Positive work done : Work done by a force on a body (or an object) is said to be positive work done when the body is displaced in the direction of applied force.

Examples :

i) The body falling freely under the action of gravity has positive work done by the gravitational force.

ii) The work done by the engine is positive.

Negative work done : The work done by a force on a body is said to be negative work done when the body is displaced in a direction opposite to the direction of the force.

Examples :i)When an object is lifted upward to a certain height, then the work done by the force of gravity (equal to the weight of the object) on the object is negative.

ii) Work done by frictional force as force of friction and the displacement are opposite to each other.

iii) Work done by a person with a suitcase on his head moving upwards in the vertical direction. Here the displacement is in the upward direction and the force of gravity acts in the downward direction.

iv) When brakes are applied on a moving vehicle, work done by the braking force is negative.

Zero work : If S = 0 i.e., the body does not move from its position on the application of force, then W = 0

Thus, no work is done by the force if it fails to displace the body.

Ex : When a person pushes a wall but fails to move the wall, then work done by the force on the wall is zero.

b) When a body moves in a direction perpendicular to the direction of the force no work is done by the force.

Examples :

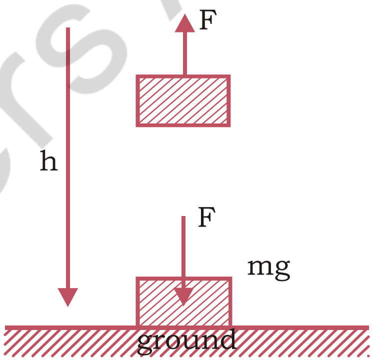
i) When a person carrying a suitcase in his hand or on his head is walking horizontally, the work done against gravity is zero.

ii) No work is done on a body when it moves along a circular path.

iii) Work done by the flying aeroplane is zero as the force and displacement are perpendicular to each other.

Work done against gravity :

If a body is lifted vertically upwards, then the force required to lift the body is equal to it weight. So, whenever work is done against gravity, the amount of work done is equal to the product of weight of the body and the vertical distance through which the body is lifted.



Work done by against gravity

Suppose a body of mass 'm' is lifted vertically upwards through a distance 'h'. In this case the force required to lift the body will be equal to weight of the body (m × g).

Work done in lifting a body = weight of body × vertical distance

W = mg × h

Where, m = mass of body

g = acceleration due to gravity at that place

h = height through which the body is lifted

WORK SHEET - 1

Single Answer Type

1. When displacement is perpendicular to the force, work done is
   1) positive 2) negative 3) zero 4) may be positive or negative
2. Calculate the work done by a passenger standing on a platform holding a suitcase of 10 kgwt
   1) 15 2) 10 3) 0 4) 5
3. Unit of work is
   1) Joule 2) erg 3) newton 4)Both (1) & (2)
4. Mathematical Expression for work is
   1) Force × Distance moved in the direction of applied force
   2) $\dfrac{\text{Force}}{\text{Dis tan ce moved in the direction of force}}$
   3) $\dfrac{\text{Dis tan ce in the dirction of force}}{\text{Force}}$
   4) None of these
5. Work is said to be done
   1) when no force is applied 2) when a force produces no motion.
   3) when a force produces motion. 4) None of these

Multi Answer Type

6. Choose the correct statements :
   1)When displacement is opposite to the force work done = - (force × displacement)
   2)When displacement is opposite to the force work done = + (force × displacement)
   3)Work done by frictional force is negative
   4)Work done by frictional force is positive
7. The work done by a force on a body depends on two factors
   1) Magnitude of the force. 2) External dimensions of the body
   3) Distance through which the body moves 4) Colour of the body
8. Choose the correct statements :
   1)When a stone tied to a string is whirled in a circle, the work done on it by the string is zero
   2)When brakes are applied on a moving vehicle, work done by the braking force is negative.
   3)Work done by the flying aeroplane is zero as the force and displacement are perpendicular to each other.
   4)The body falling freely under the action of gravity has positive work done by the gravitational force.

Reasoning Answer Type

9. *Statement I :* Work done is said to be one erg if a force of one dyne displaces the body through a distance of 1 cm along the direction of force.
Statement II : Work is said to be one joule, if a force 1 newton displaces a body through a distance of 1 m along the direction of force.
1) Both Statements are true, Statement II is the correct explanation of Statement I.
2) Both Statements are true, Statement II is not correct explanation of Statement I.
3) Statement I is true, Statement II is false.
4) Statement I is false, Statement II is true.

Comprehension Type

Work done in lifting a body (W) = mg × h

10. How much is the mass of a man if he has to do 2500 joule of work in climbing a tree 5m tall ? ($g = 10\ m/s^2$)
1) 30 kg 2) 40 kg 3) 50 kg 4) 45 kg

11. An object of 100 kg is lifted to a height of 10 m vertically. What will be the work done? [$g = 9.8\ m/s^2$]
1) 9800 J 2) 9008 J 3) 9.8 J 4) 8.9 J

12. A coolie lifts a box of 15 kg from the ground to a height of 2.0 m. The work done by the coolie on the box is (Given $g = 9.8\ m/s^2$)
1) 250 J 2) 294 J 3) 300 J 4) 350 J

Matrix Matching Type

13.

Column - I	**Column - II**
a) 1Joule	1) 10^7 erg.
b) 1erg	2) $1\ kg\ m^2\ s^{-2}$
c) Work done in lifting a body	3) positive work done
d) Body falling freely under the action of gravity	4) Weight of body × vertical distance
	5) $1\ g\ cm^2\ s^{-2}$

Integer Answer Type

14. A boy pushes a book by applying a force 5N, the work done by this force in displacing the book through 20 cm along the direction of the push is ____ J

Subjective Answer Type

15. A person of mass 50 kg climbs a tower of height 72 metre. The work done is

[$g = 9.8\ m/s^2$]

SYNOPSIS - 2

Introduction to Energy

It is often said that a person A is more energetic than a person B. The meaning of this statement is that a person A can do more work than the person B. Similarly, a person after doing a lot of work gets tired and after that he is not able to do much work. It is clear that a person doing work expends something. This 'something' is known as the energy of the person. The energy spent by a person is equal to the work done by him. Human beings and animals get energy by eating food.

It may be noted that anything which is capable of doing work has energy. For example, the steam pushes up the lid placed on the boiling water container. It means, the steam has the ability or capacity to do work. The work done by the steam on the lid is equal to the energy of the steam.

Definition of energy

If a person can do a lot of work we say that he has a lot of energy or he is very energetic. In physics also, anything which is able to do work is said to possess energy.

Thus, energy is the ability to do work or the capacity to do work.

Units of energy

Unit of energy is same as that of the unit of work as work is a form of energy.

So, S.I. unit of energy is **Joule (J).**

When we say that energy of a body is 1 joule, it means, this body has the capacity to do 1 J work.

Commercial unit of Energy

The commercial unit (or trade unit) of energy is kilowatt-hour which is written in short form as kWh. Kilowatt-hour is usually used as a commercial unit of electrical energy.

One kilowatt-hour is the amount of electrical energy consumed when an electrical appliance having a power rating of 1 kilowatt is used for 1 hour. Since a kilowatt means 1000 watts, so we can also say that one kilowatt-hour is the amount of electrical energy consumed when an electrical appliance of 1000 watts is used for 1 hour.

1 kilowatt-hour is the amount of energy consumed at the rate of 1 kilowatt for 1 hour. That is, 1 kilowatt-hour = 1 kilowatt for 1 hour

or 1 kilowatt-hour =1000 watts for 1 hour

Note:

Watt or kilowatt is the unit of electrical power but kilowatt-hour is the unit of electrical energy.

Energy is a scalar quantity.

Dimensional formula of energy = ML^2T^{-2}

Kinds of Energy

In actual practice there are many kinds of energy, such as mechanical energy; heat energy; light energy; sound energy, electrical energy; nuclear energy; chemical energy, etc. Let us discuss about mechanical energy.

Mechanical energy (M.E)

The sum of kinetic energy (K.E) and potential energy (P.E) of a body is known as mechanical energy. $\therefore$ M.E = K.E + P.E

Kinetic energy:- Energy possessed by a body by virtue of it's motion is called kinetic energy

Ex: (1) Moving vehicle

Energy has many forms, such as thermal energy (Heat Energy), sound Energy, Light Energy.

Expression for Kinetic energy :-

The kinetic energy of a body of mass 'm' moving with a speed v is $\frac{1}{2} \times m \times v^2$

Potential Energy:- Energy possessed by a body (or) system by virtue of its position.

Ex:-(1) Water stored at a height, (2) compressed spring

Gravitational potential energy :-

The Potential energy due to height above the earth's surface is called gravitational potential energy.

In general, if the potential energy at the ground is taken as zero, the potential energy of an object at a height h above the ground is given by

$$U = mgh$$

The energy results from the force of attraction mg between the earth and the object.From newton's third law, both earth and the object attract each other. Hence, strictly speaking energy 'mgh' is not the potential energy of the object alone it is the potential energy of object-earth system.

Heat Energy:-

Heat is the energy that is transferred between a system and its environment because of a temperature difference that exists between them.

Heat is an Internal energy that consists of the kinetic and potential energies associated with the random motion of the atoms, molecules and other micro scopic bodies within object.

Sound Energy:-

Sound is a form of energy, that is produced by a body when it is in the state of vibration. It propagates in the form of Longitudinal waves through Elastic media and causes sensation of hearing.

Light Energy:-

$\rightarrow$ Light is a form of energy, which causes sensation of vision.

$\rightarrow$ Light travels from one place to another place in the form of Electromagnetic waves.

$\rightarrow$ E.M wave can transport energy and deliver it to a body on which it falls.

Elastic potential energy :-

When a spring is streched or compressed from its natural length, its get extra energy. It can return to its natural length by performing some work.

The extra energy stored in a streched or compressed spring is called elastic potential energy.

A streched rubber band also has potential energy, where as rubber band at its natural length lying on a table has no elastic potential energy.

Other forms of energy :-

Besides mechanical energy, energy can exist in several other forms.

Charged particles and electric currents can produce electrical energy and magnetic energy.Electric batteries,cooking gas,petrol etc., have chemical energy stored in them.Even matter itself is a concentrated form of energy and can be converted into other forms of energy such as kinetic energy and heat energy.

Electrical energy : Energy is associated with electric current is called electrical energy

The flow of electrical current causes bulbs to glow, fans to rotate and bells to ring.

Work and energy :

Whenever work is done on an object, it's energy increases.

When we push a block kept on a table, the block starts moving. We do work on the block and the block aquires kinetic energy.

WORK SHEET - 2

Single Answer Type

1. The workdone is always
   1) greater than energy spent 2) less than energy spent
   3) some times greater than & sometimes less than energy
   4) equal to energy spent
2. As a body rolls down a inclined plane, it has
   1) Only kinetic energy 2) Only potential energy
   3) Both kinetic energy and potential energy
   4) Neither kinetic energy nor potential energy
3. An object of mass 1kg is raised through a height h.Its potential energy is increased by 1J.Height h is ($g = 9.8\ m/s^2$)
   1) 0.109 m 2) 0.111 m 3) 0.102 m 4) 0.123 m
4. The S.I unit of energy is
   1) joule 2) erg 3) watt 4) newton
5. The energy possessed by a body by virtue of its position (or) configuration is called
   1) Heat energy 2) P.E 3) K.E 4) Light energy

Multi Answer Type

6. Choose the correct statements :
   1) 1 kilowatt-hour is the amount of energy consumed at the rate of 1 kilowatt for 1 hour
   2) Work done by external forces on the system is equal to the increase in the system's energy
   3) Work done by external forces on the system is equal to the decrease in the system's energy
   4) 1 kilowatt-hour is the amount of energy consumed at the rate of 1 kilowatt for 2 hours

7. Choose the corect statements :-
1) Heat is the energy that is transferred between a system and its environment because of a temperature difference that exists between them.
2) Sound is a form of energy, that is produced by a body when it is in the state of vibration
3) The energy stored in a streched spring is called elastic potential energy
4) The energy stored in a compressed spring is called elastic potential energy

8. Choose the correct statements :
1) Unit of energy is same as that of the unit of work.
2) Capacity to do work is known as energy.
3) The commercial unit of energy is kilowatt-hour.
4) When we say that energy of a body is 1 joule, it means, this body has the capacity to do 1 J work.

Reasoning Answer Type

9. *Statement I* :Kinetic energy of the body is due to virtue of its motion

Statement II :Potential energy of the body is due to virtue of its position
1) Both Statements are true, Statement II is the correct explanation of Statement I.
2) Both Statements are true, Statement II is not correct explanation of Statement I.
3) Statement I is true, Statement II is false.
4) Statement I is false, Statement II is true.

Comprehension Type

The sum of kinetic energy (K.E) and potential energy (P.E) of a body is known as mechanical energy

10. Gravitational potential energy (U) of the body is given by

1) mgh 2) $\frac{1}{2} \times m \times v^2$ 3) $\frac{1}{2} \times m \times v$ 4) mgh^2

11. The kinetic energy of a body depends
1) on its mass only 2) on its speed only
3) on its mass as well as on its speed
4) neither on its mass nor on its speed

12. The mechanical energy is the sum of
1) P.E & K.E 2) Thermal energy & light energy
3) sound energy & nuclear energy 4) K.E & heat energy

Matrix Matching Type

13.

Column - I	Column - II
a) Water stored at a height	1) Sound energy
b) Moving vehicle	2) kinetic energy
c) Forms of energy	3) potential energy
d) Dimensional formula of energy	4) ML^2T^{-2}
	5) Light energy

Integer Answer Type

14. The kinetic energy of a ball of mass 200 g moving at a speed of 20 cm/s is ____× 10^4erg

SYNOPSIS - 3

Relation between kinetic energy and momentum :

Let us consider a body of mass 'm' having a velocity 'v' , then momentum of the body P = mass × velocity $\Rightarrow P = m \times v$

$$\Rightarrow \quad v = \frac{P}{m} \qquad \text{---------} (1)$$

From definition, kinetic energy (K.E) of the body

$$K.E = \frac{1}{2}mv^2 \qquad \text{---------} (2)$$

Now putting the value of (1) in (2) we have

$$K.E = \frac{1}{2}m\left(\frac{P}{m}\right)^2$$

$$K.E. = \frac{1}{2}m\frac{P^2}{m^2} = \frac{1}{2}\frac{P^2}{m} = \frac{P^2}{2m} \qquad \text{-----} (3)$$

Thus we can write $P^2 = 2m \times K.E \Rightarrow P = \sqrt{2m \times K.E}$

Thus momentum = $\sqrt{2 \times \text{mass} \times \text{kinetic energy}}$

Note :

1. For same momentum $K.E \propto \frac{1}{m}$

   Kinetic energy varies inversely as the mass.
2. If two bodies have same momentum, ratio of their kinetic energy is

   $$\frac{K.E_1}{K.E_2} = \frac{m_2}{m_1} \qquad \left[E \propto \frac{1}{m}\right]$$
3. If two bodies have same kinetic energy, ratio of their momenta is $\frac{P_1}{P_2} = \sqrt{\frac{m_1}{m_2}}$
4. If the momentum of a body is increased to x times, its kinetic energy increases to x^2 times.
5. If the kinetic energy of a body is increased to x times, its momentum increases to $\sqrt{x}$ times.

WORK SHEET - 3

Single Answer Type

1. If P is the momentum of a body of mass m, its kinetic energy E is given by

1) $\frac{P}{2m}$ 2) $\frac{P}{2m^2}$ 3) $\frac{P^2}{2m}$ 4) $\frac{P^2}{4m}$

2. Momentum can be defined as

1) $\sqrt{2 \times \text{mass} \times \text{kinetic energy}}$ 2) $\frac{\sqrt{2 \times \text{mass}}}{\text{K.E}}$

3) $\frac{\sqrt{2 \times \text{mass}}}{\text{K.E}^2}$ 4) $\frac{\sqrt{2 \times \text{K.E}}}{\text{mass}}$

3. Two bodies having kinetic energy K_1 and K_2 have equal masses.Their momenta are p_1 and p_2 respectively, then p_1/p_2 is

1) $K_1:k_2$ 2) $K_2:k_1$ 3) $\sqrt{K_2}:\sqrt{K_1}$ 4) $\sqrt{K_1}:\sqrt{K_2}$

4. The ratio of kinetic energies of two bodies is 2:1 and their momenta are in the ratio of 1:2.The ratio of their masses are in the ratio

1) 1:4 2) 4:1 3) 8:1 4) 1:9

Multi Answer Type

5. When a bullet is fired from a gun
1)Gun and bullet have same momenta in magnitude
2)Bullet will have more kinetic enrgy
3)Gun will have more kinetic enrgy
4)Gun and bullet have different value of momenta in magnitude

6. Choose the correct statements:
1) Unit of kinetic energy is joule 2) Unit of momentum is kg m/s
3) Unit of kinetic energy is erg 4) Unit of momentum is g cm/s

7. Choose the correct statements :

1) For same momentum $\text{K.E} \propto \frac{1}{m}$

2) If two bodies have same momentum, ratio of their kinetic energy is $\frac{\text{K.E}_1}{\text{K.E}_2} = \frac{m_2}{m_1}$

3) For same momentum $\text{K.E} \propto m$

4) If two bodies have same momentum, ratio of their kinetic energy is $\frac{\text{K.E}_1}{\text{K.E}_2} = \frac{m_1}{m_2}$

Reasoning Answer Type

8. *Statement I* :A body at rest can have kinetic energy and momentum
Statement II :A body cannot have momentum without kinetic energy
1) Both Statements are true, Statement II is the correct explanation of Statement I.
2) Both Statements are true, Statement II is not correct explanation of Statement I.
3) Statement I is true, Statement II is false.
4) Statement I is false, Statement II is true.

Comprehension Type

If two bodies have same momentum, ratio of their kinetic energy is $\frac{K.E_1}{K.E_2} = \frac{p_1^2}{p_2^2}$

If two bodies have same kinetic energy, ratio of their momenta is $\frac{P_1}{P_2} = \sqrt{\frac{m_1}{m_2}}$

9. Two masses 1 kg and 4 kg are moving with equal kinetic energy.Then ratio of their linear momenta is
1) 1:2 2) 2:1 3) 1:4 4) 4:1

10. If the kinetic energy of a body is doubled, then its momentum increases to
1) 2 times 2) 4 times 3) $\sqrt{2}$ times 4) $2\sqrt{2}$ times

11. If the momentum of a body is twice as that the kinetic energy numerically, then velocity of the body is
1) 1 m/s 2) 2 m/s 3) 4 m/s 4) $\frac{1}{2}$ m/s

Matrix Matching Type

12.

Column - I	Column - II
a) momentum of a body increased to x times	1) its kinetic energy increases to x^2 times
b) If the kinetic energy of a body is increased to x times	2) momentum increases to $\sqrt{x}$ times
c) If two bodies have same kinetic energy	3) ratio of their momenta is $\frac{P_1}{P_2} = \sqrt{\frac{m_1}{m_2}}$
d) Work-energy theorem	4) Initial K.E - Final K.E
	5) $\frac{1}{2}mv^2 - \frac{1}{2}mu^2$

Integer Answer Type

13. A body of mass 4 kg is moving with a momentum of 12 kg ms^{-1} its kinetic energy is
__________ J

Subjective Answer Type

14. Two bodies A and B have their masses in the ratio 3:1 and kinetic energies are in the ratio 1:3 The ratio of their velocities is

SYNOPSIS - 4

Law of conservation of energy :

According to this law

"Energy can neither be created nor be destroyed, but can be changed from one form to another form".

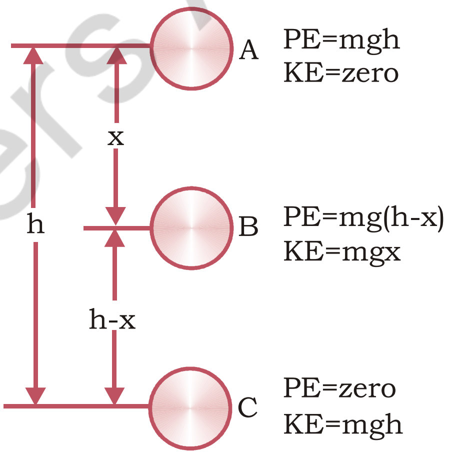
Examples:

1) When a body falls from a certain height, its P.E gradually changes into kinetic energy but the total sum of both the energies remains the same.

2) When coal is burnt in a steam engine, the chemical energy of coal disappears and an equivalent amount of heat and light energies are obtained.

The law of conservation of energy of freely falling body :

The total energy of a freely falling body at any instant is constant.



Consider a body of mass 'm' at a height 'h' above the ground. Suppose this position of the body is A. Suppose the body at 'A' is at rest i.e v = 0.

At the position 'A' :

Potential energy at 'A', P.E = mgh

kinetic energy at 'A', K.E = $\frac{1}{2}mv^2 = \frac{1}{2}m(0)^2 = 0$

$\therefore$ Total energy of the body at A = P.E + K.E = mgh + 0 = mgh -------------- (1)

Let the body falls freely under the action of gravity to position 'B' through a height x. Now, the height of the body from the ground = h – x

At position 'B'

Potential energy of the body at 'B' , P.E = mg (h – x) = mgh – mgx

kinetic energy of the body at 'B' , $K.E. = \frac{1}{2}mv^2$ ------------ (a)

where v is the velocity of the body at position 'B'.

But here a = g and s = x, u = 0 as body at A is at rest

using $v^2 - u^2 = 2as \Rightarrow v^2 = 2as \Rightarrow v^2 = 2gx$ ------------- (b)

from equation (a) and (b) we have $K.E = \frac{1}{2}m \times 2gx = mgx$

Now, total energy at the point 'B' = P.E + K.E = mgh – mgx + mgx = mgh ------ (2)

Finally, let the body touches the ground at 'C', so that the distance through which it falls = h

At position 'C'

Potential energy at 'C', P.E = mg (0) = 0

Kinetic energy at 'C', $K.E = \frac{1}{2}mv^2$ ------------------ (c)

where v is the velocity of the body just at position 'C'.

Here u = 0 [$\because$ body is at rest at position A, a = g and s = h]

we know that $v^2 - u^2 = 2as \Rightarrow v^2 - 0 = 2gh \Rightarrow v^2 = 2gh$ ------------------- (d)

from equation 'c' and 'd' we have $K.E = \frac{1}{2}m(2gh) = mgh$

$\therefore$ Total energy at the point 'C' = P.E + K.E = 0 + mgh = mgh------------------- (3)

From (1), (2) and (3) it is clear that the total energy of a body at any instant during free fall of a body remains constant. Hence, the law of conservation of energy is verified.

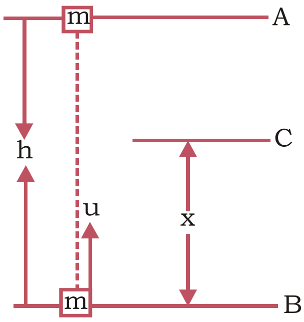
Note :

1) The total energy (K.E + P.E) of the freely falling body is converted into sound and heat energy, when the body strikes the ground.
2) For a freely falling body, potential energy changes into kinetic energy.
3) For a body projected vertically upwards, kinetic energy changes into potential energy.

Conservation of mechanical energy for a vertically porjected body

Statement : The total energy in the universe is constant and it can be neither created nor destroyed.

Consider a body of mass "m" it is projected vertically upwards with an initial velocity "u"



At Point B :-

The point is on the ground so h = 0

Potential energy P.E. = mgh = mg(0) = 0, Initial velocity = u

Kinetic energy KE = $\frac{1}{2}$m v^2 = $\frac{1}{2}mu^2$ $\therefore$ Total energy = PE + KE = $\frac{1}{2}mu^2$

$$E_B = \frac{1}{2}mu^2$$

At point A :

This point is at a height "h" from the ground. At this point velocity is zero v = 0.

$$KE = \frac{1}{2}m\,v^2 = \frac{1}{2}m\,(0)^2 = 0$$

PE = mgh, Initial velocity = u, acceleration a = -g, distance travelled s = h

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

We will get $0^2 - u^2 = 2(-g)h \Rightarrow -u^2 = -2gh \Rightarrow h = \frac{u^2}{2g}$

$$\therefore PE = mgh = mg\left(\frac{u^2}{2g}\right) = \frac{1}{2}mu^2$$

$$\therefore \text{ Total Energy } = PE + KE = \frac{1}{2}mu^2 + 0$$

$$E_A = \frac{1}{2}mu^2$$

At point C :

This point is at a height "x" from the ground and let the velocity of the body at this point be "v".

h = x

Potential energy PE = mgh = mgx

$$KE = \frac{1}{2}mv^2$$

initial velocity = u, acceleration a = -g, displacement s = x

from $v^2 - u^2 = 2as$, we will get

$$v^2 - u^2 = 2(-g)\,x \;\Rightarrow x = \frac{v^2 - u^2}{-2g} = \frac{u^2 - v^2}{2g}$$

$$\therefore PE = mg\left[\frac{u^2 - v^2}{2g}\right] = \frac{1}{2}mu^2 - \frac{1}{2}mv^2$$

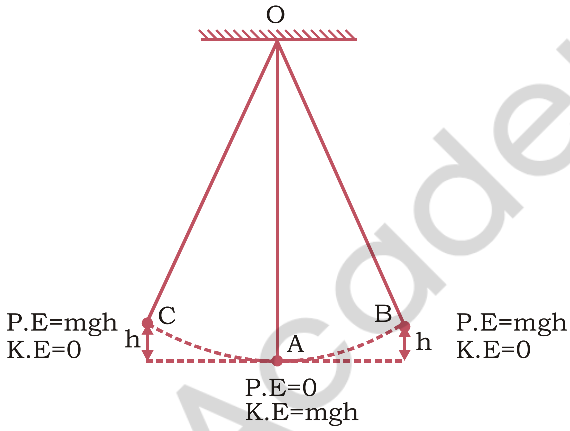
$$\therefore \text{total energy} = PE + KE = \frac{1}{2}mu^2 - \frac{1}{2}mv^2 + \frac{1}{2}mv^2$$

$$E_c = \frac{1}{2}mu^2$$

At A.B and C the total energy is constant.

Law of conservation of Energy: The sum total of energy in a system is a constant quantity. It can neither be created nor destroyed. However, energy can change from one form to another form.

Law of conservation of energy in case of a simple pendulum :



Motion of simple pendulum

Let us consider a simple pendulum suspended from a rigid support 'O'. Its resting position is 'A'. When it is displaced to one side and then released, it swings from one side to the other, reaching equal distance and equal height on either side. Neglecting the friction between the bob and the surrounding air (i.e., considering the pendulum as an isolated system), the motion of the pendulum can be easily explained by applying the law of conservation of energy as follows :

(1) As the bob of the pendulum swings from A to B, the kinetic energy changes into potential energy and at B (extreme position), its total mechanical energy is the potential energy (no kinetic energy) and so it comes to rest momentarily in this position.

(2) As it swings back from B to A, the potential energy decreases and the kinetic energy increases. At A (resting position), it has the total mechanical energy in the form of kinetic energy and the potential energy is zero.

(3) Again, when it swings from A to C, the kinetic energy decreases and the potential energy increases. The potential energy becomes maximum at C (the other extreme position).

(4) From C to A, the potential energy again changes into kinetic energy. At an intermediate position (between A and B or between A and C), it has both the kinetic energy and potential energy, but the sum of both the energies (i.e., the total mechanical energy) remains constant throughout the swing.

Proof :

Let 'm' be the mass of the bob of a simple pendulum.

Let it is displaced from A to B so that its height from the mean position is 'h'.

$\therefore$ The P.E of the bob at height 'h' = mgh ---------------- (1)

When the bob reaches back the mean position with velocity 'v', then K.E of the bob at mean position (A) = $\frac{1}{2}mv^2$ ------------------- (2)

Now using, $v^2 - u^2 = 2as$,

we get, $v^2 - 0^2 = 2gh$ [$\because$ u = 0 and s = h]

Therefore the above equation can be written as $v^2 = 2gh$ ---------------- [3]

using (3) in (2) we have

$$K.E = \frac{1}{2} m \times 2gh = mgh$$

Thus P.E of the bob of a simple pendulum when raised to height h is equal to the kinetic energy of the bob of pendulum at its mean position. This is the law of conservation of energy.

Transformation of energy: Energy changes happen all around us. The change of energy from one form to another form is called the transformation of energy.

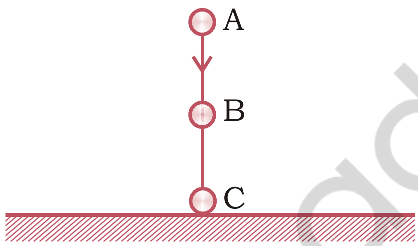
A few more examples of changes of energy are given blow:

DEVICE	ENERGY CHANGE
Electric fan	Electrical energy into mechanical energy
Car batteries	Chemical energy into electrical energy
Cycle dynamo	Mechanical energy into electrical energy
Microphone	Sound energy into electrical energy
Loudspeaker	Electrical energy into sound energy
Solar cell	Light energy into electrical energy
Electric torch	Chemical energy into electrical energy and then into light energy
Electric motor	Electrical energy to mechanical energy

WORK SHEET - 4

Single Answer Type

1. A ball is thrown upwards from a point 'A'. It reaches up to the highest point 'B' and returns then
   1) K.E at 'A' = K.E at 'B' 2) P.E at 'A' = P.E at 'B'
   3) P.E at 'A' = K.E at 'B' 4) P.E at 'B' = K.E at 'A'
2. The potential energy of a body at a height h is mgh. When it falls to the ground, its K.E becomes
   1) 2mgh 2) mgh/2 3) mgh 4) mgh^2
3. A body is dropped from point A as shown in the figure. When it comes to point B, it has



   1) only K.E. 2) only P.E 3) both K.E and P.E 4) none of these
4. A stone of mass 'm' is thrown vertically upwards with a velocity v. The K.E at the highest point is
   1) $\frac{1}{2}mv^2$ 2) zero 3) $2\left(\frac{1}{2}mv^2\right)$ 4) 2 mgh
5. The potential energy of a freely falling object decreases continuously. What happens to the loss of potential energy ?
   1) It is continuously converted into sound energy
   2) It is continuously converted into kinetic energy
   3) It is continuously converted into magnetic energy
   4) none of these

Multi Answer Type

6. Choose the correct statements :
   1) In case of freely falling body and body projected vertically up mechanical energy remains constant
   2) When a body is released from some height on falling through certain distance P.E lost by it is equal to K.E gained by it
   3) When a body is projected vertically up on reaching certain height K.E lost by it is equal to P.E gained by it
   4) When wood is burnt, the chemical energy changes into heat and light energies.

7. Choose the correct statements :
   1) If a stone is thrown up vertically and returns of the ground, its P.E is maximum at the maximum height.
   2) If a stone is thrown up vertically and returns of the ground, its P.E is minimum on the ground.
   3) If a stone is thrown up vertically and returns of the ground, its P.E is maximum on the ground.
   4) If a stone is thrown up vertically and returns of the ground, its P.E is minimum at the maximum height.
8. When a body falls from a certain height
   1) Its P.E gradually changes into kinetic energy
   2) The total sum of both the energies (K.E & P.E) remains the same
   3) Its kinetic energy gradually changes into P.E
   4) The total sum of both the energies (K.E & P.E) does not remains same

Reasoning Answer Type

9. *Statement I :* When an electric drill is used to bore a hole in a wooden block, smoke starts rising.
   Statement II : Mechanical energy converts into heat energy.
   1) Both Statements are true, Statement II is the correct explanation of Statement I.
   2) Both Statements are true, Statement II is not correct explanation of Statement I.
   3) Statement I is true, Statement II is false.
   4) Statement I is false, Statement II is true.

Comprehension Type

P.E =mgh,K.E =$1/2mv^2$

10. A body is moving horizontally at a height of 60m has its P.E equal to K.E. Then velocity of that body is (g = 9.8 m/s^2)
    1) $7ms^{-1}$ 2) $20\sqrt{3}\, m/s$ 3) $3.5ms^{-1}$ 4) $2.8ms^{-1}$
11. A freely falling body acquires a velocity 'v' after losing potential energy x. Then the mass of the body is
    1) x/v^2 2) $2x/v^2$ 3) $2v^2/x$ 4) $x/2v^2$
12. The P.E and K.E of a Helicopter flying horizontally at a height 400m are in the ratio 5 : 2. Then velocity of that helicopter is (g = 9.8 m/s^2)
    1) $56ms^{-1}$ 2) $28ms^{-1}$ 3) $14ms^{-1}$ 4) $35ms^{-1}$

Matrix Matching Type

13.

Column - I	**Column - II**
a) electron revolves in a orbit	1) no energy
b) Bended bow	2) kinetic energy
c) In explosive devices Inter conversion of chemical energy changes to	3) potential energy
d) Freely suspended mass less spring	4) Heat energy
	5) sound energy

Integer Answer Type

14. A body is moving horizontally at a height of 10m has its P.E equal to K.E. Then velocity of that body is ($g = 9.8\ m/s^2$)__________m/s

Subjective Answer Type

15. A body of mass 1kg is projected vertically up with K.E equal to 196J. The height at which its K.E is equal to its P.E is ($g = 9.8\ m/s^2$)

SYNOPSIS - 5

Power :

It is usually said that a machine is more powerful than a man. This means a machine can do more work than a man. Moreover, a machine can do the same work in less time than a man. Thus, power depends not only on the work done but also on the time taken to do it.

Definition: Power is defined as the rate of doing work.

i.e., $$P = \frac{\text{Workdone}}{\text{Time taken}} = \frac{W}{t}$$

Note:

i) Power may also be defined as the amount of work done in one unit of time.

ii) Power is a scalar quantity.

Thus, power depends on two factors (i) the amount of work done, and (ii) the time taken.

1. When a body takes lesser time to do a particular amount of work, its power is said to be greater and vice versa, i.e., $P \propto \frac{1}{t}$ [for the same amount of work].

2. When a body does more amount of work in a particular time, its power is said to be greater and vice versa, i.e., $P \propto W$ [for a constant time]

Power in terms of force (F) and velocity (v) :

$$P = \frac{\text{Workdone}}{\text{Time taken}} = \frac{W}{t} = \frac{F \times S}{t} = F \times \left(\frac{S}{t}\right) = F \times v$$

Power = Force × velocity.

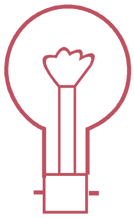
$\therefore$ Power can also be defined as the product of force and velocity.

Unit of Power:

1. S.I unit of power $= \frac{\text{Workdone}}{\text{time taken}} = \frac{\text{joule}}{\text{second}} = Js^{-1} = \text{watt(W)}$

$$\therefore\ 1\text{ watt} = 1Js^{-1}$$

2. C.G.S unit of power $= \dfrac{\text{Work done}}{\text{time taken}} = \dfrac{\text{erg}}{\text{second}} = \text{erg s}^{-1}$.



60W

Electrical power is measured in watt (W)

Note : In case of power of an electric bulb we use, Power $= \dfrac{\text{energy consumed}}{\text{time taken}}$

Relationship between the S.I unit and C.G.S unit of power :

$1\text{W} = 1\text{Js}^{-1} = 10^7 \text{ erg s}^{-1}$

Practical Unit of Power :

The unit of power in the British engineering system is horse power, denoted by 'hp'.

The power of machines (like engine of a scooter or a car or a bus) is usually expressed in horse power (hp). So the practical unit of power is horse power (hp).

1horse power (hp) = 746watt = 746Js^{-1} = 0.746 kW

Commercial Unit of Energy :

We know, the S.I unit of electrical energy is joule and we know that "A joule is the amount of electrical energy consumed where an appliance of 1watt power is used for one second".

Actually, joule represents a very small quantity of energy and, therefore, it is inconvenient to use where a large quantity of energy is involved.

So, for commercial purposes we use a bigger unit of electrical energy which is called "kilowatt - hour".

Kilowatt-hour is usually used as a commercial unit of electrical energy. One kilowatt-hour is the amount of electrical energy consumed when an electrical appliance having a power rating of 1kilowatt is used for 1 hour.

Since a kilowatt means 1000 watts, so we can also say that one kilowatt - hour is the amount of electrical energy consumed when an electrical appliance of 1000 watts is used for 1 hour.

Note : (i) Kilowatt is the unit of power whereas Kilowatt hour is the commercial unit of electrical energy.

(ii) *Electric energy consumed in kWh = power in kW × time in hrs*

Relation between Kilowatt hour and Joule:

1 kWh = 1 kilowatt × 1 hour

= 1000 watt × 1 hour

=1000 watt × 3600 second

= 36×10^5 watt second or 1 kWh = 36×10^5 J

$$\left[\because 1 \text{ watt} = \frac{1 \text{ Joule}}{1 \text{ second}} \Rightarrow 1 \text{ watt second} = \text{joule}\right]$$

= 3.6×10^6 J = 3.6 MJ [1 MJ = 10^6 J]

Therefore, 1kilowatt hour is equal to 3.6×10^6 joules of electrical energy.

Note:

1. 1 watt or kilowatt is the unit of electrical power but kilowatt hour is the unit of electrical energy.
   [1 watt-hour (Wh) = 1 watt × 1 hour = 1 Js^{-1} × 3600s = 3600J = 3.6×10^3 J]
2. The electrical energy used in homes, shops and industries is measured in kilowatt-hour(k Wh).

*3. 1 kilowatt-hour (or 1kWh) of electrical energy is commonly known as '1 unit' of electricity.

WORK SHEET - 5

Single Answer Type

1. power of an electric bulb

   1) $\dfrac{\text{time taken}}{\text{energy consumed}}$ 2) $\dfrac{\text{energy consumed}}{\text{time taken}}$

   3) energy consumed × time taken 4)none of these

2. Power is equal to

   1) Force × velocity 2)Force × acceleration

   3) velocity× acceleration 4)Force ×time

3. Power is measured in

   1) joule 2)newton 3)horse power 4)metre per second

4. A vehicle of mass 200 Kg is driven with a constant acceleration 2 ms^{-2} along a straight level road against a constant resistance 50 N. When the velocity of the vehicle is 10 ms^{-1}.Power of the engine is

   1) 7.5 KW 2) 4.5 KW 3) 6.5 KW 4) 5.5 KW

5. An energy of 4 kJ causes a displacement of 64 m in 2.5 s.The power delivered is

   1)16 W 2) 160 W 3) 1600 W 4)16000 W

6. Choose the correct statements :

   1) 1horse power = 746watt

   2) 1Watt = 10^7 erg s^{-1}

   3) Electric energy consumed in kWh = power in kW × time in hrs

   4) 1Watt = 10^9 erg s^{-1}

Reasoning Answer Type

7. *Statement I :* A joule is the amount of electrical energy consumed where an appliance of 1watt power is used for one second

   Statement II : Kilowatt is the unit of power whereas Kilowatt hour is the commercial unit of electrical energy

   1) Both Statements are true, Statement II is the correct explanation of Statement I.

   2) Both Statements are true, Statement II is not correct explanation of Statement I.

   3) Statement I is true, Statement II is false.

   4) Statement I is false, Statement II is true.

Comprehension Type

Power in terms of force (F) and velocity (v)

$$P = \frac{\text{Workdone}}{\text{Time taken}} = \frac{w}{t} = \frac{F \times s}{t} = F \times \left(\frac{s}{t}\right) = F \times v$$

8. A man does 200 J of work in 10 seconds and a boy does 100 J of work in 4 seconds. Who is delivering more power?
   1) man 2) boy
   3) Both are delivering same power 4) can't say
9. A person A does 500 J of work in 10 minutes and another person B does 600 J of work in 20 minutes. Let the power delivered by A and B be P_1 and P_2 respectively. Then,
   1) $P_1 = P_2$ 2) $P_1 > P_2$ 3) $P_1 < P_2$ 4) P_1 and P_2 are undefined
10. Time taken to perform 440 J of work at a rate of 11 W is
   1) 30 s 2)40 s 3) 50 s 4) 60 s

Matrix Matching Type

11.

Column - I	**Column - II**
a) Kilo - Watt	1) 10^3 W
b) Mega-watt	2) 10^6 W
c) Giga-watt	3) 10^9 W
d) C.G.S Unit of power	4) 1 g cm^2s^{-3}
	5) 1 erg/second

Integer Answer Type

12. 1 kWh = __________ × 10^5 J

Subjective Answer Type

13. A boy of mass 55 kg, runs up a flight of 40 stairs, each measusring 0.15 m in 15 s. the power developed by the boy in kilowatts and Horse power

14. A girl of mass 50 kg, climbs a flight of 100 stairs each measuring 0.25 m in height, in 20 s. the power in Watts and Horse power is

WORK SHEET – 1 (KEY)				
1) 3	**2)** 3	**3)** 4	**4)** 1	**5)** 3
6) 1,3	**7)** 1,3	**8)** 1,2,3,4	**9)** 2	**10)** 3
11) 1	**12)** 2	**13)** (1,2), 5,4,3	**14)** 1	

10. W = 2500 J, h = 5 m,
 $g = 10\ m/s^2$ m = ?
 we know W = mgh = 50 kg

11. m = 100 kg, h = 10 m, W = ?
 work done against gravity
 W = mgh = 100 × 9.8 × 10 J = 9800 J

12. m = 15 kg, h = 2.0 m
 $g = 9.8\ m/s^2$, W = ?
 W = mgh = 15 × 9.8 × 2.0 = 294 J

14. work done = Force × displacement
 = 5 N × 0.2 m = 1 J

15. Mass of the person = 50 kg
 Height of tower be climbs = 72 m
 Work done = ?
 Work done = m × g × h = 50 × 9.8 × 72 = 35280 J

WORK SHEET – 2 (KEY)				
1) 4	**2)** 3	**3)** 3	**4)** 1	**5)** 2
6) 1,2	**7)** 1,2,3,4	**8)** 1,2,3,4	**9)** 2	**10)** 1
11) 3	**12)** 1	**13)** 3,2, (1,2,3, 4), 4	**14)** 4	

3. Potential energy is increased by mgh, Thus
 mgh = 1 J

(1 kg) × (9.8 m/s²) × h = 1 J

$$h = \frac{1J}{(1kg)\times(9.8m/s^2)} = 0.102\,m$$

14. Kinetic energy $= \frac{1}{2}\times 200\times(20)^2 = 40,000 erg$

WORK SHEET – 3 (KEY)				
1) 3	**2)** 1	**3)** 3	**4)** 3	**5)** 1,2
6) 1,2,3,4	**7)** 1,2	**8)** 4	**9)** 1	**10)** 3
11) 3	**12)** 1,2,3,(4,5)			

4. $\frac{K_1}{K_2} = \frac{2}{1}$

$\frac{P_1}{P_2} = \frac{2}{1}$

$\frac{K_1}{K_2} = \frac{P_1^2}{2m_1}\times\frac{2m_2}{P_2^2}$

$\frac{2}{1} = \frac{m_2}{4m_1} \Rightarrow \frac{m_2}{m_1} = \frac{8}{1}$

13. $K.E = \frac{P^2}{2m} = \frac{144}{2\times 4} = 18J$

14. ratio of masses of two bodies = 3 : 1
Ratio of K.E. of bodies = 1 : 3
Ratio of veaclcocities = $V_1 : V_2$ = ?

We know, $K.E. = \frac{1}{2}\times m\times V^2$

$K.E_1 = \frac{1}{2}\times m_1\times V_1^2$

$K.E_2 = \frac{1}{2}\times m_2\times V_2^2$

$$\frac{K.E_1}{K.E_2} = \frac{1}{3} \quad \text{and} \quad \frac{m_1}{m_2} = \frac{3}{1}$$

WORK SHEET – 4 (KEY)				
1) 4	**2)** 3	**3)** 3	**4)** 2	**5)** 2
6) 1,2,3,4	**7)** 1,2	**8)** 1,2	**9)**	**10)** 1,2,3,4
11) 2	**12)** 1	**13)** (2,3), 3, (4,5), 1	**14)** 14	

10. $\frac{1}{2} \times mV^2 = mgh$

$$V = \sqrt{2 \times 10 \times 60} = \sqrt{1200} = 20\sqrt{3}$$

11. $\frac{1}{2} \times mV^2 = mgh$

$$\frac{1}{2} mV^2 = x$$

$$m = \frac{2x}{V^2}$$

12. $\frac{mgh}{\frac{1}{2} mV^2} = \frac{5}{2}$

$$\frac{2gh}{V^2} = \frac{5}{2} \Rightarrow V^2 = \frac{4gh}{5} = \frac{4 \times 9.8 \times 400}{5} = 56m/s$$

14. $\frac{1}{2} mV^2 = m \times g \times h$

$$V^2 = 2gh \Rightarrow V = \sqrt{2gh} \Rightarrow v = \sqrt{2 \times 9.8 \times 10} = 14$$

15. Mass of the body = 1 Kg
Kinetic energy of the body = 196 J
Height at which K.E. = P.E = ?

$$\frac{1}{2}\times m\times V^2 = m\times g\times h$$

196 J = 1 ×9.8 5h

$$h=\frac{196}{9.8}=20m$$

WORK SHEET – 5 (KEY)

1) 2	**2)** 1	**3)** 3	**4)** 2	**5)** 3
6) 1,2,3	**7)** 2	**8)** 2	**9)** 2	**10)** 2
11) 1,2,3,(4,5)	**12)** 36			

5. $\text{Power}=\frac{\text{Work}}{\text{time}}=\frac{4000J}{2.5}=1600W$

13. $\text{Power}=\frac{\text{Work}}{\text{time}}=\frac{F\times S}{\text{time}}=\frac{550N\times 40\times 0.15m}{15\,\text{seconds}}=220W$

$\text{Power in Hp}=\frac{220}{750}=0.29Hp$ and $\text{Power in KW}=\frac{220}{1000}=0.22KW$

14. $\text{Power}=\frac{\text{work}}{\text{time}}=\frac{F\times S}{\text{time}}=\frac{500N\times 100\times 0.25m}{20\,s}=625\,W$

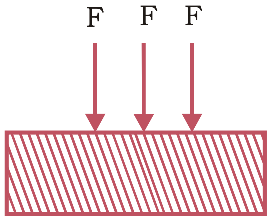
$\text{Power in Hp}=\frac{625}{750}=0.83\,Hp$

FLUID PRESSURE

SYNOPSIS - 1

Thrust :

When a body is placed on a surface, the weight of the body acts downward and the force exerted by the body on the surface is equal to the weight of the body. **The total force exerted by the body perpendicular to the surface is known as thrust.**



Example : Consider a rectangular block of mass 2 kg lying on the ground. The thrust on the surface of the ground due the block

= weight of the block

= mg

= 2 kg × 9.8 ms^{-2}

= 19.6 kg ms^{-2}

= 19.6 N

Units of thrust : Since thrust is a type of force its units are same as that of the force.

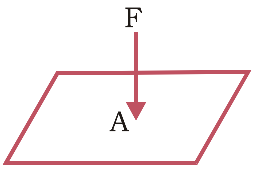
S.I. unit of thrust = newton (N)

C.G.S. unit of thrust = dyne

Pressure: Thrust acting over a unit area of the surface is called pressure.

(or)

Normal force acting per unit area of the surface is called the pressure.



Pressure

Mathematically, $\text{Pressure} = \dfrac{\text{normal force (or Thrust)}}{\text{Area}}$

If P is the pressure, F is the force (perpendicular) and A is the area of contact, then

$$P = \frac{F}{A}$$

Note :

(i) Pressure is directly proportional to the thrust i.e., the more the thrust, the move is the pressure. (provided area is same)

(ii) Pressure is inversely proportional to the area of cross-section i.e., the less the area of cross section, the more is the pressure. (provided thrust is same)

(iii) Pressure is a scalar quantity.

Units of pressure :

As $$P = \frac{F}{A}$$

So in S.I system the unit of pressure = $\frac{N}{m^2}$ or pascal

In C.G.S system the unit of pressure = $\frac{dyne}{cm^2}$

Note : (1) N/m^2 is called pascal in honour of French physicist blaise pascal.

Other unit of pressure:

1. other unit of pressure is bar or atmosphere
   1 bar = 10^5 N/m^2 = 10^5 pascals = 10^5 Pa
2. 1millibar = 10^2 N/m^2 = 10^2 Pa

2. **Applications of pressure :**

1) Animals like camels walk easily in deserts as compared to horses or donkeys because they have broad feet. Broad feet exert less pressure on sandy ground.

2) A heavy truck is fitted with six to eight wheels. This increases the area of contact on which their weight acts and hence reduces their pressure on the ground.

3) The skiers use flat and long skies to slide on the snow because the larger the area of cross-section, the less is the pressure on the snow.

Hence, a skier can easily slide over snow without sinking his feet in the ground.

It is for the same reason that sledges are never provided with wheels because the wheels increase pressure on snow.

4) The cutting edge of knives, blades and axes are sharpened. As the cutting edge is sharpened, the area of contact decreases and hence pressure exerted by it increases. Thus, they can easily penetrate a given surface.

5) Foundations of high-rise buildings are kept wide so that they exert less pressure on the ground and do not sink in due to the extremely high pressure of the building.

1. Mathematically Pressure = $\frac{\text{Thrust}}{\text{Area}}$

2. Pressure $\propto$ Thrust (provided area is same)

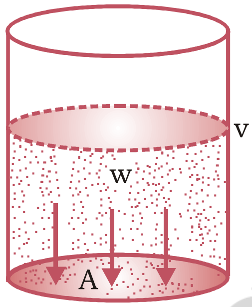
3. Pressure $\propto \frac{1}{\text{Area}}$ (provided thrust is same)

Pressure in fluids :

Fluid : A substance which can flow from one point to another is called fluid. Since liquids and gases can flow, so they are known as fluids.

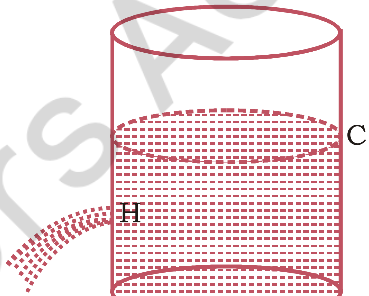
A fluid exerts three types of pressure 1) Downward pressure
2) Upward pressure
3) Lateral pressure

1. Consider a vessel (V) containing some water of weight (W), say 500 gm. wt. Let the area of its base (A) be 100 cm^2. Then the weight of water (W) is the thrust acting on the base of area 100 cm^2. This shows that liquids exert downward pressure.



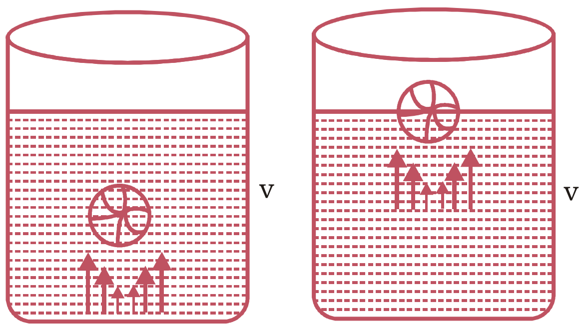
Downward pressure of water

2. Take a long cylindrical vessel containing water and punch a hole (H) on its wall as shown in the above figure. The water comes out with a speed and falls at distance. This proves that liquid has lateral pressure.



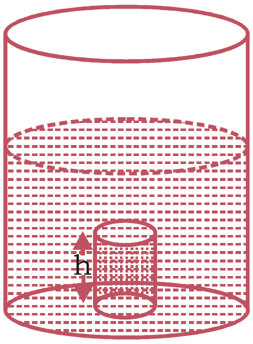
Lateral pressure of water

3. Take a foot ball and immerse it in water in a vessel (V) and leave it. The ball immediately comes up and floats on water. This shows that water (or fluid) exerts pressure in the upward direction.



Upward pressure action on football immersed in water

Mathematical expression for pressure in fluids :



Consider a beaker filled with a liquid of density d. Now imagine a cylindrical column of the liquid of height h and cross-sectional area A.

The force acting on the base of this imaginary cylindrical column of liquid is equal to the weight of the liquid contained in this column of liquid.

i.e., F = weight of liquid in cylindrical column of liquid F = mg ---------------- (1)

Now, mass of liquid in the cylinder column of liquid.

m = volume of cylindrical column × density of liquid

= Area of cross section × length of cylindrical column × density of liquid

$$m = A\,h\,d$$

$\therefore$ weight of liquid in cylindrical column of liquid = mg = Ah d g

Putting this value in equation (1) we get F = Ah d g

$\therefore$ pressure exerted by liquid at depth 'h' $P = \dfrac{F}{A} = \dfrac{Ah\,d\,g}{A} \Rightarrow p = h\,d\,g$

Laws of liquid pressure :

Following are the laws of liquid pressure :

1) Pressure at a point inside the liquid increases with the depth from the free surface of the liquid.

2) Pressure at a point inside the liquid at a given depth increases with the increase in the increase in the density of the liquid

3) Pressure is same in all directions, about a given point within the liquid.

4) Pressure is same at all points in a horizontal plane at a given depth in a stationary liquid.

5) A liquid seeks its own level.

WORK SHEET - 1

Single Answer Type

1. The ratio of the C.G.S unit of pressure to the S.I unit of pressure is
   1) 10 2) 0.1 3) 5 4) 15
2. A force of 16N acts on an area of 50 cm^2. What is the pressure in pascal?
   1) 3200 Pa 2) 4200 Pa 3) 5200 Pa 4) 2200 Pa
3. With the increase in the weight of an object the pressure
   1) increases 2) decreases 3) is not affected 4) none of these
4. With the increase in the area of contact of an object the pressure
   (Note : Thrust remains same)
   1) increases 2) decreases 3) is not affected 4) none of these
5. Pressure exerted by a body on a surface is
   1) thrust × area 2) thrust ÷ area
   3) area ÷ thrust 4) thrust ÷ volume

Multi Answer Type

6. Choose the correct statements :
   1) One pascal is the pressure generated by force of 1N on 1 m^2 area .
   2)The S.I. unit of thrust is newton
   3)1 pascal is equal to 1 N/m^2.
   4)Pressure is dirctly proportional to force applied.
7. The physical quantities having the same units are
   1) thrust 2) weight 3) acceleration 4)velocity

Reasoning Answer Type

8. *Statement I :* Animals like camels walk easily in deserts as broad feet exert less pressure on sandy ground.
   Statement II : Foundations of high rise buildings are kept very wide so that they do not sink under the extremely high pressure of buildings.
   1) Both Statements are true, Statement - II is the correct explanation of Statement-I
   2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
   3) Statement - I is true, Statement - II is false.
   4) Statement - I is false, Statement - II is true.

Comprehension Type

The pressure inside a liquid of density d at a depth 'h' below its surface is hdg

9. Liquid pressure at a point in a liquid does not depend on
   1) density of liquid
   2) shape of the vessel in which the liquid is kept
   3) depth of the point from the surface
   4) acceleration due to gravity

10. Pressure at any point inside a liquid is
 1) directly proportional to density of the liquid
 2) inversely proportional to density of the liquid
 3) directly proportional to square root of density of the liquid
 4) inversely proportional to square of density of liquid
11. As the depth of a liquid increases, the pressure of liquid
 1) decreases 2) increases 3) remains same 4) none of these

Matrix Matching Type

12.

Column-I	Column-II
a) S.I system the unit of pressure	1) 10^5 Pa
b) C.G.S system the unit of pressure	2) $\frac{N}{m^2}$
c) 1 bar	3) $\frac{dyne}{cm^2}$
d) 1millibar	4) 10^2 N/m^2
	5) 10^2 Pa

Integer Answer Type

13. The ratio of the S.I unit of pressure to the C.G.S unit of pressure is_________

Subjective Answer Type

14. What is the magnitude of force required in newton's to produce a pressure of 27500 Pa on an area of 200 cm^2 ?
 1) 650 N 2) 750 N 3) 550 N 4) 450 N

15. How much the hydrostatic pressure exerted by water at the bottom of a beaker? Take the depth of water as 45 cm. (density of water 10^3 kg/m^3)

 Note : Pressure exerted by a standing liquid due to its weight is called hydrostatic pressure.
 1) 4410 Pa 2) 4420 Pa 3) 4430 Pa 4) 4440 Pa

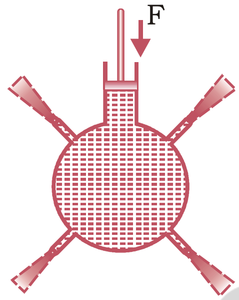
SYNOPSIS - 2

Transmission of pressure in liquids : (PASCAL'S LAW)

This law is also known as " **the principle of transmission of fluid-pressure**."

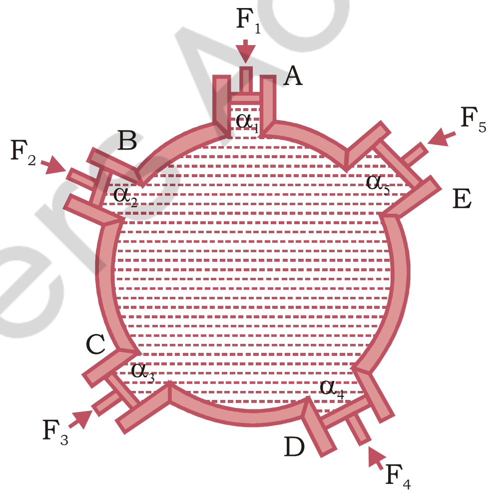
This law states that " **The pressure exerted at any point in an enclosed and incompressible liquid is transmitted equally in all direction."**

Example : Take a round bottom flask with a number of narrow openings on its sides, provided with an air-tight piston in its mouth. Fill it to the brim with water. Now push the piston down. Water will come out in jets with equal force from all the openings. This shows that the pressure exerted at one point is transmitted equally in all directions.



Transmission of pressure in a liquid

Explanation: Consider a vessel full of water and filled with air tight piston in different positions as shown in the diagram.



Equal transmission of pressure

Let the piston at A be pushed down with a force F_1. Pressure P on the piston is

$$P = \frac{F_1}{a_1}$$

Where 'a_1' is the area of cross-section of piston at A. It will be observed that to hold pistons at B, C, D and E we have to apply forces F_2, F_3, F_4 and F_5 on them such that

$$\frac{F_1}{a_1}=\frac{F_2}{a_2}=\frac{F_3}{a_3}=\frac{F_4}{a_4}=\frac{F_5}{a_5}$$

where a_2, a_3, a_4 and a_5 are the areas of cross-section of pistons at B, C, D and E respectively. This indicates that pressure is transmitted equally in all directions as stated by Pascal's law.

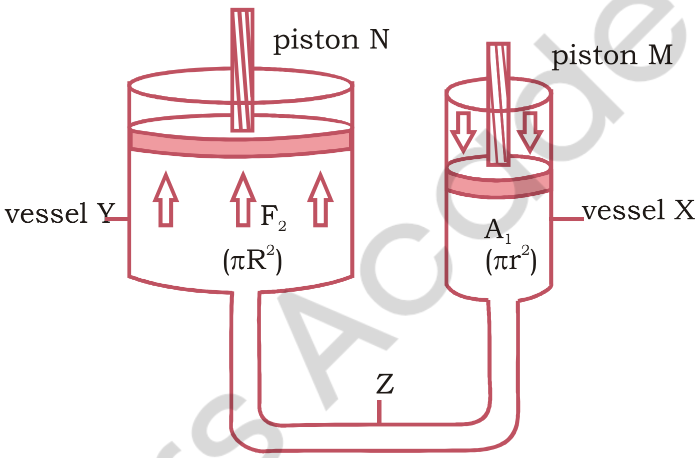
Application of Pascal's law :

Pascal's law is used to multiply force in machines such as the hydraulic press or Bramah press, hydraulic lift and hydraulic brake.

Principle of a Hydraulic machine : (Hydraulic press or Bramah press)

Hydraulic press works on the principle of Pascal's law.

Construction : It consists of two cylindrical vessels X and Y of different cross sections. Let the cross sectional area of X be 'A_1' and that Y be 'A_2'



Principle of a hydraulic machine

The vessels contain a liquid. The vessel X is provided with water tight piston M. The vessel X has smaller diameter than vessel Y. The vessel Y is provided with watertight piston N. r and R are the radii of vessel X and vessel Y respectively. Let the area of cross-section of vessel X with a smaller diameter be A_1 and that of vessel Y be A_2. So $A_2 > A_1$.

A weight is placed on piston M of the vessel X. It exerts a force F_1 on the piston M. Therefore, the pressure applied on piston M in the downward direction is $\frac{F_1}{A_1}$.

According to Pascal's law, the pressure exerted on the piston M is transmitted by the liquid to the piston N.

$\therefore$ The upward pressure exerted on the piston N is $\frac{F_1}{A_1}$.

Hence, the upward force (F_2) exerted on piston N is

F_2 = Pressure on the piston N × Area [Since force = pressure × area]

$$F_2 = \frac{F_1}{A_1} \times A_2 \quad \text{or} \quad \frac{F_2}{F_1} = \frac{A_2}{A_1}$$

Since $A_2 > A_1$ therefore $F_2 > F_1$

Thus a small force F_1 applied on the smaller piston M can be used to exert a large force F_2 on the bigger piston N. This is the principle of a hydraulic machine.

Note: Applying the principle of hydraulic machines, we get :

$$\text{Mechanical advantage} = MA = \frac{\text{Load}}{\text{Effort}}$$

$$= \frac{\text{Area of larger piston}}{\text{Area of smaller piston}} = \frac{\pi R^2}{\pi r^2} = \frac{R^2}{r^2}$$

$$MA = \frac{(\text{Radius of larger piston})^2}{(\text{Radius of smaller piston})^2}$$

Note :

i) Larger piston is generally referred as press plunger

ii) Smaller piston is referred as pump plunger

Uses of hydraulic press :

1. It is used for compressing the cotton bales and straw.
2. It is used for extracting oil from oil seeds.
3. It is used for punching holes in metals.
4. It is used for giving specific shapes to metal sheets.
5. It is used for servicing automobiles in service stations.

Atmospheric pressure :

The whole Earth is surrounded by a blanket of air known as the atmosphere. The atmosphere extends up to a height of about 1600 km. The weight of all the layers of air exerts a force on the surface of the Earth. The force exerted on unit area of the Earth's surface due to the atmosphere is called atmospheric pressure.

Standard atmospheric pressure :

The normal or the standard pressure is the average pressure of the atmosphere at sea level at 273 K and is expressed as a pressure of one atmosphere (1 atm).

It is found that 1 atm pressure can balance a column of mercury 0.76 m high. Thus the normal or standard pressure is 0.76 m Hg.

We are not aware of this because the blood in our body exerts a pressure which is slightly greater than the atmospheric pressure.

we can express it in pascal as :

0.76m Hg pressure $= 0.76 \times 13600 \times 9.8 = 10^5$ Pa (approximately)

(since density of mercury = 13600kgm^{-3} and g = 9.8ms^{-2})

Thus **1 atm = 0.76 m Hg = 10^5 Pa**

Note : If the atmospheric pressure (P_0) acting on the free surface of liquid is also taken into account then total pressure in a liquid at a depth h = Atomospheric pressure + pressure due to liquid column = P_0 + hdg

Measurement of atmospheric pressure :

The instrument used to measure the atmospheric pressure is called Barometer. It was constructed by Torricelli in 1643.

Construction of simple Barometer :

It consists of a glass tube with a narrow uniform bore and of length 100 cm. It is closed at one end. The tube is carefully filled with perfectly pure and dry mercury so that no air bubbles are left inside the tube.

Thumb is placed tightly on the open end of the tube and then it is inverted in a bowl containing mercury.

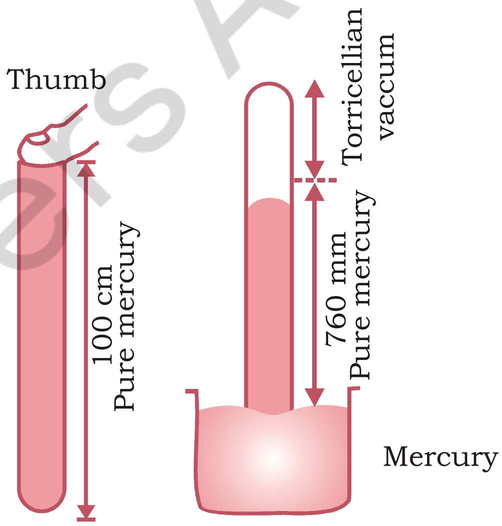
The thumb is removed from the open end, under the surface of mercury in the bowl.

It is observed that some mercury flows down, thereby creating an empty space which is commonly called Torricellian vacuum.

It is found that at the sea level, the vertical height of mercury supported in the tube is 76 cm above the mercury level in the bowl.

When an equilibrium is established, we can say that pressure exerted by 76cm vertical height of mercury column is equal to the pressure exerted by the air column at the surface of mercury in the bowl.

In other words, the air exerts as much pressure as is exerted by 76 cm of vertical height of mercury column.



Simple Barometer

WORK SHEET - 2

Single Answer Type

1. The liquid used in Barometer is
   1) mercury 2) kerosene 3) water 4) alcohol
2. Standard atmospheric pressure is
   1) 76 × 13.6 × 980 cm of mercury column 2) 76 dyne cm^{-2}
   3) 76 × 13.6 cm of water column 4) 76 × 980 dyne cm^{-2}
3. The column of mercury in a barometer is 76 cm Hg. Calculate the atmospheric pressure if the density of mercury = 13600 kgm^{-3}. (Take g = 10 ms^{-2})
   1) 1.03×10^5 Pa 2) 1.03×10^3 Pa 3) 1.03×10^4 Pa 4) 1.03×10^6 Pa
4. The value of atmospheric pressure on the surface of earth at sea level is nearly Take density of mercury = 13600 kg/m^3, density of water = 1000 kg /m^3
   1) 10^5 Pa 2) 10^3 Pa 3) 10^1 Pa 4) 10^4 Pa
5. If the atmospheric pressure (P_0) acting on the free surface of liquid is also taken into account the total pressure in a liquid at a deoth 'h' is
   1) Atmospheric pressure + pressure due to liquid column
   2) Atmospheric pressure – pressure due to liquid column
   3) Atmospheric pressure × pressure due to liquid column
   4) Atmospheric pressure / pressure due to liquid column

Multi Answer Type

6. A force of 400 N acts on an area of 0.04m^2 then the pressure exerted is
   1) 1 pacsal 2) 10^4 pascal 3) $10^5 \frac{dyne}{cm^2}$ 4) $10^4 \frac{N}{m^2}$
7. If a water of height 10m is taken on a glass tube of height 20m then(density of water is 10^3kg/m^3) (Take g = 10 m/s^2)
   1) The pressure at the bottom of glass tube due to liquid column is 2 atm
   2) The pressure at the bottom of glass tube due to liquid column is 1 atm
   3) The total pressure at the bottom of glass tube (due to liquid and atmosphere) is 3 atm
   4) The total pressure at the bottom of glass tube (due to liquid and atmosphere) is 2 atm
8. Hydraullic pressure can be used
   1) For servicing automobiles in serivce stations
   2) For extracting oil from oil seeds
   3) For punching holes in mtels
   4) For giving specific shapes to metal sheets

Reasoning Answer Type

9. *Statement I :* A small force applied on the smaller piston can be used to exert a large force on the bigger piston. This is the principle of hydraulic machine.
Statement II : The pressure exerted at any point in an enclosed and incompressible liquid is transmitted unequally in all directions.
1) Both Statements are true, Statement - II is the correct explanation of Statement-I
2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
3) Statement - I is true, Statement - II is false.
4) Statement - I is false, Statement - II is true.

Matrix Matching Type

10.

Column-I	Column-II
a) Density of mercury	1) 10^5 pa
b) 1 atm is equal to	2) 1 $gfcm^{-2}$
c) Average atmospheric pressure on earth's surface in C.G.S system	3) 13.6 g/cm^3
d) Atmospheric pressure at 0°C at sea level	4) 13600 kgm^{-3}
	5) 0.76 m of mercury

Integer Answer Type

11. A liquid of density 12 kg/m^3 exerts a pressure of 600 Pa at a point inside a liquid. Height of liquid column above that point is ________ m[g = 10 m/s^2]

Subjective Answer Type

12. If the mercury in the barometer is replaced by water, what will be the resulting height of the water column ?
Density of water = 1000 kgm^{-3} density of mercury = 13600 kgm^{-3}

SYNOPSIS - 3

Buoyant Force

When an object is immersed in a liquid, it experiences an upward force. This force is called buoyant force. Thus, the upward force acting on an object immmersed in a liquid is called buoyant force.

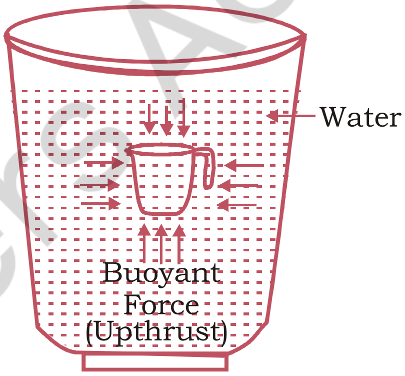
It is due to the upward 'buoyant force' exerted by a liquid that the weight of an object appears to be less in the liquid than its actual weight in air. The upward force exerted by a liquid is also known as 'upthrust'. In other words, the buoyant force is also known as upthrust

Cause of Buoyant Force

In oder to understand why liquids exert an upward buoyant force, let us consider a mug filled with water immersed in a bucket containing water as shown in Figure. Water exerts force on the sides of the mug as well as on its top and bottom (shown by arrows).

The sideways forces exerted by water on the mug, being equal and opposite, cancel out. Now, there is a force of water acting on the top of the mug (which acts in the downward direction), and a force of water acting on the bottom of the mug (which acts in the upward direction).

We know that the pressure exerted by a liquid increases with depth and acts in all directions (even upwards). Now, as the top A of the mug is at a lower depth in water, it experiences less force downwards.



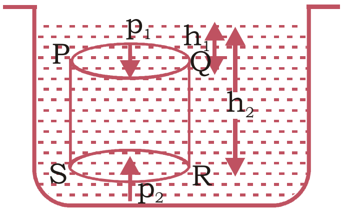
Cause of buoyant force

The bottom B of the mug is at a greater depth in water, so it experiences more force in the upward direction. Thus, there is a net force on the mug in the upward direction. The net upward force on the mug is equal to the difference in the upward force acting on its bottom and the downward force acting on its top. This net upward force acting on the mug is the buoyant force (which reduces the effective weight of mug and makes it feel lighter).

From this discussion we conclude that: As we lower an object into a liquid, the greater upward pressure of liquid underneath it provides an upward force called the buoyant force (or upthrust).

Mathematical expression for Upthrust or Buoyant force:

Let us consider a cylinderical body PQRS of cross-sectional area A immersed in a liquid of density d. Let the upper surface PQ of the body be at a depth h_1, below the free surface of liquid, and the lower surface RS of the body be at a depth h_2 below the free surface of liquid.



At depth h_1 pressure on the upper surface PQ is $p_1 = h_1dg$

$\therefore$ Downward thrust on the upper surface PQ is

F_1 = pressure × area = h_1 dg × A = h_1 dgA ....(1)

At depth h_2, pressure on the lower surface RS is $P_2 = h_2$ d g

$\therefore$ Upward thrust on the lower surface RS is $F_2 = H_2$ dg A ....(2)

From above equations(1) and (2) it is clear that $F_2 > F_1$ because $h_2 > h_1$ and therefore, the cylinder will experience a net upward force.

$\therefore$ Resultant upward thrust (or buoyant force) on the body is

$F_B = F_2 - F_1$ = dgA – h_1 dgA = A($h_2 - h_1$) dg

But A ($h_2 - h_1$) = V, the volume of cylinder, $\therefore$ upthrust F_B = V dg

But Vdg = Volume of solid immersed × density of liquid × acceleration due to gravity

= Volume of liquid displaced × density of liquid × acceleration due to gravity

= mass of liquid displaced × accleration due to gravity

= weight of the liquid displaced by the immersed part of the body

Thus upthrust is defined as the weight of the liquid displaced by the immersed part of the body.

Factors Affecting Bouyant Force:

The magnitude of buoyant force acting on an object immersed in a liquid depends on two factors:

(i) volume of object immersed in the ;liquid, and

(ii) density of the liquid.

Let us discuss these two factors in somewhat detail, one by one.

Introduction to Archimedes' Principle:

We know, when a body or an object is immersed (partially or completely) in a fluid. It experiences an upthrust or buoyant force. A Greek scientist Archimedes' conducted many experiments and concluded that, the upthrust or buoyant force is equal to the weight of the fluid displaced by the body.

Before we go further and study Archimedes' principle, we should know the meaning of the term displaced liquid.

Displaced liquid:

Suppose we have a bucket filled with water upto the brim. Now, if we immerse an object into this bucket full of water, then the object will occupy some of the volume in the bucket which was earlier occupied by water. Due to this the object will 'push out' some of the water from the bucket. This 'pushed out water' is the 'displaced water'.

So we can now say that when an object is immersed in a bucket filled with water, it displaces some of the water which overflows from the bucket.

And when an object is completely immersed in water, then the volume of water displaced will be equal to the volume of the object itself.

Statement of Archimedes' Principle:

When an object is wholly (or partially) immersed in a liquid, it experiences a buoyant force (or upthurst) which is equal to the weight of liquid displaced by the immersed part of the object.

In other words,

loss of weight or Buoyant force = Wt. of fluid displaced by the immersed part of the body.

Important conclusion:

i) According to Archimedes' principle,

Buoyant force = Weight of the displaced liquid

or $V_1\rho g = V_2\rho g$

where, V_1 = volume of the immersed body

ρ = Density of the liquid

g = Acceleration due to gravity

V_2 = Volume of the displaced liquid or $V_1 = V_2$

i.e., when a body is completely immersed in a liquid, then it displaces volume of the liquid equal to its own volume.

ii) loss of weight = weight in air – weight in liquid

iii) Apparent weight (i.e., weight of body in liquid) = Real weight – Buoyant force.

Application of Archimede's Principle:

(a) **Determination of Relative Density or Specific gravity of a Solid:**

According to Archimedes principle, apparent loss of weight of a substance immersed in a liquid is equal to weight of displaced liquid . This principle can be utilised to determine the relative density of a solid substance (that does not dissolve in water).

We know, relative density of a substance

$$= \frac{\text{mass of any volume of substance in air}}{\text{mass of water of an equal volume}}$$

Since weight of a body is proportional to mass,

$$\text{Relative density of a substance} = \frac{\text{weight of any volume of substance in air}}{\text{Apparent loss of weight of body in water}}$$

The weight of the given substance is determined by a spring balance accurately (W_1). Then the body is completely immersed in water in a beaker without touching the sides and its weight in water W_2 is determined. Then relative density of a substance $= \dfrac{W_1}{W_1 - W_2}$

i.e., Relative density(R.D) of a solid

$$= \frac{\text{Weight of solid in air}}{\text{loss of weight of solid in water}} = \frac{W_{air}}{W_{air} - W_{water}}$$

(b) **Determine of Relative density (or R.D) or Specific gravity of liquids using Archimedes' principle :**

Take a body which sinks in both liquids and water. Determine its weight in air (W_1), in water (W_2) and in the given liquid (W_3) with a spring balance. Then the loss of weight of the body in water = $W_1 - W_2$ gram. weight loss of weight of the body in liquid ($W_1 - W_3$) gram wt. The body displaces a liquid equal to its volume (V)

$$\text{Relative density of the liquid} = \frac{\text{mass of 'V' volume of liquid}}{\text{mass of 'V' volume of water}}$$

Since weight is proportional to mass, it can be replaced by weight

$$\text{Relative density of liquid} = \frac{\text{weight of 'V' volume of liquid}}{\text{weight of 'V' volume of water}}$$

$$= \frac{\text{weight of displaced liquid by the body}}{\text{weight of displaced water by the body}}$$

$$= \frac{\text{Loss of weight of the body in liquid}}{\text{Loss of weight of the body in water}} \quad \frac{W_{air} - W_{liquid}}{W_{air} - W_{water}}$$

WORK SHEET - 3

Single Answer Type

1. According to Archimede's principle
   1) Buoyant force = weight of fluid displaced by immersed part of the body.
   2) loss of weight of the body in liquid = weight in air – weight in liquid.
   3) Apparent weight of the body = Real weight – Buoyant force.
   4) All of these.
2. Buoyant force acting on an object due to a fluid generally acts
   1) in the downward direction
   2) side ways
   3) in the upward direction
   4) sometimes in the upward direction and sometimes in the downward direction
3. Two cylinders of same height but of radius 'r' and '2r' are immersed in the same liquid, if the buoyant force exerted on the first cylinder is 50 units what will be the buoyant force on teh 2nd cylinder?
   1) 200 units 2) 100 units 3) 50 units 4) 25 units
4. A solid of density d has weight 'W'. Then what will be its apparent weight when it is completely submerged in a liquid of density d_L ?
   1) $W\left[1-\frac{d_L}{d}\right]$ 2) $W\left[\frac{d_L}{d}-1\right]$ 3) $W[d_L-d]$ 4) $W\left[\frac{d_L}{d}\right]$
5. Two balls, one of iron and the other of aluminium experience the same upthrust when dipped in water if
   1) both have same mass
   2) one has half the volume as that of the other
   3) both have equal volume
   4) one has one-fourth of the volume as that of the other
6. The ratio between density of a substance and density of water at 4°C is called
   1) Relative density of the substance 2) Density of the substance
   3) Specific gravity 4) Both (1) and (3)

Multi Answer Type

7. A stone weights 15 gm in air and 12 gm in water. The relative density and density
   1) The relative density of the stone is 5
   2) The density of stone is 5 g/cc in C.G.S system.
   3) The density of stone is 5000 kg/m^3 in S.I system.
   4) The relative density of the stone is 6

8. Three cubes of volume V,V/4 and V/8 respectively are immersed in the same liquid. If the buoyant force exerted on the 3rd cube is 40 units. Then

1) Buoyant force on 1st cube is 80 units 2) Buoyant force on 1st cube is 320 units
3) Buoyant force on 2nd cube is 80 units 4) Buoyant force on 2nd cube is 320 units

Reasoning Answer Type

9. *Statement-I:* As the volume of solid object immersed inside the liquid increases, the upward 'buoyant force also increases.
Statement-II: As the density of liquid increases, the buoyant force exerted by it also increases.
1) Both Statements are true, Statement II is the correct explanation of Statement I.
2) Both Statements are true, Statement II is not correct explanation of Statement I.
3) Statement I is true, Statement II is false.
4) Statement I is false, Statement II is true.

Comprehension Type

A body weighs 500gf in air and 300gf when completely immersed in water.

10. Find the apparent loss in weight of the body.
1)500gf 2)300gf 3)200gf 4)800gf
11. Find the buoyant force acting on the body
1)500gf 2)300gf 3)200gf 4)800gf
12. Find the volume of the body.
1)500 cm^3 2)300 cm^3 3)200 cm^3 4)800 cm^3

Matrix Matching Type

13.

Column - I	**Column - II**
a) loss of weight	1) newton
b) apparent weight	2) Real weight – Buoyant force
c)S.I. unit of upthrust	3) mass of body × acceleration due to gravity
d) Real weight	4) Weight of fluid displaced

Integer Answer Type

14. The buoyant force acting on a solid volume 1.6 m^2, immersed in sea water of density 1030 kg m^{-3}.(Take g = 10 m/s^2) is________N(Ans: 16480)

Subjective Answer Type

15. A solid weighs 30 N when dipped in water. Find the density of the solid if it weighs 40 N in air ?

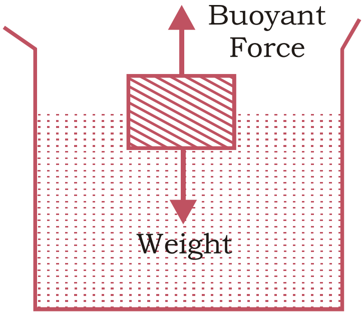
SYNOPSIS - 4

Floatation :

When a body is immersed in a liquid, two forces act on it in opposite directions. The forces are

(i) The weight of the body acting vertically downwards and

(ii) The upthrust or buoyant force acting vertically upwards.



Law of floatation :

According to the law of floatation, the weight of the floating body is equal to the weight of the liquid displaced by the immersed part of the body.

i.e., weight of the floating body = weight of the liquid displaced (by the immersed part of the body).

$\Rightarrow$ mass of floating body × g = mass of liquid displaced × g

$\Rightarrow V_{\text{floating body}} \times d_{\text{body}} = V_{\text{liquid displaced}} \times d_{\text{liquid}}$

$\Rightarrow V_{\text{body}} \times d_{\text{body}} = V_{\text{body inside or submerged}} \times d_{\text{liquid}}$

(since when a body floats,

Volume of liquid displaced = Volume of body that is inside the liquid).

or Fraction of body inside the liquid= $f_{\text{inside}} = \dfrac{V_{\text{body submerged}}}{V_{\text{liquid}}} = \dfrac{d_{\text{body}}}{d_{\text{liquid}}}$

Apparent weight of a floating body :

According to the principle of floatation, when a body floats in a liquid, the weight of the body is equal to the weight of the liquid displaced by its submerged part.

Thus, the upthrust by the liquid is equal to the weight of the body.

$\therefore$ Apparent weight = Real weight – Upthrust = 0

Thus, a floating body appears to have no weight (or its apparent weight is zero).

WORK SHEET - 4

Single Answer Type

1. The magnitude of upthrust is always equal to
   1) The weight of the fluid displaced by the immersed part of the body.
   2) The mass of the fluid displaced by the immersed part of the body.
   3) Both (1) and (2)   4) Neither (1) nor (2)
2. Apparent weight of a floating body is equal to
   1) Real weight – Upthrust   2) Real weight + Upthrust
   3) Real weight × Upthrust   4) Real weight / Upthrust

3. According to the law of floatation

1) Fraction of body inside the liquid $f_{inside} = \dfrac{V_{body submerged}}{V_{liquid}}$

2) Fraction of body inside the liquid $f_{inside} = \dfrac{d_{body}}{d_{liquid}}$

3) Both(1) and (2) 4) Neither (1) nor (2)

4. A block of wood floats in water with $\frac{2}{5}$ th of its volume above the surface. Calculate the density of wood.
1) 0.6 g/cm^3 2) 1.6 g/cm^3 3) 2.5 g/cm^3 4) 3.6 g/cm^3

5. A cylinder made of copper and aluminium floats in mercury of density $13.6\,gcm^{-3}$, such that 0.26th part of it is below mercury. Then the density of solids is

1) $3.536g\,cm^{-3}$ 2) $2.536\ g\,cm^{-3}$ 3) $4.536\ g\,cm^{-3}$ 4) $5.536\ g\,cm^{-3}$

Multi Answer Type

6. A hollow cylinder of copper of length 25 cm and area of cross-section $15\,cm^2$, floats in water with $\frac{3}{5}$ of its length inside water.Then

1) apparent density of hollow copper cylinder is $0.6\ g\,cm^{-3}$
2) weight of the cylinder is 225 gf
3) extra force required to completely submerge it in water is 150 gf
4) Extra force required to completely submerge it in water is 225 gf

7. When a body is immersed in a liquid, two forces act on it in opposite directions. The forces are
1) The weight of the body acting vertically downwards.
2) The upthrust or buoyant force acting vertically upwards.
3) The upthrust or buoyant force acting vertically downwards.
4) The weight of the body acting vertically upwards.

Reasoning Answer Type

8. *Statement I :* According to the law of floatation, the weight of the floating body is equal to the weight of the liquid displaced by the immersed part of the body.

Statement II : According to the law of floatation, the weight of the floating body is not equal to the weight of the liquid displaced by the immersed part of the body.

1) Both Statements are true, Statement - II is the correct explanation of Statement-I
2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
3) Statement - I is true, Statement - II is false.
4) Statement - I is false, Statement - II is true.

Comprehension Type

Fraction of body inside the liquid= $f_{inside} = \frac{V_{body\,submerged}}{V_{liquid}} = \frac{d_{body}}{d_{liquid}}$

9. If the density of ice is 0.9 g cm^{-3}, what portion of an iceberg will remain below the surface of water in the sea ? (density of sea water = 1.1 g cm^{-3})

1) $\frac{9}{11}$ th part 2) $\frac{11}{9}$ th part 3) $\frac{3}{4}$ th part 4) $\frac{4}{3}$ th part

10. A block of wood of density 600 kg m^{-3} and volume 0.6 m^3 floats in water of density 1000 kg m^{-3}. How much of it is below water level ?

1) 1.36 m^3 2) 2.36 m^3 3) 0.36 m^3 4) 3.36 m^3

11. A body made of iron floats in mercury. Find the fraction of volume, which remains immersed in mercury.
(Densities of iron and mercury are 7.8 g cm^{-3} and 13.6 g cm^{-3} respectively)

1) 0.574 2) 1.57 3) 2.754 4) 3.547

Integer Answer Type

12. The density of a substance is 0.6 g cm^{-3}. It floats with $\frac{2}{3}$rd of its volume in a liquid. The density of the liquid is _______ × 10^{-3} g/cm^3.

WORK SHEET – 1 (KEY)				
1) 2	**2)** 1	**3)** 1	**4)** 2	**5)** 2
6) 1,2,3,4	**7)** 1,2	**8)** 2	**9)** 2	**10)** 1
11) 2	**12)** 2,3,1,(4,5)	**13)** 10^5	**14)** 3	**15)** 1

1. C.G.S unit of pressure = $\frac{\text{dyne}}{\text{cm}^2}$ - - - - (1)

   S.I unit of pressure = $\frac{N}{m^2} = \frac{10^5\text{dyne}}{10^4\text{cm}^2} = 10\frac{\text{dyne}}{\text{cm}^2}$ - - - - - - - (2)

   dividing 1 by 2 $\frac{\frac{\text{dyne}}{\text{cm}^2}}{\frac{10\text{dyne}}{\text{cm}^2}} = \frac{1}{10} = 0.1$

2. F = 16 N, $A = 50\,\text{cm}^2 = \frac{50}{10000}\text{m}^2$; P = ? We know that $P = \frac{F}{A}$

   $\Rightarrow$ $P = \frac{16 \times 10000}{50}\text{pa}$ = 3200 pa

3. With the increase in the weight of an object the pressure increases.

   As $P = \frac{F}{A}$ $\Rightarrow$ $P \propto F$ (weight)

4. With the increase in the area of contact of an object the pressure decreases.

   As $P = \frac{F}{A}$ $\Rightarrow P \propto \frac{1}{A}$

9. Liquid pressure at a point in a liquid does not depend on shape of the vessel in which the liquid is kept

10. Pressure at any point inside a liquid is directly proportional to density of the liquid.

11. As the depth of a liquid increases, the pressure of liquid increases.

13. The S.I unit of thrust = newton = 10^5 dyne.
    The C.G.S unit of force = dyne

    $\therefore$ $\frac{10^5\text{dyne}}{\text{dyne}} = 10^5$

14. $A = 200\,cm^2 = \dfrac{200}{10000}\,m^2$

$P = 27500$ Pa , $F = ?$

$\therefore$ We know that $P = \dfrac{F}{A}$

$\Rightarrow F = P \times A = 27500 \times \dfrac{200}{10000} N = 550$ N

15. h = 45 cm = 0.45 m

$g = 9.8\ m/s^2$

$d = 1000\ kg / m^3$

we known p = hdg

= 0.45 × 9.8 × 100 Pa = 4410 Pa

WORK SHEET – 2 (KEY)

1) 1	**2)** 1	**3)** 1	**4)** 1	**5)** 1
6) 2,4	**7)** 1,3	**8)** 1,2,3,4	**9)** 3	**10)** (3,4),1,2,5
11) 5	**12)** 2			

WORK SHEET – 3 (KEY)

1) 4	**2)** 3	**3)** 1	**4)** 1	**5)** 3
6) 4	**7)** 1,2,3	**8)** 2,3	**9)** 2	**10)** 3
11) 3	**12)** 3	**13)** 4,2,1,3	**14)** 16480	**15)** 1

3. We know buoyant force = $F_B = V_{body} \times d_{liquid} \times g \Rightarrow F_B \propto V_{body}$ (since d_{liquid} and g are constant).

$$\Rightarrow \frac{F_B}{F_B^1} = \frac{\pi r^2 l}{\pi (2r)^2 l} \Rightarrow \frac{F_B}{F_B^1} = \frac{1}{4} \Rightarrow \frac{50}{F_B^1} = \frac{1}{4} \Rightarrow F_B^1 = 200\,\text{units}$$

4. Given, $d_{solid} = d$, $W_{body} = W$, $d_{liquid} = d_L$, App.Wt = ?

We know, App.wt = Real wt – buoyant force = W – buoyant force

How to get buoyant force = ?

We know buoyant force, $F_B = V_{body} \times D_{liquid} \times g$

$$F_B = \frac{m_{body}}{d_{body}} \times d_{liquid} \times g = \frac{W/g}{d_b} \times d_L \times g = W \times \frac{d_L}{d_b}$$

$\therefore$ Apparent weight = Real weight – buoyant force $= W - \frac{w}{d} \times d_L = W\left(1 - \frac{d_L}{d}\right)$

15. Weight of the body in air W_1 = 40 N
Weight of the body in water, W_2 = 30 N
$\therefore$ Loss in weight of the body in water, $W_1 - W_2$ = 40 N – 30 N = 10 N
According to Archimedes' principle,
Loss in weight of the body = weight of water displaced by the body = 10 N
$\therefore$ Relative density of the solid =

$$\frac{\text{weight of the solid in air}}{\text{weight of water displaced by the solid}}$$

$$= \frac{W_1}{W_1 - W_2} = \frac{40\ N}{10\ N} = 4$$

$\therefore$ Density of the solid = Relative density of the solid × Density of water
= 4 × 10^3 kg m^{-3}
Hence relative density of solid = 6

WORK SHEET – 4 (KEY)				
1) 1	**2)** 1	**3)** 3	**4)** 1	**5)** 1
6) 1	**7)** 1,2	**8)** 3	**9)** 1	**10)** 3
11) 1	**12)** 9			

4. $V_{Inside} = V - \frac{2}{5}V = \frac{3}{5}V$

$$\frac{V_{In}}{V} = \frac{d_S}{d_L} \Rightarrow \frac{\frac{3}{5}V}{V} = \frac{d_{Wood}}{1} \quad (\because d_{Water} = 1\ g/cm^3 \text{ in CGS})$$

$$d_{Wood} = \frac{3}{5}\ g/cm^3$$

5. d_L = 13.6 g/cm^3, d_S = ?

$V_{inside} = 0.26\ V$ then $\frac{V_{in}}{V} = \frac{d_S}{d_L}$

$$d_S = \frac{0.26 \times V}{V} \times 13.6 = 3.536\ g/cm^3$$

6. l = 25 cm, A = 15 cm^2, V = 25 ×15 = 375 cm^3

(1) apparant density = $\frac{\frac{3}{5}l}{l} = \frac{d_S}{d_L} = \frac{3}{5} = 0.6\ g/cm^3$

(2) Weight = V d_s g = $375 \times \frac{3}{5} \times g = 225$ gf

(3) upthrust = V d_L g = 375 × 1 × g = 375 gf

Extra force = 375 – 225 = 150 gf

9. fraction of the substance inside the liquid is

$$\frac{V_{Inside}}{V_{Liquid}} = \frac{d_{Substance}}{d_{Liquid}} = \frac{0.9}{1.1} = \frac{9}{11}$$

10. $V_{in} = V \times \frac{d_S}{d_L} = 0.6 \times \frac{600}{1000} = 0.36\ m^3$

11. fraction of volume inside is $= \frac{d_S}{d_L} = \frac{7.8}{13.6} = 0.574$

12. Sol: $\frac{2}{3} = \frac{0.6}{d_L} \Rightarrow d_L = \frac{0.6 \times 3}{2} = 0.9\ g/cm^{-3}$

GRAVITATION

SYNOPSIS - 1

Gravitation and gravity:

The earth attracts (or pulls) all the objects towards its centre. The force with which the earth pulls the objects towards it is called the gravitational force of earth or gravity (of earth). It is due to the gravitational force of earth that all the objects fall towards the earth when released from a height.

The gravitational force of earth (or gravity of earth) is responsible for holding the atmosphere above the earth; for the rain falling to the earth and for the flow of water in the rivers. It is also the gravitational force of earth and for the flow of water in the rivers. It is also the gravitational force of earth(or gravity of earth)which keeps us firmly on the ground.

Gravitation:

Every body in this universe attracts every other body with a force known as 'force of gravitation'. Gravitation is the force of attraction between any two bodies in the universe. The attraction between the sun and the earth, the attraction between a table and a chair lying in a room, the attraction between the earth and a satellite revolving around it, etc.; are all examples of gravitation.

Gravity:

Gravity is a special case of gravitation. Gravity is the attraction between the earth and any object lying on or near its surface. A body thrown up falls back on the surface of the earth due to earth's force of gravity.

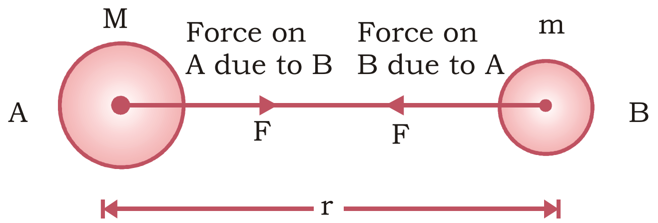
Universal law of gravitation or Newton's law of gravitation:

The law states that everybody in this universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.

Note:- The force acts along the line joining centres of the two bodies.

Relation between gravitational force between two bodies and the distance between them.

Consider two bodies A and B having masses M and m respectively. Let the distance between these bodies be r.



If F is the force with which the two bodies attract each other, then according to the law of gravitation

$F \propto Mm$ ....(1) and $F \propto \frac{1}{r^2}$ ....(2)

Combining eqns. (1) and (2), we get

$$F \propto \frac{Mm}{r^2} \text{ or } F = G\frac{Mm}{r^2} \qquad .....(3)$$

where G is constant and is known as universal gravitational constant.
Eqn (3) gives the magnitude of gravitational force between two interacting bodies of masses M and m separated by distance 'r'.

Definition of universal gravitational constant (G):

We know, $F = \frac{Mm}{r^2}$ or $G = \frac{Fr^2}{Mm}$

If M = 1 unit, m = 1 unit and r = 1 unit, then G = F

Thus, universal gravitational constant (G) is defined as the force of attraction between two bodies of unit masses separated by a unit distance.

Units of universal gravitational constant (G):

We know, $F = \frac{GMm}{r^2}$ or $G = \frac{Fr^2}{Mm}$

$$\therefore \quad G = \frac{\text{unit of force} \times (\text{unit of distance})^2}{\text{unit of mass} \times \text{unit of mass}}$$

Since S.I. unit of force is newton (N).
S.I. unit of distance is metre (m), S.I. unit of mass is kilogram (kg).

$$\therefore \quad \text{S.I. unit of } G = \frac{Nm^2}{kg^2} \text{ or } Nm^2\,kg^{-2}$$

Numerical value of gravitational constant G:

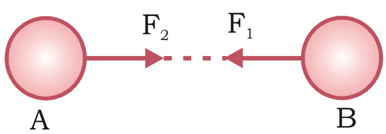
Henry Cavendish first determined the value of G experimentally in the year 1778, by using a sensitive balance.
The numerical value of G is experimentally found to be $6.67 \times 10^{-11} Nm^2Kg^{-2}$.

Newton's law of gravitation is known as universal law of gravitation:

This is because the law of gravitation holds good for any pair of bodies in the universe, whether the bodies are big or small, or whether they are celestial or terrestrial.

Characteristics of Gravitational force:

1. Gravitational force between two bodies or objects does not need any contact between them. It means, gravitational force is **action at a distance**.
2. Gravitational force between two bodies varies inversely proportional to the square of the distance between them, Hence, gravitational force is an **inverse square force.**
3. The gravitational forces between two bodies or objects from an action reaction pair. If object A attracts object B with a force F_1 and the object B attracts object A with a force F_2, then $F_1 = -F_2$



Free fall:

The falling of a body (or object) from a height towards the earth under the gravitational force of earth (with no other forces acting on it) is called free fall.

Note:-

1) The acceleration of an object falling freely towards the earth does not depend on the mass of the object. Hence it is same for bodies of any mass
2) A freely falling body has acceleration equal to acceleration due to gravity (g).
3) The acceleration produced in the freely falling bodies is the same for all the bodies and its does not depend on the mass of the falling body.

Acceleration due to gravity:

The acceleration with which a body falls towards the earth due to earth's gravitational pull is known as acceleration due to gravity. It is denoted by 'g'.

Expression for the acceleration due to gravity (Relation between G and g)

Consider a body of mass m near the surface of the earth

The force acting on the body is the gravitational force of the earth. The magnitude of the gravitational force acting on the body due to the earth is given by

$$F = \frac{GMm}{R^2} \quad \ldots(1)$$

where, M = mass of the earth, R = radius of the earth

[Here, height of the body from the surface of the earth is neglected as compared to the radius of the earth because R = 6400 km is very large.]

This gravitational force (F) produces acceleration equal to 'g' in the body of mass m. So according to Newton's second law of motion,

$$F = mg \quad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}(2)$$

Equating equations(1) and (2) $mg = \frac{GMm}{R^2}$ or $g = \frac{GM}{R^2}$ ____________(3)

which is the expression for the acceleration due to gravity.

WORK SHEET - 1

Single Answer Type

1. The relation between g(acceleration due to gravity) and G(gravitational constant)

   1) $g = \frac{GM}{R^2}$ 2) $g = \frac{GM}{R}$ 3) $g = \frac{G}{R^2 M}$ 4) $g = \frac{G}{R^2}$

2. If F_1 is the force of attractionm for the bodies at separation r_1 and F_2 is the force fpr the separation r_2, then

   1) $F_1 r_1^2 = F_2 r_2$ 2) $F_1 r_1 = F_2 r_2^2$ 3) $F_1 r_1^2 = F_2 r_2^2$ 4) $F_1 r_1 = F_2 r_2$

3. Force of gravitation can be between

   1) moon and the earth 2) sun and the earth
   3) moon and the sun 4) all of these

4. If 'F' is the force with which the two bodies attract each other which are at a distance 'r' then according to the law of gravitation

   1) $F \propto \frac{1}{r^3}$ 2) $F \propto \frac{1}{r}$ 3) $F \propto \frac{1}{r^2}$ 4) $F \propto r$

5. Every body in this universe attracts every other body with a force known as
   1) force of gravitation 2) electrostatic force 3) magnetic force 4) All of these

6. Choose the correct statement:
   1) The direction of acceleration due to gravity is always towards the centre.
   2) The aceeleration has the same value in magnitude whether the particle falls downwards or moves at some angle with the vertical
   3) The direction of acceleration due to gravity is always away from the centre.
   4) The aceeleration has the different value in magnitude whether the particle falls downwards or moves at some angle with the vertical

Multi Answer Type

7. Choose the correct statements
   1) Gravitational force on a particle due to number of particles is the vector sum of all the forces due to individual particles
   2) Gravitational force obeys inverse square law
   3) Gravitational force between any two bodies is always attractaive type only
   4) Gravitational force acts along line joining the two interacting particles

8. Choose the correct statements:
   Universal law of gravitation states that
   1) Everybody in this universe attracts every other body with a force which is directly proportional to the product of their masses
   2) Inversely proportional to the square of the distance between their centres.
   3) Everybody in this universe attracts every other body with a force which is inversely proportional to the product of their masses
   4) Directly proportional to the square of the distance between their centres.

Reasoning Answer Type

9. *Statement I* : The force of attraction between two objects is called the force of gravitation
Statement II : The magnitude of gravitational force and its direction is given by the universal law of gravitation which was formulated by Newton.
1) Both Statements are true, Statement - II is the correct explanation of Statement-I
2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
3) Statement - I is true, Statement - II is false.
4) Statement - I is false, Statement - II is true.

Comprehension Type

Universal law of gravitation states that everybody in this universe attracts every other body with a force which is directly proportional to the product of their masses inversely proportional to the square of the distance between their centres.

10. Universal law of gravitation is given by the formula

1) $F = G\frac{Mm}{r^2}$ 2) $F = G\frac{M}{r^2}$ 3) $F = G\frac{Mm}{r^3}$ 4) $F = G\frac{Mm}{r}$

11. In universal law of gravitation the constant G is
1) Independent of the nature of the particles
2) Independent of space where they are kept
3) Independent of time at which the force is considered
4) All of these

12. The unit of G is

1) $\frac{Nm^2}{kg^2}$ 2) $\frac{Nm}{kg^2}$ 3) $\frac{Nm^2}{kg}$ 4) $\frac{Nm^2}{g^2}$

Matrix Matching Type

13.

Column-I	**Column-II**
a) Gravitational force	1) attractive force
b) Scalar	2) $Nm^2\ kg^{-2}$
c) unit of gravitational constant	3) 6.67×10^{-11}
d) numerical value of gravitational constant	4) dyne $cm^2\ g^{-2}$
	5) gravtitational constant

Integer Answer Type

14. The weight of a body of mass 5 kg is ________ N

Subjective Answer Type

15. The gravitational force between two protens kept at a separation of 1 femtometre (1 femtometre = 10^{-15} m). The mass of a proton is 1.67×10^{-27} kg (approximately)

1) 1.86×10^{-32} N 2) 1.86×10^{-34} N 3) 1.86×10^{-33} N 4) 1.86×10^{-35} N

SYNOPSIS - 2

Factors on which the acceleration due to gravity depends:

Acceleration due to gravity is

i) directly proportional to the mass of the earth and

ii) inversely proportional to the radius of the earth.

The value of acceleration due to gravity (g) on the earth:

We know, $g = \frac{GM}{R^2}$

Now, $G = 6.673 \times 10^{-11}\ Nm^2kg^{-2}$,$M = 5.98 \times 10^{24}$ kg (Mass of earth)

$R = 6.4 \times 10^6$ m (Radius of earth)

Substituting these values in equation (1), we get

$$g = \frac{6.673 \times 10^{-11} Nm^2kg^{-2} \times 5.98 \times 10^{24} kg}{\left(6.4 \times 10^6 m\right)^2} = 9.8\ Nkg^{-1} = 9.8\ kgms^{-2}kg^{-1} = 9.8\ ms^{-2}$$

Value of 'g' on the surface of the moon:

We know, $g_{moon} = \frac{GM_m}{R_m^2}$ ....(1)

M_m (mass of the moon) = 7.4×10^{22} kg, R_m (radius of the moon) = 1.75×10^6 m

$G = 6.673 \times 10^{-11}\ Nm^2kg^{-2}$

Then, from eqn. (1) $g_{moon} = \frac{6.673 \times 10^{-11} Nm^2kg^{-2} \times 7.4 \times 10^{22} kg}{\left(1.75 \times 10^6 m\right)^2} = 1.6\ ms^{-2}$

Now, $\frac{g_{moon}}{g_{earth}} = \frac{1.7ms^{-2}}{9.8ms^{-2}} = \frac{1}{6}$ or $g_{moon} = \frac{1}{6} g_{earth}$

Thus, acceleration due to gravity on the surface of moon is $\frac{1}{6}$ the times the acceleration due to gravity on the surface of the earth.

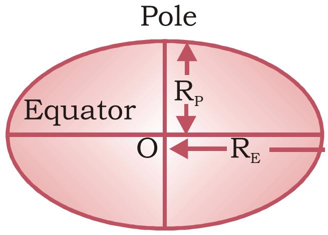
Variation in the value of 'g':

1. **Variation in the value of 'g' with the shape of the earth**;

The acceleration due to gravity 'g' on the surface of the earth is given by

$G = \frac{GM}{R^2}$ ________________(1)

This expression for 'g' is calculated by considering the earth as a spherical body. In fact, the earth is not spherical in shape but it is egg shaped as shown in figure



Therefore, the radius of the earth (R) is not constant throughout. Hence, the value of 'g' is different at different points on the earth.
The equatorial radius (R_E) of the earth is about 21 km longer than its polar radius (R_p).

Now from equation (1)value of 'g' at equator is given by $g_e = \dfrac{GM}{R_p^2}$

__________(2)

Value of 'g' at pole is given by $g_p = \dfrac{GM}{R_p^2}$ _____________(3)

Dividing equation (3) by equation (2), we get $\dfrac{g_p}{g_E} = \left(\dfrac{R_E}{R_p}\right)^2$

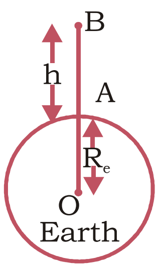
Since $R_E > R_P$ $\therefore$ $g_p > g_E$
Thus, value of 'g' is more at equator than at poles.

2. ***Variation in the value of 'g' with the altitude (or height) above the surface of the earth.***

We know, acceleration due to gravity on the surface of the earth is given by

$$g = \frac{GM}{R^2} \qquad \ldots(1)$$

Now, let a body be at a height h above the surface of the earth.



The distance of the body from the centre of the earth = (R + h).
Therefore, acceleration due to gravity at height 'h' is given by

$$g_h = \frac{GM}{(R-h)^2} \qquad \ldots(2)$$

Dividing (2) by (1) we get $\frac{g_h}{g} = \frac{GM}{(R+h)^2} \times \frac{R^2}{GM} = \frac{R^2}{(R+h)^2}$

or $\frac{g_h}{g} = \left(\frac{R}{R+h}\right)^2$ ...(3)

Since (R + h) > R $\therefore \frac{g_h}{g} < 1$ or $g_h < g$

This shows that the value of 'g' decreases as we go higher and higher. Thus, value of 'g' decreases with the height from the surface of the earth.

3. **Variation in the value of 'g' with depth below the surface of the earth.**
The value of 'g' decreases with depth below the surface of the earth.
The value of 'g' at depth d below the surface of the earth is given by

$$g_d = \left(1 - \frac{d}{R}\right)g \qquad g_d = g\left(\frac{R-d}{R}\right)$$

This shows that the value of 'g' decreases as we go deep into the crest of the earth.

Note:-At the centre of the earth, depth, d = R

$\therefore$ g (at centre of he earth) = 0

Thus, value of 'g' at the centre of the earth is zero.

4. ***Effect of latitude (Effect of rotation of the earth about its own axis).*** Due to the rotational motion of the earth about its own axis, the value of g at a place increases with the increase in latitude of the place. Hence due to rotation of the earth, the weight of a body is maximum at the poles and minimum at the equator. In fact rotation has no effect on the value of g at the poles.

Gravity meters:sensitive instrument used to measure small changes in the value of g at a given location are called gravity meters.

WORK SHEET - 2

Single Answer Type

1. Acceleration due to gravity on the surface of moon is

   1) $\frac{1}{4}$ the times the acceleration due to gravity on the surface of the earth.

   2) $\frac{1}{16}$ the times the acceleration due to gravity on the surface of the earth.

   3) $\frac{1}{2}$ the times the acceleration due to gravity on the surface of the earth.

   4) $\frac{1}{6}$ the times the acceleration due to gravity on the surface of the earth.

2. Value of 'g' is
   1) more at equator than at poles 2) less at equator than at poles
   3) equal at equator and poles 4) more at poles than at equator

3. The correct relation between 'g' (acceleration due to gravity) and 'G'(universal gravitational constant) is

   1) $g = \frac{GM}{R^2}$ 2) $g = \frac{GM}{R}$ 3) $g = \frac{G}{R^2}$ 4) $g = \frac{GM}{2R^3}$

4. Find the value of acceleration due to gravity at a height of 12,800 km from the surface of the earth.Earth radius = 6,400 km
   1)1.7 m/s^2 2)1.09 m/s^2 3)2.09 m/s^2 4)4.09 m/s^2

5. Density of earth in terms of 'g' is acceleration due to gravity,M is mass of the earth,R is radius of earth

   1) $\frac{3g}{4\pi RG}$ 2) $\frac{3G}{4\pi Rg}$ 3) $\frac{4G}{3\pi Rg}$ 4) $\frac{4G}{3Rg}$

6. The mass of a body on the surface of the earth is 70 kg. What willbe its (i) mass and (ii) weight at an altidue of 100 km? Radius of the earth is 6371 km.
   1) 70 kg, 664.46 N 2) 70 kg, 66.446 N
   3) 70 kg, 6.6446 N 4) 70 kg, 6644.6 N

Multi Answer Type

7. Choose the correct statements:
   1) The equitorial radius of earth is greater than polar radius
   2) acceleration due to gravity is minimum at the poles than at the equator
   3) acceleration due to gravity decreases with increase in the value of h
   4) As the g decreases with height the weight of an object also decreases

8. Choose the correct statements :
   1) The weight of the body on the moon is about one-sixth of its weight on the earth
   2) Rotation also affects effective value of g
   3) At the centre of earth g is zero
   4) If one goes above the earth surface or goes into deep mine, the value of g changes

9. Acceleration due to gravity is
1) directly proportional to the mass of the earth
2) inversely proportional to the radius of the earth
3) directly proportional to the radius of the earth
4) inversely proportional to the mass of the earth

Reasoning Answer Type

10. *Statement I :* Sensitive instrument used to measure small changes in the value of 'g' at a given location are called gravity meters.
Statement II : The value of 'g' is different at different points on the earth.

1) Both Statements are true, Statement - II is the correct explanation of Statement-I
2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
3) Statement - I is true, Statement - II is false.
4) Statement - I is false, Statement - II is true.

Comprehension Type

The value of g varies with depth below the surface of the earth,the altitude (or height) above the surface of the earth,with the shape of the earth.

11. Acceleration due to gravity at height 'h' is given by the relation(all the terms have their usual meanings)R is radius of the earth.

1) $g_h = \frac{GM}{(R-h)}$ 2) $g_h = \frac{GM}{(R+h)^2}$ 3) $g_h = \frac{2G}{(R-h)^2}$ 4) $g_h = \frac{GM}{(R-h)^2}$

12. Variation in the value of 'g' with depth(d) below the surface of the earth is given by(all the terms have their usual meanings)R is radius of the earth.

1) $g_d = \left(1 - \frac{d}{R}\right)g$ 2) $g_d = \left(1 - \frac{R}{d}\right)g$ 3) $g_d = \left(1 + \frac{R}{d}\right)g$

4) $g_d = \left(g - \frac{d}{R}\right)$

13. Choose the correct relations :
1)Value of 'g' decreases with the height from the surface of the earth
2)The value of 'g' decreases with depth below the surface of the earth.
3)Value of 'g' is less at equator than at poles
4)Both(1)& (2)

Integer Answer Type

14. The value of G is ________$\times 10^{-14}$

Subjective Answer Type

15. Density of earth is 5.488 $\times 10^3$ kgm^{-3}. Assume earth to be a hemogeneous sp[here. Find the value g on the surface of the earth. Use the known values of R and G

WORK SHEET – 1 (KEY)				
1) 1	**2)** 3	**3)** 4	**4)** 3	**5)** 1
6) 1,2	**7)** 1,2,3,4	**8)** 1,2	**9)** 2	**10)** 1
11) 4	**12)** 1	**13)** 1,5,(2,4),3	**14)** 49.0	**15)** 2

15. The gravitational force is

$$F = \frac{Gm_1m_2}{r^2} = \frac{\left(6.67\times10^{-11}\frac{Nm^2}{kg^2}\right)\times\left(1.67\times10^{-27}kg\right)^2}{\left(10^{-15}m\right)^2} = 1.86\times10^{-34}N.$$

WORK SHEET – 2 (KEY)				
1) 4	**2)** 1	**3)** 1	**4)** 2	**5)** 1
6) 1	**7)** 1,3,4	**8)** 1,2,3,4	**9)** 1,2	**10)** 2
11) 4	**12)** 1	**13)** 4	**14)** 667	

6. Mass m = 70 kg Weight on the surface of the earth = mg = 70 × 9.8 = 686 N The mass of the body at the altidue of 100 km is also the same as that on the surface of the earth i.e., 70 kg

Weight of the body at a height h is mg\`

$h = 100 \times 10^3$ m = 10^5 m

Weight = $mg' = mg\left(1-\frac{2h}{R}\right) = 70\times9.8\left(1-\frac{2\times10^5}{6371\times10^3}\right) = 664.46N$

15.

$$g = 4\pi RGD/3 = 4\times3.14\times6371\times10^3\times6.67\times10^{-11}\times5.488\times10^3/3 = 9.8ms^{-2}$$

WAVE MOTION & SOUND

SYNOPSIS - 1

Introduction of wave : There are two ways of transfer of energy from one point to other.

1. By the transport of matter and
2. Without the transport of matter (i.e through wave motion]

Wave : A wave is produced by the vibrations of the particles of the medium through which it passes.

When a wave passes through a medium, the medium itself does not move along the direction of the wave, only the particles of the medium vibrate about their fixed positions. For example, when a water wave passes over the surface of water in a pond, it does not drive water to one side of the pond, only the water molecules vibrate up and down about their fixed positions. Similarly, when sound waves produced by ringing bell come to us through air, there is no actual movement of the air from the bell to our ears. Only the sound energy travels through the vibrations of the air molecules. The light from the sun also comes to us in the form of light waves, there being no direct contact between the sun and the earth. Thus

A wave is a disturbance by which energy is transferred from one point to the other through vibrations of the medium particles without their actual movements.

(OR)

A periodic disturbance produced in a material medium due to the vibrating motion of the particles of the medium is called a wave.

Wave motion : The movement of a disturbance produced in one part of a medium to another involving the transfer of energy but not the transfer of matter is called wave motion.

Examples : The following are examples of wave motion

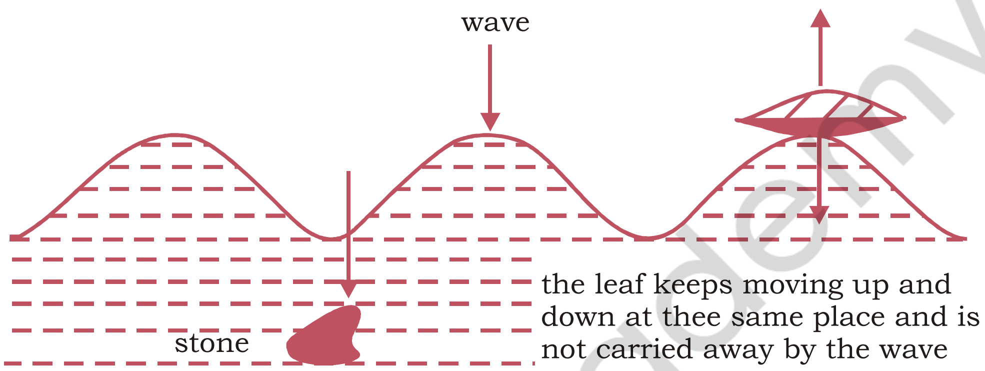
1) Formation of ripples on the water surface.
2) Propagation of sound wave through air or any other material medium.

Explanation of wave motion: If we drop a stone into a pond, we see circular water waves (ripples) spreading out in all directions on the surface of the water .

a. Ripples produced in water when a stone is dropped into a pond

If we place a small leaf on the water surface, the leaf moves up and down about its original position but does not move away from or towards the source of disturbance along with the waves.

This shows that the disturbances moves from one place to another but the water is not carried with it. The water particles simply move up and down about their mean positions. The formation of ripples on the surface of water is an example of wave motion. The material in which the wave motion is produced called a medium. Water surface is the medium of wave motion in the above example. In the above example, when the stone is



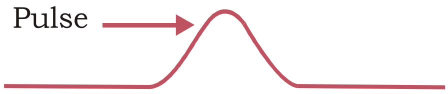
b. Wave motion does not carry matter (material) away from or towards the source of disturbance

thrown into the pond, the energy carried by the stone disturbs the water molecules close to it. By gaining the energy from the stone, the water molecules near the stone start vibrating up and down. These vibrating water molecules transfer some of the energy to the next set of water molecules which also start vibrating, and so on. In this way, water wave is formed. We can now say that, wave motion is a vibratory disturbance produced in one part of the medium that travels to another part involving the transfer of energy but not the transfer of any matter with it. The disturbance itself is called a wave. Sound is also an example of wave motion. The sound energy of our speech reaches the listener's ear through the vibratory motion of the air particles.

Characteristics of wave motion

1. In wave motion the particles of the medium vibrate about their mean positions. The particles of the medium don't move from one place to another.
2. During a wave motion, energy is transferred from one point of the medium to another. There is no transfer of matter through the medium.
3. During wave motion, the medium does not move as a whole only the disturbance travels through the medium.
4. A wave motion travels at the same speed in all directions in any medium. The speed of a wave depends upon the nature of the medium through which it travel.

Pulse: The wave set up by a single disturbance in the medium is called a pulse



Ex: We clap our hands.

Classification of waves based on necessity of medium: Depending upon the requirement of medium for the propagation of wave, the waves are classified in the following two groups.

(i) Mechanical waves (or elastic waves]

(ii) Electromagnetic waves.

(i) Mechanical waves:

The waves which need a material medium for their propagation are called mechanical waves. The medium may be a solid, a liquid or a gas.

(OR)

The wave which required material media for their transmission is called mechanical wave.

Note: Mechanical waves cannot travel through vacuum.

Ex. Vibrations in a rope, vibrations in a stretched string, vibrations on the surface of water, sound waves in air etc., are the mechanical waves.

(ii) Electromagnetic waves (non-mechanical waves):

The waves which don't need a material medium for their propagation are called electromagnetic waves.

(OR)

The waves which do not required material media for their transmission is called electromagnetic waves.

Note: (i) electromagnetic waves can travel through vacuum.

ii) electromagnetic waves travel in vacuum with the speed of light i.e 3×10^8m/s

Example : Light waves, X-rays, Gamma rays, Radio waves, Microwaves etc., are the examples of electromagnetic waves.

Classification of waves based on propagation of wave & direction of vibrating particles: On the basis of the relative directions of the propagation of the wave with respect to direction of the periodic changes in the medium (such as displacement, pressure etc.) the waves are classified into the following two groups.

(i) Longitudinal waves (L.W) **(ii) Transverse waves (T.W)**

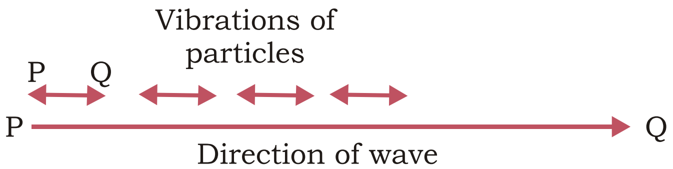
Longitudinal wave: A wave in which the particles of the medium oscillate (vibrate) to-and-fro (back and forth) in the same direction in which the wave is moving, is called a longitudinal wave. (OR)

A wave in which the particle of the medium vibrate up and parallel to the direction of wave is longitudinal wave.

Ex: 1. Sound waves in air 2. Waves in spiral spring

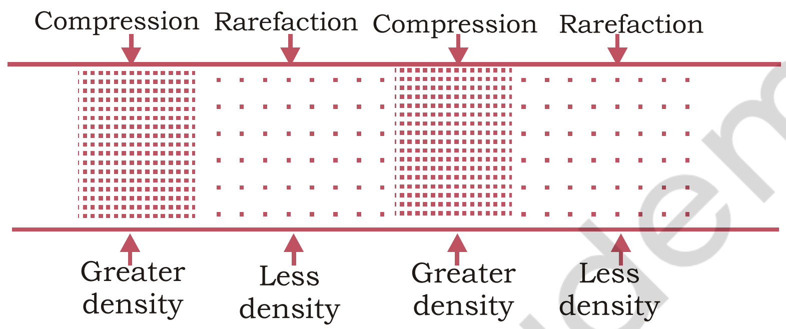
3. The waves produced in air when a sitar wire is plucked.

Representation of a longitudinal wave : In this figure, the direction of wave has been shown from P to Q, in the horizontal plane. The direction of vibrations of the particles is also along PQ, parallel to the direction of wave. That is, the particle of the medium vibrate back and forth in the horizontal direction.



Compression and Rarefactions of a longitudinal wave :

Compression : The part of a longitudinal wave in which the density of the particles of the medium is higher than the normal density is called a compression.



Pictorial representation of a longitudinal wave

Rarefaction : The part of a longitudinal wave in which the density of the particles of the medium is lesser than the normal density is called a rarefaction.

Note :

1. Compression and rarefaction are formed alternately in longitudinal wave.
2. The distance between the two successive compressions or between the two successive rarefactions is equal to one wavelength (λ).
3. Longitudinal waves can travel through all media i.e. solids, liquids and gases.
4. The phase difference between two successive compressions or rarefactions is equal to 2π radians.

The Sound waves in air are longitudinal waves: When a sound wave passes through air, the particles of air vibrate back and forth parallel to the direction of sound wave. Thus, when a sound wave travels in the horizontal direction, then the particles of the medium also vibrate back and forth in the horizontal direction.

It should be remember that the waves produced in air when a sitar wire is plucked are longitudinal waves, because those are sound waves.

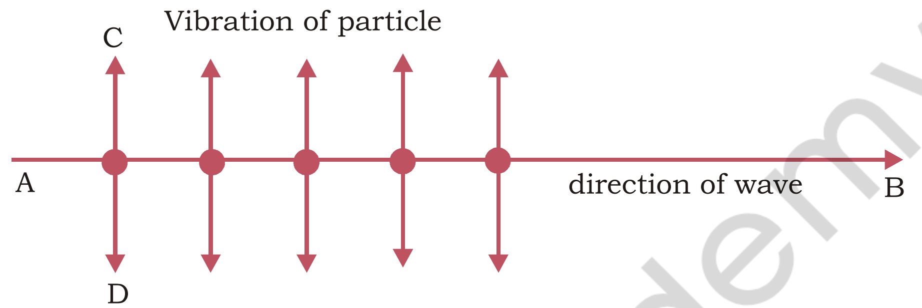
Transverse wave (T.W) : A wave in which the particles of the medium oscillate (vibrate) up and down, i.e perpendicular to the direction in which the wave is moving is called a transverse wave.

(OR)

If the particles of the medium vibrate perpendicular to the direction of the propagation of the wave then the wave is called transverse wave **(or)** When the particles of a medium oscillate at right angles to the direction of propagation of a wave, then the wave so produced is called a transverse wave.

Examples :
1. Waves on the surface of water
2. Waves on a long stretched rubber tube
3. Waves along a stretched string.
4. Even the light waves and radio waves are transverse waves.

Representation of a transverse wave : In this figure, the direction of wave is from A to B but the vibration of the particles are along CD which is at right angles to the direction of wave AB. So, this is a transverse wave.



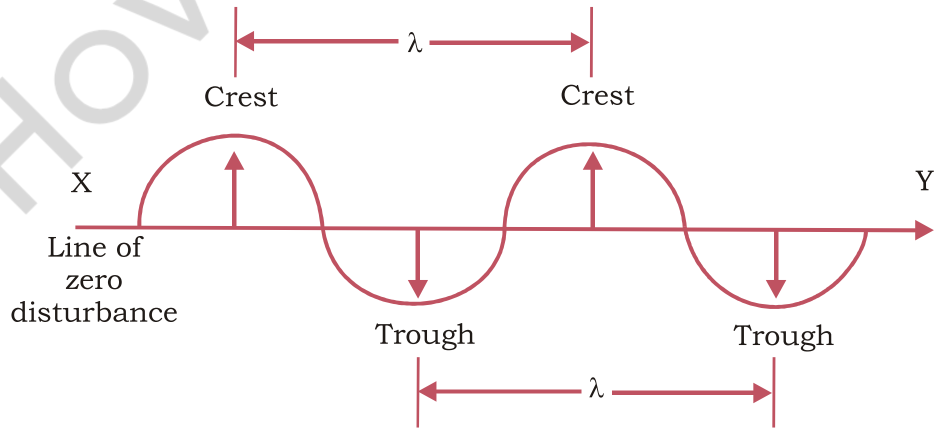
Representation of a transverse wave

Crest and trough of a transverse wave :

We know that when a transverse wave travels horizontally in a medium, the particles of the medium vibrate up and down in the vertical direction. When the vibrating particles move upward or above the line of zero disturbance, they form an 'elevation' or 'hump' and when the vibrating particles move downward or below the line of zero disturbance, they form a 'depression' or 'hollow'.

Crest: The 'elevation' or 'hump' in a transverse wave is called crest. In other words, a crest is that part of the transverse wave which is above the line of zero disturbance of the medium. In figure XY is the line is zero disturbance.

Trough : The 'depression' or 'hollow' in a transverse wave is called trough. In other words, a trough is that part of the transverse wave which is below the line of zero disturbance.



Crest and trough of a transverse wave

Note :

(1) The distance between the two consecutive crests or between the two consecutive troughs is equal to one wavelength (λ).

(2) The distance between a crest and the adjoining trough is $\frac{\lambda}{2}$

(3) A transverse wave cannot travel inside the liquid and in gases.

(4) Propagation of a transverse wave, through a medium, results in the formation of crests and troughs.

Difference between transverse waves and longitudinal waves :

Transverse waves	Longitudinal waves
1. In transverse waves, the particles of the medium vibrate at right angles to the direction of wave. 2. Transverse waves consist of crest and troughs. 3. Transverse waves can be propagated only through a solid or over the surface of a liquid but not in a gas. 4. In transverse waves, the distance between the two consecutive crests or between the two consecutive troughs is equal to one wavelength. 5. It is represented by displacement distance graph.	1. In longitudinal waves, the particles of the medium vibrate parallel to the direction of wave. 2. Longitudinal waves consist of compression and rarefactions. 3. Longitudinal waves can be propagated through solids, liquids, as well as gases. 4. In longitudinal waves, the distance between the two successive compressions or between the twp successive rarefactions is equal to one wavelength. 5. It is represented by density distance graph.

WORK SHEET - 1

Single Answer Type

1. The wave in which crests and troughs are formed
   1) longitudinal wave 2) transverse wave
   3) both (1) and (2) 4) none of these
2. If the distance between two consecutive crests is 52cm,then the distance between consecutive trough is
   1) 104cm 2) 26cm 3) 52cm 4) Zero
3. A stone is thrown in a pound of water .The result is formation of
   1) crests and troughs 2) compressions and rarefraction
   3) crests and rarefraction 4) troughs and compressions
4. Which of the following wave is a mechanical wave ?
   1) Light wave 2) Sound wave 3) Radio wave 4) Micro wave
5. The Wave in which compressions and rarefractions are formed
   1) Longitudinal 2) Transverse 3) Both (1) and (2) 4) Neither (1) nor (2)
6. Light wave is an example of
   1) Longitudinal wave 2) Electromagnetic
   3) Transverse wave 4) Both (2) & (3)

Multi Answer Type

7. Longitudinal waves can travel through
   1) solids 2) liquids 3) gases 4)air
8. Which of the following is true
   1) Transverse waves can propagate through solids
   2) Longitudinal waves cannot propagate through solids
   3) Transverse waves cannot propagate through gases
   4) Longitudinal waves can propagate through solids
9. Which of the following is true :
   1) Waves carry energy with them
   2) The disturbances move without the actual physical transfer of matter
   3) Property of inertia is a important characteristic of a good medium
   4) The disturbances move with the actual physical transfer of matter

Reasoning Answer Type

10. Statement I : When the displacement of particles of a medium is at right angles to the direction of wave, the wave is said to be a transverse wave.
    Statement II : When the displacement of particles of a medium is parallel to the direction of propagation of the wave, the wave is said to be longitudinal wave.
    1) Both Statements are true, Statement - II is the correct explanation of Statement-I
    2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
    3) Statement - I is true, Statement - II is false.
    4) Statement - I is false, Statement - II is true.

Comprehension Type

During longitudinal wave motion, the places where the particles are close are said to be in state of compression. While places where the particles are farther are said to be in the state of rare fraction.

11. At compressional regions the longitudinal wave have
    1) greater density 2) less density
    3) zero density 4) none
12. At rarefraction regions the longitudinal wave have
    1) greater density 2) less density
    3) zero density 4) none
13. Which of the following are example for longitudinal waves.
    1) sound waves in air 2) waves in spiral spring
    3) waves produced in air when a sitar wire is plucked 4) all of these

Matrix Matching Type

14.

Column-I	Column-II
a) speed of electromagnetic waves	1) longitudinal wave
b) waves in the spiral spring	2) 3×10^8 m/s
c) hump in a transverse wave	3) trough
d) depression in a transverse wave	4) crest
	5) 10^7 m/s

Integer Answer Type

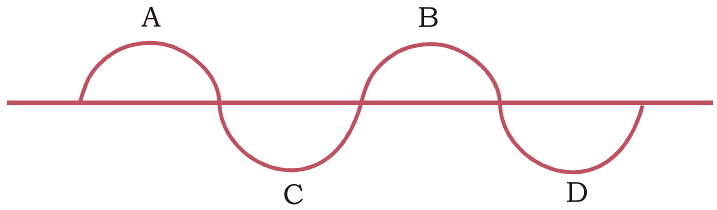
15. The speed of electromagnetic wave is _______ $\times$ 10^8 m/s

Subjective Answer Type

16. If the distance between a crest and the adjoining trough is 40 cm . then the wave length will be
17. If the distance between the crest and adjoining trough is 23cm, then the distance between the two consecutive crests is ______cm

SYNOPSIS - 2

1. **Phase :** The points on a wave which are in the same state of vibration are said to be in the same phase.



In the above figure A, B are in the same phase and C, D are in the same phase.
Ex : All points that lie on the crests are in the same phase similarly all points that lie on the trough are in the same phase.

2. **Time period (T) or Periodic time :** The time in which a vibrating body completes one vibration is called time period **or** The time required to produce one complete wave (or cycle) is called time period of the wave.
Ex : Suppose two waves are produced in 1 second. Then the time required to produce one wave will be 1/2 second or 0.5 second. In other words, the time period of this wave will be 0.5 second.
Note : The S.I unit of time period is second (s).

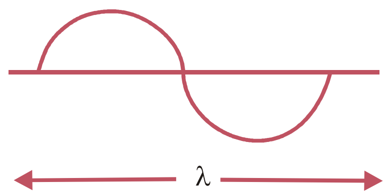
3. **Frequency (f or υ) :** The number of complete waves (or cycles) produced in one second is called frequency of wave **or** The number of vibrations per second is called frequency.
Unit : The S.I unit of frequency is hertz (which is written as Hz).
Hertz: When a vibrating body produces one vibration in one second, then its frequency is said to be one hertz.
1 hertz is equal to 1 vibration per second.

i.e. 1 hertz $= \dfrac{1 \text{ vibration (cycles)}}{1 \text{ second}}$, 1 kHz = 1000 Hz

Ex : If 10 complete waves (or vibrations) are produced in one second, then the frequency of the waves will be 10 hertz (or 10 cycles per second).
Note1: The frequency of a wave is fixed and does not change even when it passes through different substances.
Note2: It does not depend on the wave velocity, amplitude and nature of the medium.

4. **Wavelength (λ):** Wavelength of a wave is the length of one wave.
The distance travelled by the wave in one time period is called the wavelength **or** The distance between two nearest particles which are in the same phase is called wave length. It is denoted by the Greek letter λ (lambda).

Ex:



Here the length of the wave is λ.

Unit : The S.I unit of wave length is meter (m).

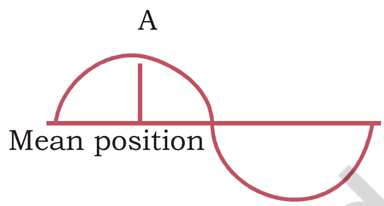
5. **Wave velocity (velocity of wave) :** The distance travelled by a wave in one second is called the velocity of wave. The wave velocity is denoted by v.

$$\text{Wave velocity} = \frac{\text{distance travelled by the wave}}{\text{time taken}}$$

Unit : The S.I unit of wave velocity is m/s or ms^{-1}.

6. **Amplitude (A) :** The maximum displacement of the particles of a medium from their mean positions during the propagation of a wave is called amplitude of the wave. It is represented by the letter 'A'.

Ex:



Here A is the amplitude of the wave.

Unit : The S.I unit of amplitude is metre (m).

Note : The amplitude of a wave is a measure of its energy. Thus the greater the amplitude of a wave, the greater the energy carried by the wave.

7. **Relation between time Period (T) and frequency (f):**

The frequency of a wave is the reciprocal of its time–period.

i.e., $\text{frequency} = \dfrac{1}{\text{time period}} \Rightarrow f = \dfrac{1}{T} \Rightarrow T = \dfrac{1}{f}$

Where f = frequency of the wave and T = time period of the wave.

Relationship between, time period, wavelength and velocity:

We know that, $\text{velocity of the wave} = \dfrac{\text{distance travelled by the wave}}{\text{time taken}}$

Suppose a wave travels a distance λ in time T, then $v = \dfrac{\lambda}{T}$

[i.e. the relation between wave velocity, wavelength and time period]

Hence T is the time taken by one wave. We know that $\dfrac{1}{T}$ becomes the number of waves per second and this is known as frequency (f) of the wave.

So the above equation can also be written as, $v = f \times \lambda$

Where, v = velocity of the wave, f = frequency, λ = wavelength

In other words velocity of a wave = frequency × wavelength

Thus, the velocity (or speed) of a wave in a medium is equal to the product of its frequency and wavelength. The formula $v = f \times \lambda$ is called wave equation.

1. The time period of a wave is equal to reciprocal of the frequency of a wave.

$$\text{i.e., } T = \frac{1}{f} \quad \Rightarrow f = \frac{1}{T}$$

2. Wave velocity $= \dfrac{\text{distance travelled by the wave}}{\text{time taken}} \Rightarrow v = \dfrac{\lambda}{T}$

3. Velocity of a wave = frequency × wavelength

$$v = f \times \lambda \qquad \Rightarrow f = \frac{v}{\lambda} \quad \Rightarrow \lambda = \frac{v}{f}$$

WORK SHEET - 2

Single Answer Type

1. The reciprocal of time period of the wave is called __________of the wave.
   1) wave velocity 2) frequency 3) wave length 4) amplitude
2. The points on a wave which are in the same state of vibrations are said to be in the same
   1) phase 2) time period 3) frequency 4) wave velocity
3. A wave of wave length 0.60cm is produced in air and it travels at a speed of 300m/s.Then the frequency will be
   1) 5000Hz 2)50000Hz 3)500Hz 4)50Hz
4. A tuning fork produces 256 waves in 2 seconds. Calculate the frequency of the tuning fork.
   1) 1.120 Hz 2) 125 Hz 3) 128Hz 4) 130Hz
5. The maximum displacement of the particles of a medium from their mean positions during the propagation of a wave is
   1) amplitude of the wave 2) velocity of the wave
   3) frequancy of the wave 4) none
6. Choose the correct statement:
   1) The frequency of a wave is fixed and does not change even when it passes through different substances.
   2) The time required to produce one complete wave (or cycle) is called time period of the wave.
   3) When a vibrating body produces one vibration in one second, then its frequency is said to be one hertz
   4) The S.I unit of time period is second (s).
7. which of the following is true :
   1) The time interval between the formation of two successive crests (or) troughs is called time period
   2) The S.I unit of frequency is Hz
   3) The S.I unit of wave length is m
   4) The S.I unit of wave velocity is m/s or ms^{-1}.

Reasoning Answer Type

8. Statement I : The relation between wave velocity(v) ,wave length(λ) and frequency(n) is $\lambda = v \times n$

Statement II : The relation between wave velocity(v) ,wave length(λ) and frequency(n) is $\lambda = \frac{v}{n}$

1) Both Statements are true, Statement - II is the correct explanation of Statement-I
2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
3) Statement - I is true, Statement - II is false.
4) Statement - I is false, Statement - II is true.

Comprehension Type

The distance travelled by a wave in one second is called the velocity of wave

9. The velocity of sound in air is 344 m/sec . what is the wavelength of a sound wave of frequency 32Hz?

1) 9.75m 2) 10.75m 3) 7.5m 4) 8.25m

10. A wave travels at a speed of 330m/s. If wavelength is 2.2cm, what will be the frequency of the wave ?

1) 15,000Hz 2)14,500Hz 3) 15,500Hz 4)14,000Hz

11. Calculate the wavelength of radio waves of frequency 10^9Hz. The speed of radio waves is 3×10^8 m/s.

1) 20cm 2) 35cm 3)30cm 4) 25cm

Matrix Matching Type

12.

Column-I frequency	Column-II Time period
a) 40 Hz	1) 0.02 sec
b) 100 Hz	2) 0.05 sec
c) 50 Hz	3) 0.01 sec
d) 20 Hz	4) 0.025 sec
	5) 0.04 sec

Integer Answer Type

13. The velocity of sound in air is 340 m/sec. Then ___ m is the wavelength of a sound wave of frequency 34Hz?

Subjective Answer Type

14. A sound wave travelling in air has wavelength of 1.6×10^{-2}m. If the velocity of sound is 320m/s, calculate the frequency of sound.

15. Two sound waves in air have wavelength ratio 1:3. Then their frequency ratio will be

SYNOPSIS - 3

Sound:

Sound is a form of energy which emitted by a vibrating body that travels in the form of waves and causes the sensation of hearing. Sound cannot travel through vacuum.

Production of sound:

We hear many sounds every day such as the sound of our school bell, an alarm clock, a barking dog and so on. We talk and communicate with others by producing sounds.

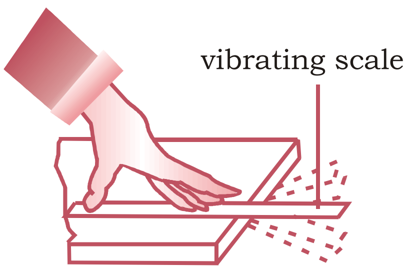
Sound is produced when a body vibrates (moves back and forth rapidly). In other words, sound is produced by vibrating bodies.

Note: Vibrations of the bodies produces sound so vibrations are the causes of sound.

The following experiments demonstrate this fact.

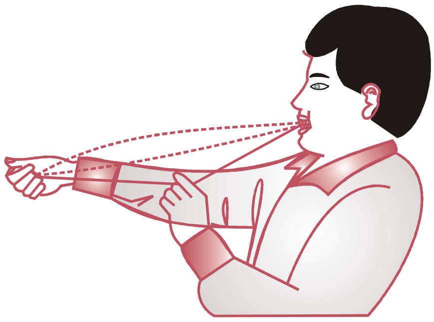
Activity (1): Take a drum and beat it. Observe what happens you will hear the sound of the drum. Now, touch the membrane of the drum. What do you feel? You will be able to feel its vibrations. When the sound stops, touch the membrane of the drum again, you will not feel any vibrations so we can say that only vibrating membrane of the drum produces sound.

Activity (2): Take a metre scale and place it on a table end press the metre scale with one hand and cause it to vibrate as shown in figure you will see that the vibrating metre scale produces sound. Now stop the metre scale from vibrating (by touching it with your five-finger). It will also stop producing sound.



A vibrating object

Activity (3): Stretch a string by holding one end in your mouth under the teeth and the other end in one hand pluck it near the middle you will notice that the string starts vibrating and a sound is heard. After some time when the string stops vibrating, so sound is heard.



Stretching string produces sound

EXPERIMENT:

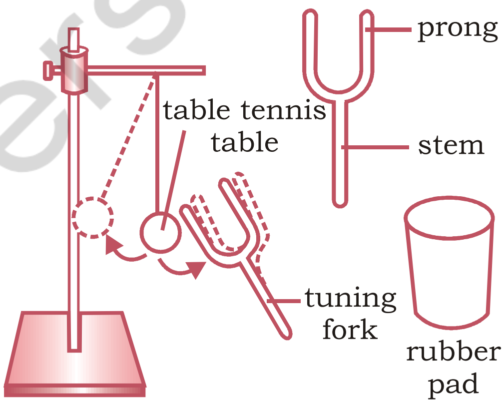
Aim: To demonstrate that sound is produced by a vibrating body.

Aids: Tuning fork, Rubber pad, Table tennis ball, Thread, Stand

Method: Hit the tuning fork hard against a rubber pad. It produces sound. If you look at the prongs of the tuning fork closely, they look hazy because they are vibrating. Suspend the table tennis ball with the thread tied to the stand. Bring the prong of the vibrating tuning fork near the ball.

Observation: The ball jumps to-and-fro. This shows that the prongs of the tuning fork are vibrating.

Result: Every source of sound is a vibrating body.



Tuning fork produces sound.

Sound need a material medium to travel:

The substance through which sound travels is called a medium. The medium can be a solid substance, a liquid or a gas.

Solids, liquids and gases are called material media. Sound needs a material medium like solid, liquid or gas to travel.

In other words, sound can travel through solids, liquids and gases but it cannot travel through vacuum (or empty space). Sound waves are called mechanical waves because they need a material medium (like solid, liquid or gas) for their propagation.

Note: Sound travels about 15 times faster in steel than in air.

EXPERIMENT :

Aim: To demonstrate that sound requires a medium for propagation.

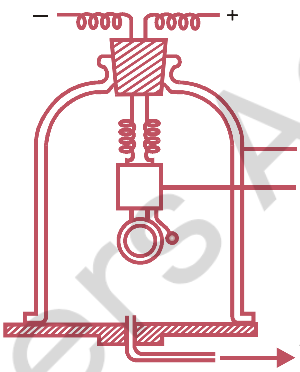
Aids: Electric bell, Glass bell jar, Vacuum pump, Battery

Method: Place the electric bell inside the glass bell jar and connect it to a battery. When the circuit is closed, you can hear the bell ring. The jar contains air and sound travels through this air.

Now, remove the air from the jar with the help of the vacuum pump connected to the bell jar. As the air is taken out, the loudness of the sound slowly decreases until the sound becomes too faint. Finally you cannot hear the bell even though the hammer of the bell is seen striking the gong as before.

Allow air to enter the jar gradually. You will hear the sound slowly increasing.

Result: Sound cannot propagate in the absence of a material medium like solid, liquid or gas.



The speed of sound: Sound takes some time to travel from the sound producing body to our ears.

The speed of sound tells us the rate at which sound travels from the sound travels from the sound producing body to our ears.

Speed of sound in different media: The speed of sound is different in different media. The speed of sound is more in solids, less in liquids and least in gases (since solids are much more elastic than liquids and gases). The speed of sound is nearly 5100 m/s in steel, 1450 m/s in water and 330 m/s in air at 0^0C.

Mathematical formula for speed of sound:

1. Speed of sound $= \dfrac{\text{Distance travelled by sound}}{\text{time taken}}$

2. Laplace's formula for velocity of sound, $v = \sqrt{\frac{\gamma P}{\rho}}$

Where $\gamma = \frac{C_p}{C_v} = \frac{\text{specific heat at constant pressure}}{\text{specific heat at constant volume}}$

P = Pressure of the medium. ρ = density of the medium.

Factors affecting the speed of sound in air or in a gas:

i) Density ii) Temperature iii) Humidity iv) Direction of wind

1. **Effect of density:** as $v \propto \frac{1}{\sqrt{\rho}}$ i.e

The speed of sound is inversely proportional to the square root of the density of the medium.

Ex: The density of oxygen is 16 times the density of hydrogen, therefore the speed of sound in hydrogen is four times the speed of sound in oxygen.

2. **Effect of temperature:** The speed of sound increases with the increase in temperature of a gas.

It is found that the velocity of sound in a gas is directly proportional to the square root of its absolute temperature i.e

$v \propto \sqrt{T}$, The reason is that with the increase in temperature there is a decrease in the density and consequently, the speed of sound increases.

The speed of sound in air increases by about 0.6 m/s (or 60 cm per second) for each degree Celsius rise in temperature i.e $V_t = V_0 + 0.6\ t$

Ex: Speed of sound in dry still air at 0°C is 330 m/s. At 25°C, the speed of sound in dry still air will be $V_{25} = V_0 + 0.6t = 330 + 0.6 \times 25 = 345$ m/s

3. **Effect of humidity:** The speed of sound increases with the increase in humidity.

The presence of water vapour in the air changes its density. The presence of water vapour reduces the density of air i.e density of moist air < Density of dry air therefore, velocity of sound in moist air > velocity of sound in dry air.

$$\left[\text{since } v \propto \frac{1}{\sqrt{\rho}}\right]$$

Hence, the velocity of sound in moist air is greater than the velocity of sound in dry air. That is why sound travels faster on a rainy day than on a dry day.

4. **Effect of wind:** The speed of sound increases or decreases according to the direction of wind.

i) If the wind blows in the same direction in which the sound travels, the velocity of sound increases i.e velocity of sound = velocity of sound in still air + velocity of wind.

i.e $v = v_s + v_w$

ii) If the wind blows in the opposite direction in which the sound travels, the velocity of sound decreases i.e velocity of sound = velocity of sound in still air

– velocity of wind

i.e $v = v_s - v_w$

Factors which do not affect the speed of sound in air:

There is no effect on the speed of sound in air due to the following factors.

i) Change in frequency ii) Change in amplitude iii) Change in pressure

iv) Change in factors like phase, loudness, pitch, quality of sound etc.

Effect of pressure:

We know, $v = \sqrt{\frac{\gamma P}{\rho}}$

Thus, if the temperature of a gas remains constant, a change in pressure of the gas remains constant, a change in pressure of the gas changes its density in the same ratio i.e if pressure P of the gas is doubled, the volume becomes half, so density (m/v) gets doubled. So P/ρ remains unchanged.

Consequently, the velocity of sound is independent of the pressure of the gas provided the temperature remains constant.

Comparison of speed of sound with speed of light: The speed of light in air is 3×10^8 ms^{-1} which is about a million times larger as compared to the speed of sound in air i.e 330 m s^{-1} at 0^0C.

Apart from this, the speed of light decreases in a denser medium (speed of light in water is 2.25 × 108 ms^{-1}, in glass is 2 × 108 ms^{-1}), while the speed of sound is more in solids, less in liquids and still less in gases (speed of sound in steel is nearly 5100 m s^{-1}, in water is nearly 1450 m s^{-1} and in air is nearly 330 m s^{-1}).

Lightning is seen much earlier than the thunder is heard: In thundering, the light is seen much earlier than the sound of thunder is heard although they are produced simultaneously, as light takes almost negligible time in comparison to sound in reaching us from the thunder.

1. Speed of sound $= \frac{\text{Distance travelled by sound}}{\text{Time taken}}$

2. Laplace's formula for velocity of sound, $v = \sqrt{\frac{\gamma P}{\rho}}$

3. The velocity of sound in a gas is directly proportional to the square root of its absolute temperature i.e $v \propto \sqrt{T}$

4. The velocity of sound is inversely root of the density in a medium. i.e $v \propto \frac{1}{\sqrt{d}}$

5. Velocity of sound independent on frequency, amplitude and pressure.

WORK SHEET - 3

Single Answer Type

1. Mechanical (elastic) waves can travel
 1) in a medium but not in a vacuum
 2) in a vacuum but not in medium
 3) in a vacuum as well as in a medium.
 4) neither in vacuum nor in a medium.
2. Calulate the velocity of sound in oxygen if the velocity of sound in hydrogen is $1248ms^{-1}$
 1) $312ms^{-1}$ 2) $78ms^{-1}$ 3) $624ms^{-1}$ 4) $342ms^{-1}$
3. Factors which affect the speed of sound in air
 1) Density 2) Temperature 3) Humidity 4) All of these
4. Which wave does not required material medium for their propagation ?
 1) electromagnetic waves 2) mechanical waves
 3) both (1) and (2) 4) none of these

Multi Answer Type

5. choose the correct option:
 1) The speed of sound is different in different media.
 2) The speed of sound is nearly 5200 m/s in steel
 3) The speed of sound is 4501 m/s in water
 4) The speed of sound is 3330 m/s in air at 0^0C
6. Sound can travel through
 1) Solids 2) liquids 3) gases 4) vacuum
7. Factores which does not effect the speed of sound in air is
 1) Change in frequency 2) Change in amplitude
 3) Change in pressure 4) Change in temperture

Reasoning Answer Type

8. Statement I : Sound waves do not require medium for propagation
 Statement II : Sound waves are called mechanical waves
 1) Both Statements are true, Statement - II is the correct explanation of Statement-I
 2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
 3) Statement - I is true, Statement - II is false.
 4) Statement - I is false, Statement - II is true.

Comprehension Type

Sound not only travel throught air or gases, but also through solids as well as liquids .

9. Speed of the sound is more in
 1) Solids 2) liquids 3) gases 4) Same in all

10. Speed of the sound is more in
 1) steel 2) water 3) rubber 4) wood
11. Speed of the sound is less in
 1) Solids 2) liquids 3) gases 4) zero in all

Matrix Matching Type

12.

Column-I	Column-II
a) Density decreases	1) Speed of sound increases
b) temperature increases	2) Speed of sound decreases
c) Humidity decreases	3) no effect
d) effect of wind	4) based on direction of wind

Subjective Answer Type

13. Calculate the temperature at which the velocity of sound in oxygen (O_2) is same as that in hydrogen (H_2) at 27^0C

SYNOPSIS - 4

Reflection of sound:

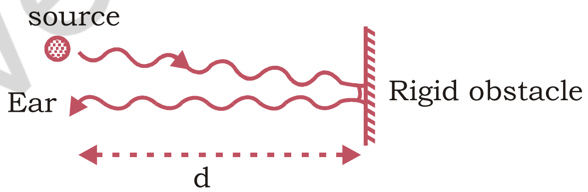
The bouncing back of sound when it strikes a hard surface is called the reflection of sound.

Echo:

It is a common experience that when we shout infront of a high mountain or a deep valley or a deep wall or in a big empty hall, we hear our sound back after a few seconds. This is known as echo. An echo is simply a reflected sound. Thus, the sound heard after reflection from a rigid obstacle is called an echo.

or

The repetition of sound caused by the reflection of sound waves is called an echo.



Minimum distance of hear an echo:

The human ear can hear two sounds separately only if they reach the ear after an interval of 1/10th of a second. This is a natural feature of the human ear. If we take the speed of sound roughly as 340 m/s, the distance travelled by sound in 1/10th of a second would be 34 m. This means that we are able to hear the original and the reflected sound if we are at a distance of 17 m or more from the reflecting surface. This results in hearing the reflected wave known as echo.

Calculation of minimum distance to hear an echo:

We know that:

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

Speed of sound = 340 m/s (in air)

Time taken = $\frac{1}{10}$ s (persistence of hearing)

(time gap between the original sound and its echo)

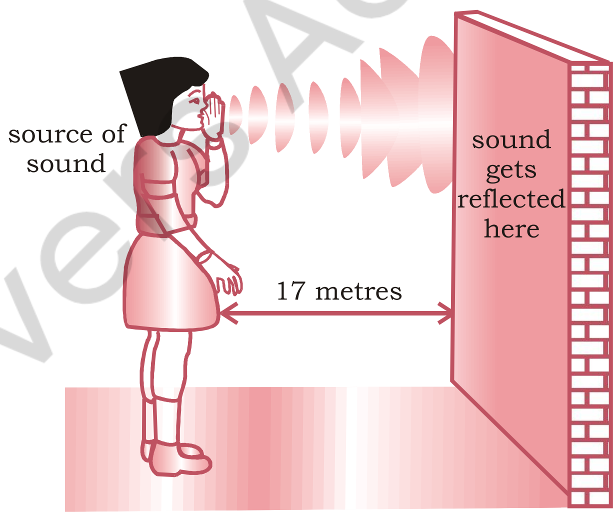
Distance travelled = ?

Now, putting these values in the above formula, we get:

$$340 \text{ m/s} = \frac{\text{Distance travelled}}{\frac{1}{10}\text{ s}}$$

$$\text{Distance travelled} = 340 \times \frac{1}{10} = 34 \text{ meters}$$

Thus, the distance travelled by sound in going from us (the source of sound) to the sound reflecting surface (wall), and then coming back to us should be 34 metres. So our distance from the sound reflecting surface (like a wall, etc,) to hear an echo should be half of 34 metres which is 34/2 = 17 metres. From this, we conclude that the minimum distance from a sound reflecting surface (like wall, etc) to hear an echo is 17 metres.

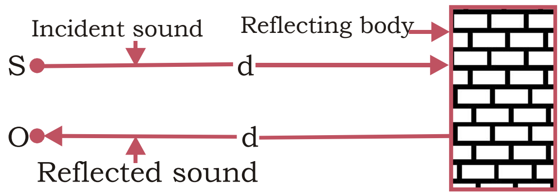


Minimum distance 17 metres between the source and the reflector produces echo.

Relation between speed of sound, time of hearing echo and distance from reflecting body.

If t is the time in which an echo is heard, d is the distance between the source of sound and the reflecting body, and v is the speed of sound, then the total distance travelled by the sound is $2d$.

S = Source of sound
d = Distance between source of sound and reflecting body.
O = Observer



$\therefore$ In the time t seconds. distance travelled by sound = 2d

Hence, in time 1 seconds. distance travelled by sound $= \frac{2d}{t}$

But, distance travelled by sound in 1 second. = Speed of sound

$\therefore \; v = \frac{2d}{t}$ or $t = \frac{2d}{v}$ or $d = \frac{v \times t}{2}$

Conditions for the formation of an echo:

1. The minimum distance between the source of sound and the reflecting body should be 17 meters.
2. The wavelength of sound should be less than the height of the reflecting body.
3. The intensity of sound should be sufficient, so that it can be heard after reflection.

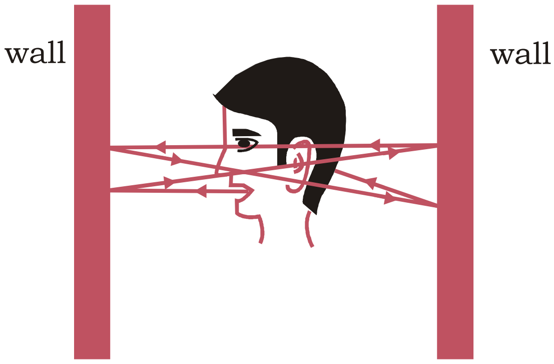
Reverberation:

If a sound is made in a big hall, the sound waves are reflected from the walls, ceiling and floor of the hall, and produce many echoes. The echo time however, so short that the many echoes overlap with the original sound. Due to this original sound seems to be prolonged and lasts for a longer time. In other words, a sound made in a big hall persists (on lasts) for a longer time.

The repeated multiple reflection of sound in any big enclosed space is called reverberation.

(or)

The persistence of sound in a big hall due to repeated reflection from the walls ceiling and floor of the hall is called reverberation. Thunder that follows lightning flash during a storm is an excellent example of reverberatory or multiple echoes. Reverberations are also produced in a closed room.



Echoes from two reflecting surfaces produces reverberations.

Note: To reduce the reverberation to almost zero level, the walls and the ceiling of the hall are covered with sound absorbing materials, such as rough plaster, fibre board or loose woolen or cotton cloth.

Note: If the distance between the observer and the cliff (obstacle) is d, and the speed of sound in air is v, then the time 't' after which the echo is heard is

$$t = \frac{\text{Total distance travelled}}{\text{speed of sound in air}}$$

$$\therefore \quad t = \frac{2d}{v}$$

Application of echo:

SONAR (Sound Navigation and Ranging): The reflection of sound can be used for measuring the depth of a sea at a certain place. The instrument used for this purpose is called SONAR which is carried in a ship.

SONAR is a device which is used to find the depth of a sea or to locate underwater objects like enemy's. submarine, shoals of fish.

We here different types of sound around us. Some sounds are pleasant to our ears, whereas some unpleasant.

Musical Sound :

Musical sound is produced by periodic vibrations. It has regular wave forms. Musical sound is produced by musical instruments like sitar, violin and drum. It produces a pleasant effect on the ear. Musical sound is one which produces pleasing sensation.

Thus, sounds which are pleasing to the ears are called music.

Noise :

Noise is produced by non-periodic vibrations. It has irregular wave forms. Noise is produced by machines in a factory, moving train by the traffic at a busy crossing, horns by trucks and buses are the example of noise. It produces an unpleasant effect on the ear.

Difference between musical sound and noise :

Musical Sound	Noise
1. Effect on Ear : It has pleasant effect on the ear	**1.** It has un - pleasant effect on the ear
2. Types of vibration : Made by regular and periodic vibrations	**2.** Made by irregular and non - periodic vibrations
3. Frequency : Has a definite frequency	**3.** Does not have a definite frequency
4. Source : It is produced by musical instruments	**4.** It is produced by machines in a factory moving buses, cars and trains etc.,
5. Wave form : Has an regular wave form	**5.** Has an irregular wave form
6. Nature : Can be reproduced	**6.** Can not be reproduced

WORK SHEET - 4

Single Answer Type

1. Regular periodic vibrations produced
   1) Musical sound 2) noise 3) Both (1) and (2) 4) Neither (1) nor (2)
2. Multiple echoes are also called
   1) Reflecting sound 2) Reverberation
   3) Ultra sound 4) None of these
3. Which one of the following material will reflect sound better?
   1) thermocole 2) curtain made from cloth
   3) steel 4) paper
4. A boy stands 66.4m in front of a building and then blows a whistle .its time interval when he hears an echo.(take speed of sound =332m/s)
   1) 0.6 sec 2)0.4 sec 3)0.8 sec 4)0.2 sec

Multi Answer Type

5. Musical sounds are
   1) Definite frequency 2) can be reproduced
   3) Produced by musical instruments 4) can't be reproduced
6. An echo returned in 3s. Then the distance of the reflecting surface from the source is (given that the speed of sound is 342m/s)
   1) 13200cm 2)513m 3) 132m 4)51300cm

Reasoning Answer Type

7. Statement I : Noise are made by irregular and non-periodic vibrations
Statement II : Reflection of sound is called echo
1) Both Statements are true, Statement - II is the correct explanation of Statement-I
2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
3) Statement - I is true, Statement - II is false.
4) Statement - I is false, Statement - II is true.

Comprehension Type

$$\text{speed of sound} = \frac{\text{Total distance travelled}}{\text{Time taken}} \quad \text{or} \quad V = \frac{2d}{t}$$

8. A boy stands 80m in front of a high wall and then blows a whistle .Then the time interval when he hears an echo is (speed of sound =340m/s)
1) 0.37 2) 0.57 3) 0.47 4) 0.17
9. A man stands at a distance of 255m from a cliff .He fires a gun and heard the echo after 1.5seconds.What will be the velocity of the sound ?
1) 330m/s 2)340m/s 3)320m/s 4)335m/s
10. A boy stands 166 m in front of a building and then blows a whistle .its time interval when he hears an echo.(take speed of sound =332m/s)
1) 1 sec 2) 4 sec 3) 8 sec 4) 3 sec

Matrix Matching Type

11.

Column-I	Column-II
a) The minimum distance between man and wall to listen the echo is	1) Echo
b) SONAR works based on the principle	2) 0.1sec
c) Persistence of hering of human ear	3) 17m
d) Reflection of sound	4) Reverberation

Integer Answer Type

12. A boy stands 85m in front of a high wall and then blows a whistle .Then the time interval when he hears an echo is _____ $\times$ 10^{-1} sec.(speed of sound =340m/s)

Subjective Answer Type

13. An echo is heard after 0.8s , when a person fires a cracker 132.8m from a high building. what is the speed of sound ?
14. A man standing near a cliff with a seconds pendulum fires a gun when the pendulum is at the mean position and hears the echo when it just reaches the extreme position.If the speed of sound is $340ms^{-1}$.Calculate his distance from the cliff

WORK SHEET – 1 (KEY)				
1) 2	**2)** 3	**3)** 1	**4)** 2	**5)** 1
6) 4	**7)** 1,2,3,4	**8)** 1,3,4	**9)** 1,2,3	**10)** 2
11) 1	**12)** 2	**13)** 4	**14)** 2,1,4,3	**15)** 3

WORK SHEET – 2 (KEY)				
1) 2	**2)** 1	**3)** 2	**4)** 3	**5)** 1
6) 1,2,3,4	**7)** 1,2,3,4	**8)** 4	**9)** 2	**10)** 1
11) 3	**12)** 4,3,1,2	**13)** 10		

4. In 2 seconds, the number of waves produced = 256

$\therefore$ in 1 second the number of waves produced $= \frac{265}{2} = 128$

$\therefore$ Frequency of the tuning fork = 128 Hz.

10. $v = 330$ m/s, $\lambda = 2.2\,\text{cm} = 0.022\,\text{m}$, $f = ?$

We know, $v = f\lambda \Rightarrow f = \frac{v}{\lambda} = \frac{330}{0.022}\,\text{Hz} = 15{,}000\,\text{Hz}$

14. $V = \frac{\lambda}{T} = \lambda f \Rightarrow f = \frac{V}{\lambda} = \frac{320}{1.6\times10^{-2}} = 20{,}000\,Hz$

15. We know, $v = f\lambda \Rightarrow f = \frac{v}{\lambda} \Rightarrow f \propto \frac{1}{\lambda}$ As wave length ratio = 1 : 3

$\therefore$ frequency ratio = 3 : 1

WORK SHEET – 3 (KEY)				
1) 1	**2)** 1	**3)** 4	**4)** 1	**5)** 1,2
6) 1,2,3	**7)** 1,2,3	**8)** 4	**9)** 1	**10)** 1
11) 3	**12)** 1,1,2,4			

2. $\frac{v_1}{v_2} = \sqrt{\frac{d_2}{d_1}} \Rightarrow \frac{v_1}{1248} = \sqrt{\frac{1}{16}} \Rightarrow \frac{v_1}{1248} = \frac{1}{4}$

$v_1 = \frac{1248}{4} = 312ms^{-1}$

13. $\frac{T_H}{M_H} = \frac{T_0}{M_0} \Rightarrow \frac{300}{2} = \frac{T_0}{32} \Rightarrow T_0 = 16 \times 300 = 4800$

$\Rightarrow T_0 = 4800 - 273 = 4527° C$

WORK SHEET – 4 (KEY)				
1) 1	**2)** 2	**3)** 1	**4)** 2	**5)** 1,2,3
6) 2,4	**7)** 2	**8)** 3	**9)** 2	**10)** 1
11) 3,1,2,(1,4)	**12)** 5			

13. Speed of sound $= \frac{2d}{t}$

$= \frac{2 \times 132.8}{0.8}$

$= \frac{2 \times 1328}{8} = 332 m/s$

14. Let the distance be 'd'. The time taken for one complete oscillation (i.e.) the time period) by a seconds pendulum = 2s.

$\therefore$ The time taken for it to move from the mean to the extreme position = $\frac{1}{4} \times 2s = 0.5s$

speed of sound = $340ms^{-1}$

Distance travelled by sound before the echo is heard = 2d

$\therefore$ 2d = speed × time

2d = 340 × 0.5 $\Rightarrow$ d = 85 m

ELECTRICITY

SYNOPSIS - 1

Electric current:

The rate of flow of charge in a circuit is called electric current. In other words, it is the amount of charge flowing per second. It is denoted by the the letter I.

If Q is the charge which is flowing through a conductor in time t, then current is given by $I = \frac{Q}{t}$

Unit of current:

The S.I unit of current is ampere and it is denoted by the letter 'A'.

The S.I unit of Q is coulomb and that of t is second.

Thus, the S.I unit of electric current is $\frac{1\,\text{coulomb}}{1\,\text{second}} = 1A$

Definition of ampere:

When a charge of coulomb flows through a conductor in one second, then the current flowing through the conductor is said to be one ampere.

Thus, when 1 coulomb of charge flows through a conductor in 1 second, then the current flowing through it is said to be 1 ampere.

1 ampere $= \frac{1\,\text{coulomb}}{1\,\text{second}}$

Smaller units of electric current:

Sometimes smaller units of current are also used. These are microampere and milliampere.

1 microampere = $1\,\mu A = 10^{-6}$ A

1 milliampere = $1\,mA = 10^{-3}$ A

Bigger unit of electric current:

Sometimes the magnitude of the current flowing in a conductor is very large. This large magnitude of current is expressed in bigger units, such as kilo ampere and mega ampere.

1 kilo ampere (kA) = 1000 A = 10^3 A

1 mega ampere (MA) = 1,000,000 A = 10^6 A.

Flow of current: In metals, the moving charges are the electrons constituting the current, while in electrolytes and ionized gases, electrons and positively charged ions are the ions moving charges which constitute current.

The charge on an electron is negative and is -1.6×10^{-19} coulomb (symbol C). Therefore, I C charge is carried by electrons. Hence if I A current flows through a conductor, it implies that 6.25×10^{18} electrons pass in 1 second across the cross section of the conductor.

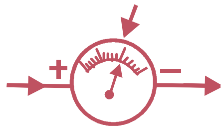
The direction of current is conventionally taken opposite to the direction of motion of electrons.

If n electrons pass through a cross section of a conductor in time t, then total charge passed

Q = n × e and current in conductor $I = \frac{Q}{T} = \frac{ne}{t}$

Instrument by which current measured:

Current is measured by an instrument called ammeter.



WORK SHEET - 1

Single Answer Type

1. If the electronic charge is 1.6×10^{-19} C, then the number of electrons passing through a section of wire per second, when the wire carries a current of 2ampere is
   1) 1.2×10^{-12} A 2) 1.25×10^{19} A 3) 1.6×10^{-8} A 4) 1.6×10^{4} A
2. A conductor carries a current of 2A. How long will it take for 1800C of electricity to flow through a given cross-section ?
   1) 15min 2) 10 min 3) 5 min 4) 1 min
3. The rate of flow of charge in a circuit is called
   1) Electric potential 2) Electric current
   3) Electric charge 4) All of these
4. If 'Q' is the charge which is flowing through a conductor in time 't' then current ' I' is given by
   1) $I = Q \times t$ 2) $I = Q/t$ 3) $I = Q + T$ 4) $I = Q^2 /T$

Reasoning Answer Type

5. Statement - I : When a charge of 1 coloumb flows through a conductor in one second then current flowing through the conductor is said to be one ampere.
   Statement - II : Electron is negatively charge body.
   1) Both Statements are true 2) Both Statements are false.
   3) Statement - I is true, Statement - II is false.
   4) Statement - I is false, Statement - II is true.

6. Statement - I : Current is said to be one ampere when 6.25x 10^{18}electrons passing through the conductor in unit time.

Statement - II : $I = \frac{ne}{t}$.

1) Both Statements are true
2) Both Statements are false.
3) Statement - I is true, Statement - II is false.
4) Statement - I is false, Statement - II is true.

Multi Answer Type

7. Choose the correct statements :
1) One micro ampere = 10^{-6} A
2) One milli ampere = 10^{-3}A
3) One kilo ampere = 10^{3}A
4)One mega ampere = 10^{6}A

8. In metals moving charges constituting current are
1) Electrons
2) Positively charged ions
3) Protons
4) All of these

Matrix Matching Type

9.

Column - I	**Column - II**
a) Instrument used to measure current	1) Ammeter
b) S.I. Unit of charge	2) Coloumb
c) S.I. Unit of current	3) Ampere
d) Magnitude of charge on an electron	4) 1.6×10^{-19}

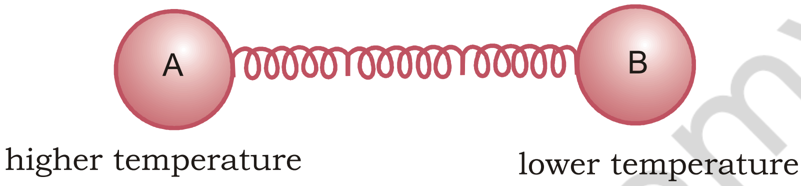
Integer Answer Type

10. One coloumb per second = ________ ampere

SYNOPSIS - 2

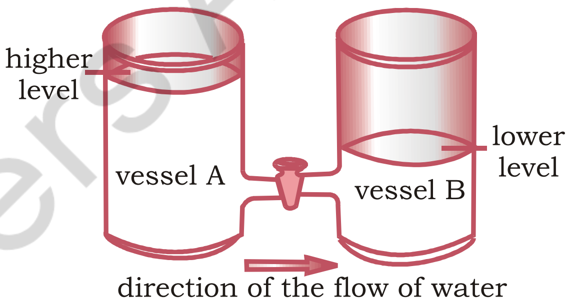
Introduction:

When two bodies at different temperatures are brought in contact then irrespective of the quantity of heat contained by the two bodies, heat flows from the body at higher temperature to the body at lower temperature by conduction. This heat continues to flow till both the bodies acquire the same temperature



Heat flows from the body at higher temperature to the body at lower temperature.

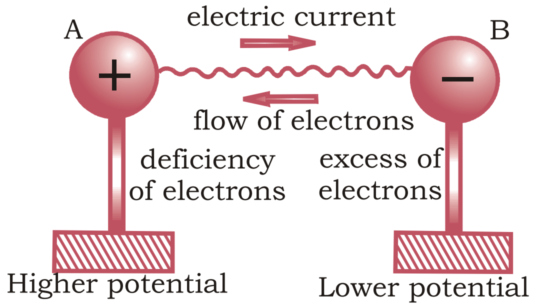
Similarly, if two vessels containing water at different levels are connected together, the water flows from the vessel containing water at a higher level to the vessel containing water at a lower level irrespective of the quantity of water contained in the two vessels. This flow of water continues till both the vessels have water at the same level



Water (or any liquid) flows from higher level to lower level.

In a similar manner, if two charged conductors are joined by a metallic wire (or they are placed in contact), then the direction of flow of electrons is determined by a quantity called the **potential** of the conductor.

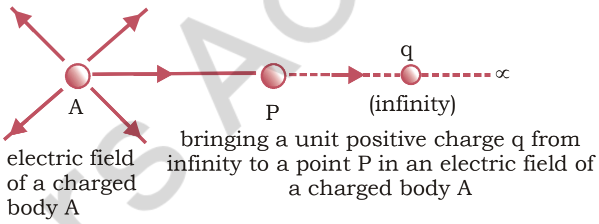
The conductor having excess of electrons is negatively charged and said to be at a lower potential, while the conductor having deficiency of electrons is positively charged and said to be at a higher potential. Keeping the convention of flow from the higher to the lower level, the electric current is said to flow from the region of higher potential to the region of lower potential (conventional direction of electric current), i.e. in the direction opposite to the direction of flow of electrons which actually constitutes the electric current



Convention current flows from A to B.
Electronic current flows from B to A.

The movement of electrons (or the flow of current) continues as long as there is a difference in potential between the two conductors. Once the two conductors have the same potential, the flow of current stops. As we know, like charges repel each other; unlike charges attract each other, hence work involved in moving a charge in the vicinity of another charge. Therefore, quantitatively the potential is measured in terms of the work done in moving the charge against the forces of repulsion.

The electric potential (or simply potential) at a point in an electric field is defined as the of work done in bringing a unit positive charge from infinity to that point.



Electric potential at a point P

Note: 1. Electric potential is denoted by V.
2. Electric potential is a scalar quantity.

If W is the amount of work done in bringing a unit charge q from infinity to a point, then the electric potential (V) at that point is given by,

$$\textbf{Electric potential (V)} = \frac{\text{Work done}}{\text{Change}} = \frac{W}{q}$$

Unit of electric potential:

The S.I unit of work is joule (symbol J) and that charge is coulomb (symbol C).

So, if W = 1 joule and q = 1 coulomb, then SI unit of

$$\text{electric potential} = \frac{1\text{ joule}}{1\text{ coulomb}} = \frac{1J}{1C} = 1JC^{-1}$$

The unit J C^{-1} (joule per coulomb) is called volt (V).] So, the S.I unit of electric potential is volt which is denoted by V.

So, 1 volt $= \dfrac{1\text{ joule}}{1\text{ coulomb}}$ or $1\text{V} = \dfrac{1\text{ J}}{1\text{ C}}$

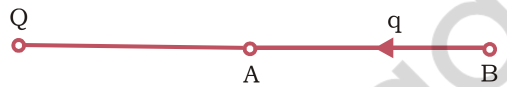
Thus, if 1 joule of work is done in bringing 1 coulomb of positive charge from infinity to a point in an electric field, then the potential at that point is 1 volt.

Potential difference:

The difference in electric potential between two points is known as potential difference.

The potential difference (p.d.) between two points in an electric field is defined as the amount of work done in moving a unit positive charge from one point to the other point

If W joule of work is done in moving a charge q coulomb from a point 1 to the point 2, the potential difference between the two points is $V_1 - V_2 = \dfrac{W}{q}$



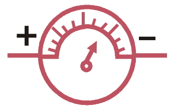
Potential difference is the amount of work done in moving a unit positive charge q from point B to point A in an electric field created by the charge Q.

Note: 1. Potential difference is abbreviated as p.d.
2. Potential difference is a scalar quantity.
3. The SI unit of potential difference is volt and noted by

Instrument by which potential difference measured:

Potential difference is measured by an instrument called voltmeter.

voltmeter



WORK SHEET - 2

Single Answer Type

1. A charge of 5 C is given a displacement of 0.5m. The work done in the process is 10 J. The potential difference between the two points will be
   1) 2 volt 2) 10 volt 3) 50 volt 4) 5 volt
2. Work done in bringing a unit positive charge from infinity to that point is
   1) Electric current 2) Electric potential
   3) Electric charge 4) All of these
3. If W is worked done, 'q' is charge then, electric potential (v) is given by
   1) w × q 2) w/q 3) $w^2/2q$ 4) w + q
4. A charge of 5 coulombs is moved from A to B into an electric field from infinity, when the work done at point A is 20J and at point B is 32J. Calculate the potential difference between points A and B.
   1) 4.2 V 2) 6.4 V 3) 2.4 V 4) 4.6 V
5. How much work is done in moving a charge of 2C from a point at 118V to a point at 128V?
   1) 20 J 2) 10 J 3) 5 J 4) 8 J

Multi Answer Type

6. Among the following, the unit of electric potential is
   1) JC^{-1} 2)Nm c^{-1} 3) Nm c 4) Volt

Comprehension Type

The difference in electric potential between two points is known as potential difference.

7. The work done in moving a unit positive charge across two points in a electric circuits , is a measure of
   1) Current 2) Potential difference
   3) Resistance 4) Power
8. A charge is taken from a point A to a point B. The work done per unit charge in the process is called
   1) The potential at A
   2) The potential at B
   3) The potential difference between B and A
   4) The current from A to B
9. What is the electrical potential at a point in an electric field when 96J work is done in moving a charge of 24C from infinity?
   1) 2.0volts 2) 3.0volts 3) 5.0volts 4) 4.0volts

Reasoning Answer Type

10. Statement - I : Earth is at zero potential.
Statement - II : The potential of the body is zero which posses same number of positive and negative charges.
1) Both Statements are true
2) Both Statements are false.
3) Statement - I is true, Statement - II is false.
4) Statement - I is false, Statement - II is true.

Matrix Matching Type

11.

Column - I	**Column - II**
a) Electric potential	1) Scalar
b) Potential difference	2) Volt
c) Work done	3) Coulomb
d) Charge	4) Joule

SYNOPSIS - 3

In 1826, a German physicist George Simon Ohm by his experiments established a relationship between electric current (I) and potential difference (V) in an electrical circuit. This relationship is known as **Ohm's law.**

Ohm's law:

According to Ohm's law, at constant temperature, the current flowing through a conductor is directly proportional to the potential different across its ends.

If I is the current flowing through a conductor and V is the potential difference (or voltage) across its ends, then according to Ohm's law:

$I \propto V$ (At constant temperature)

This can also be written as: $V \propto I$ or $V = R \times I$ .....(1)

The above equation can also be written as: $R = \frac{V}{I}$

where R = Resistance
I = current
V = Potential difference

So, we find that the ratio of potential difference applied between the ends of a conductor and the current flowing through it is a constant quantity called resistance.

So, Current, $I = \frac{V}{R}$

It is obvious from this relation that:

1. The current is directly proportional to the potential difference.

a. If the potential difference across the ends of a conductor is doubled, the current flowing through it also gets doubled.

b. If the potential difference across the ends of a conductor is halved, the current flowing through it also gets halved.

2. The current is inversely proportional to the resistance.

a. If the resistance is doubled, the current gets halved.

b. If the resistance is halved, the current gets doubled.

Thus, the strength of electric current flowing in a given conductor depends on two factors:

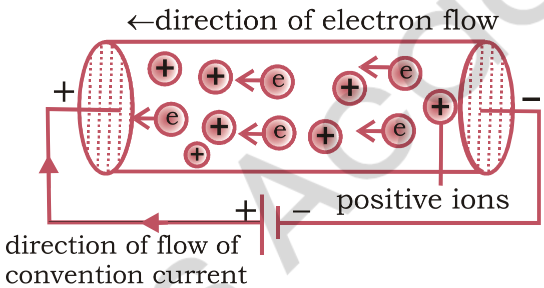
1. potential difference across the ends of the conductor.
2. resistance of the conductor.

Electrical resistance:

We have read that the electric current is the flow of electrons through a conductor. When the electrons move from one part of the conductor to the other part, they collide with other electrons and with the positive ions present in the conductor. Due to these collisions, there is some obstruction or opposition to the flow of electronic current through the conductor. These collisions tend to slow down the speed of the electrons

The property of a conductor by virtue of which it opposes the flow of electric current through it is called its resistance.

1. Resistance is denoted by the letter R.
2. Resistance is a scalar quantity.



Collisions of moving electrons with each other as well as with the positive ions offer resistance

Resistance:

The property of a conductor by virtue of which it opposes the flow of electric current through it is called its resistance. or The obstruction offered to the flow of current by the wire is called its resistance.

Note:- 1) Resistance is denoted by the letter R.
2) Resistance of a scalar quantity.

Unit of resistance

The S.I unit of resistance is ohm, which is denoted by the symbol Ω called 'omega'. According to Ohm's law:

$$\text{Resistance (R)} = \frac{\text{Potential difference (V)}}{\text{Current (I)}}$$

Now, if the potential difference (V) is I volt and the current (I) is I ampere, then the resistance (R) in the above equation will be 1 ohm,

$$1\text{ ohm} = \frac{1\text{ volt}}{1\text{ ampere}}$$

1 ohm is the resistance of a conductor such that when a potential difference of 1 volt is applied to its ends, a current of 1 ampere flows through it.

High resistances are measured in kilo-ohm and mega-ohm where

1 kilo-ohm (or 1 kΩ) = 10^3 Ω and 1 mega-ohm (or 1 MΩ) = $10^6\Omega$

Low resistances are measured in milli-ohms and micro-ohms where

1 milli-ohm (or 1 mΩ) = 10^{-3} Ω and 1 micro-ohm (or 1 $\mu\Omega$) = 10^{-6} Ω

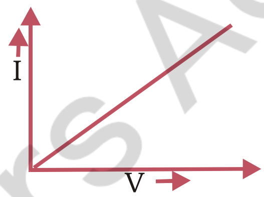
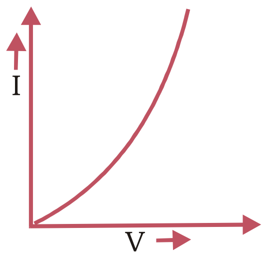
Conductance:

The reciprocal of resistance of a conductor is called its conductance(G) i, e G = 1/R.

Unit of conductance:

The SI unit of conductance is mho or (ohm)$^{-1}$ or siemen.

Ohmic and non-ohmic conductors:

Parameters	***Ohmic conductor***	***Non-ohmic conductor***
1. Ohm's law	The conductors (resistors) which strictly obey ohm's law are called ohmic conductors (resistors).	The conductors (resistors) that do not obey Ohm's law are called non-ohmic conductors (resistors).
2. Graph of *I* and V	The graph of current (*I*) against potential difference (V) is a straight line 	The graph of current (*I*) against potential difference (V) is not a straight line. 
3. Value of R	R is constant for different values of V or *I*.	R is not constant. It is different for values of V or *I*.
4. Dynamic resistance	The ratio of change in potential difference to the change in current, i.e. $\frac{\Delta V}{\Delta I}$ is called dynamic resistance. It is constant for different values of I or V.	The dynamic resistance $\frac{\Delta V}{\Delta I}$ is different for different values of *I* and V
5. Examples	All metallic conductors such as silver, copper, etc, are ohmic conductors.	Vaccum tubes, transistors, electrolytes are non-ohmic conductors.

Additional Knowledge

Superconductors:

The property by virtue of which a conductor shows almost zero resistance at a very low temperature is called superconductivity and the materials which show the property of super-conductivity are called superconductors.

The resistance of a super conductor is nearly zero and it is obtained at a very low temperature (near 0 K).

Applications of superconductors:

No resistance means no power loss, therefore, superconductors have a number of useful applications:

1. They may be used to produce very high speed and very small-sized computers.
2. Superconducting electric power transmission lines for long distance with no power loss due to heating may be possible. Hence, superconductivity is a wide area of research in physics today.

Resistors: The materials which offer very high resistance as compared to the conductors are called the resistors.

Examples: Amongst the metals, tungsten and platinum are generally used as resistors.

WORK SHEET - 3

Single Answer Type

1. A p.d of 20V is applied across the ends of a resistance of 5Ω. What current will flow in the resistance?
   1) 4A 2) 3A 3) 5A 4) 8A
2. Which of the following law's establishes the relation between electric current and, potential difference,
   1) Newton's law 2) Faraday's law 3) Ohm's law 4) Kirchoff's law
3. The relationship between potential difference (v) and electric current (I) and is resistance 'R' is given by
   1) $V = \frac{I}{R}$ 2) V = IR 3) $V = \frac{R}{I}$ 4) V - I^2R
4. The p.d. applied at the ends of a given conductor is doubled. Then the resistance of the conductor
   1) Remains constant 2) Gets halved
   3) Gets doubled 4) Gets quadrupled
5. Keeping the potential difference constant, the resistance of a circuit is doubled. By how much does the current charge?
   1) Remains constant 2) Gets halved
   3) Gets doubled 4) Gets quadrupled

Multi Answer Type

6. Choose the current statement :
   1) The current in a circuit is directly proportional to the potential difference.
   2) The current in a circuit is inversely proportional to the resistance.
   3) The current in a circuit s inversely proportional to the potential difference
   4) The current in a circuit is directly proportial to the resistance.

Comprehension Type

Ohm's law gives relation b/w electric current and potential difference.

7. The property of conductor by virtue of which it opposes the flow of electric current through it is called.
   1) Voltage 2) Current 3) Resistance 4) Conductance
8. Which of the following gives the formula for resistance(R)?
   1) $R = V \times I$ 2) $R = \frac{V}{I}$ 3) $R = \frac{V^2}{I}$ 4) $R = \frac{I^2}{V}$
9. Conductors which obey ohm's law are called
   1) Non - ohmic conductors 2) Ohmic conductors
   3) Super conductors 4) All of these

Matrix Matching Type

10.

Column - I	Column - II
a) ohm	1) Unit of resistance
b) Siemen	2) Unit of conductance
c) Ampere	3) Unit of electric current
d) Volt	4) Unit of potential difference

Reasoning Answer Type

11. Statement - I : Reciprocal of resistance is called conductance
    Statement - II : 1 ohm is the resistance of a conducted such that when a potential difference of 1 volt is applied to its ends a current of 1 ampere flows through it.
    1) Both Statements are true
    2) Both Statements are false.
    3) Statement - I is true, Statement - II is false.
    4) Statement - I is false, Statement - II is true.

Integer Answer Type

12. 10^3 ohm is equal to ________ kilo ohm

SYNOPSIS - 4

Factors affecting the resistance of a conductor:

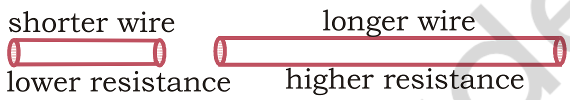
The electrical resistance of a conductor (or a wire) depends on the following factors:

1) Length of the conductor
2) Area of cross-section of the conductor (or thickness of the conductor)
3) Temperature of the conductor
4) Nature of the material of the conductor

1. Effect of the length on the resistance of a conductor:

It has been found by experiments that on increasing the length of a wire, its resistance increases and on decreasing the length of the wire, its resistance decreases. In other words, the resistance of a conductor is directly proportional to its length,

i.e. $R \propto l$ (R = resistance and l = length of conductor).-------(1)



Longer wire has higher resistance than the shorter wire since $R \propto l$

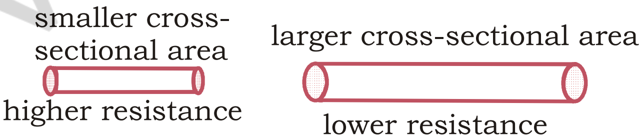
Note:-

1) If the length of the conductor (or wire) is doubled, its resistance also gets doubled.

2) If the length of the conductor (or wire) is halved, its resistance also gets halved.

2. Effect of the area of cross-section on the resistance of a conductor:

The resistance of a conductor is inversely proportional to its area of cross-section, i.e. $R \propto \frac{1}{A}$ (where R is resistance and A is the area of cross-section of conductor).---(2)



A thick wire (greater area of cross=section) has resistance and a thin wire (less area of cross-section) more resistance since $R \propto \frac{1}{A}$

Note:-

1) If the area of cross-section of the conductor doubled, its resistance gets halved.

2) If the area of cross-section of the conductor is halved, its resistance gets doubled.

3. Effect of temperature on the resistance of conductor:

The resistance of all pure metal increases with a rise in temperature decreases on lowering the temperature.

Note:-

1) The resistance of alloys change slightly with rise in temperature.

2) The resistance of alloys like manganin, constantan and nichrome remain almost unaffected with change in temperature.

4. Effect of the nature of material on the resistance of a conductor:

Some materials have low resistance, whereas some other have much higher resistance.

Note:-

1) Metals like copper, silver, aluminium, etc. have very low resistance.

2) Nichrome, constantan, etc. have higher resistance. That is why nichrome is used for making heating elements of heaters, toasters, electric irons, etc.

Specific resistance or resistivity:

From (1) and (2) it is observed that the resistance R of a conductor

a) is directly proportional to its length (l)

i.e. $R \propto l$ ...(1)

b) is inversely proportional to its area of cross-section (A),

i.e. $R \propto \frac{1}{A}$ ...(2)

c) depends upon the nature of the material

d) Changes with temperature

From the first two points, we have:

$$R \propto \frac{l}{A} \quad \text{or} \quad \boxed{R = \rho\frac{l}{A}}$$

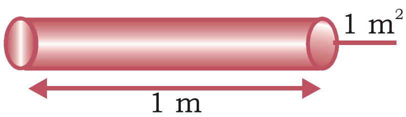
where ρ called "rho" is a constant of proportionality and is known as resistivity or

specific resistance of the conductor.

We have seen above that $R = \rho\frac{l}{A}$

If l = 1 m; A = 1 m^2, then R = ρ.

Hence, specific resistance (or resistivity) of a material is the resistance offered by 1 m length of the wire of the material having area of cross-section of 1 m^2



Specific resistance of a material

Unit of resistivity:

We have just seen the relation $R = \rho\frac{l}{A}$ or $\rho = \frac{R \times A}{l}$

Now, the unit of resistance R is ohm (Ω), the unit of area of cross-section A is metre^2 (m^2), the unit of length l is metre (m).
So, putting these units in the above equation, we get

Unit of resistivity $(\rho) = \frac{\text{ohm} \times (\text{metre})^2}{\text{metre}} = \text{ohm} \times \text{metre or } (\Omega\text{m})$

Thus, the SI unit of resistivity is ohm-metre which is written in symbol as Ωm.

For example: The resistivity of silver is 1.6 x 10^{-8} Ωm. It means that if we take a silver wire 1 metre long and having an area of cross-section of 1 m^2, then resistance of this piece of silver wire will be 1.6 × 10^{-8} Ω.

Factors affecting the resistivity:

The resistivity ρ depends on

1. The nature of the material
2. The temperature of the material (wire)

Note:-

1. If R_1 is the resistance of the conductor of length l_1 and R_2 is the resistance of the conductor of length l_2, when all other parameters remain same, then:

$$R_1 \propto l_1 \quad ....(1) \quad \text{and} \quad R_2 \propto l_2 \quad ...(2)$$

Dividing (1) by (2) $\boxed{\frac{R_1}{R_2} = \frac{l_1}{l_2}}$

2. If R_1 is the resistance of the conductor of area of cross-section A_1 and R_2 is the resistance of the conductor of area of cross-section A_2, when all other parameters remain same, then:

$$R_1 \propto \frac{1}{A_1} \quad ...(1) \text{ and } R_2 \propto \frac{1}{A_2} \quad ...(2)$$

Dividing (1) by (2) $\boxed{\frac{R_1}{R_2} = \frac{A_2}{A_1}}$

Conductivity:

The reciprocal of resistivity is called the conductivity. It is represented by the symbol σ (sigma).

Thus, conductivity σ is expressed as $\sigma = \frac{1}{\rho} = \frac{l}{RA}$

Unit of conductivity:

S.I unit of conductivity = $\frac{1}{\text{ohm} \times \text{metre}}$ or $\Omega^{-1}\text{m}^{-1}$ or siemen metre^{-1}.

WORK SHEET - 4

Single Answer Type

1. If R_1 is the resistance of the conductor of length l_1, and R_2 is the resistance of the conductor of length l_2, then the correct relation is

   1) $\frac{R_1}{R_2} = \frac{l_2}{l_1}$ 2) $\frac{R_1}{R_2} = \frac{l_1}{l_2}$ 3) $\frac{R_2}{R_1} = \frac{l_1}{l_2}$ 4) $\frac{R_2}{R_2} = \frac{l_1}{l_2}$

2. The opposition to the flow of charges in a circuit is called
   1) Electric current 2) Resistance
   3) Potential difference 4) conductance

3. A resistor of 20cm length and resistance 5 ohm is streatched to a uniform wire of 40cm length. The resistance now is
   1) 5 ohm 2) 20 ohm 3) 10 ohm 4) 200 ohm

4. The first wire resistance 8Ω, area is $2m^2$ second wire also made by the same material what is the resistance
   1) 8Ω 2) 2Ω 3) 3Ω 4) 5Ω

Multi Answer Type

5. The electrical resistance of a conductor depends on
   1) Length of the conductor
   2) Area of cross - section of the conductor
   3) Temperature of the conductors
   4) Nature of the material of the conductor

Reasoning Answer Type

6. Statement - I : If the length of the conductor is doubled; its resistance is also doubled.
   Statement - II : If the length of the conductor is halved its resistance is also doubled
   1) Both Statements are true
   2) Both Statements are false.
   3) Statement - I is true, Statement - II is false.
   4) Statement - I is false, Statement - II is true.

Matrix Matching Type

7.

Column - I Physical quantity	Column - II Units
a) Resistance	1) Ohm^{-1}
b) Resistivity	2) Ohm^{-1} $metre^{-1}$
c) Conductance	3) Ohm^{-1} metre
d) Conductivity	4) Ohm

Integer Answer Type

8. If the area of cross - section of the conductor is halved, its resistance gets______ times

Subjective Answer Type

9. The resistance of an aluminium wire of 2m length is 70Ohms. What is the resistance of a wire of 8m length of the same material and of the same material & cross sectional area?
10. Resistance of copper wire of 2Ω, area is $4m^2$ and resistance of another Al wire is 7Ω find the area.

WORK SHEET – 1 (KEY)				
1) 2	**2)** 1	**3)** 2	**4)** 2	**5)** 1
6) 1	**7)** 1,2,3,4	**8)** 1	**9)** 1,2,3,4	**10)** 1

2. Formula : Q = It $\therefore 1800 = 2 \times t$ or $t = \frac{1800}{2} = 900s = 15$ min.

WORK SHEET – 2 (KEY)				
1) 1	**2)** 2	**3)** 2	**4)** 3	**5)** 1
6) 1,2,4	**7)** 2	**8)** 3	**9)** 4	**10)** 1
11) (1,2), (1,2), (1,4), (1,3)				

1. $V = \frac{w}{q} = \frac{10}{5} = 2\,\text{volts}$

4. Potential at point A = $\frac{20}{5} = 4\,\text{volts}$

Potential at point B = $\frac{32}{5} = 6.4\,\text{volts}$

Potential difference = $V_B - V_A = 6.4 - 4 = 2.4\,\text{votls}$

5. $w = (V_A - V_B)q$

$= (128 - 118)2 = 20J$

9. $V = \frac{W}{Q} = \frac{96}{24} = 4\,\text{volts}$

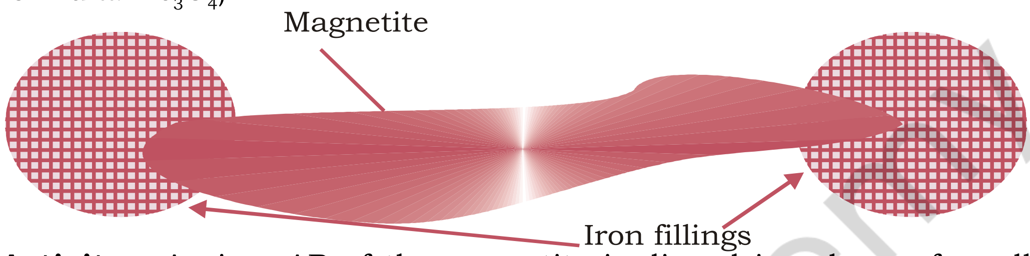
WORK SHEET – 3 (KEY)				
1) 1	**2)** 3	**3)** 2	**4)** 1	**5)** 2
6) 1,2	**7)** 3	**8)** 2	**9)** 2	**10)** 1,2,3,4
11) 1	**12)** 1			

WORK SHEET – 4 (KEY)				
1) 2	**2)** 2	**3)** 2	**4)** 1	**5)** 1,2,3,4
6) 3	**7)** 4,2,1,2	**8)** 2		

MAGNETISM

SYNOPSIS - 1

- A certain ore of iron was found to possess a property that it attracted small pieces of iron towards it.
- The ore was first extracted in Magnesia [a small town in Asia minor (Egypt now) (120 A.D)]. The ore of iron was named as "MAGNETITE" (Chemical formula: Fe_3O_4)



Activity : A piece AB of the magnetite is dipped in a heap of small iron fillings.

Observation: It is observed that a cluster of iron filling stick to the ends A and B, while there is practically, no iron filling sticking to its central region.

Conclusion: The ends A and B (where iron filling stick) are called POLES, while the central region is called neutral region.

- This piece of magnetite (Fe_3O_4) which is found in nature and is endowed with the property of attracting other small pieces of iron towards it is called a 'NATURAL MAGNET'.

Properties of Natural Magnets (N.M)

ATTRACTING PROPERTY
Natural magnet is capable of attracting small pieces of iron towards it.

DIRECTIONAL PROPERTY
When a freely suspended, by means of a suspension thread, it always points in a particular direction. Because of this property the magnetite was also called 'LEADING STONE' or LODE STONE (stone which leads)

SUBSTANCES

Magnetic Substances
Substances which are influenced or affected by a magnet is called a magnetic substances.

Non-Magnetic Substances
Substances which are neither attracted nor repelled by a magnet are called non-magnetic substances. These cannot be magnetised.
Ex: Paper, wood, glass etc.

- It is possible to turn a piece of magnetic substance into a magnet, which will also show the properties as shown by a natural magnet. "A piece of iron or steel to which attractive and directive properties of lodestone (magnetite) are imparted by artificial means is called an "ARTIFICIAL MAGNET".

KINDS OF ARTIFICIAL MAGNETS:

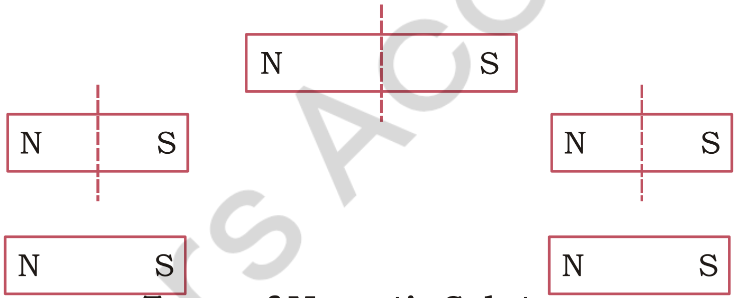
1. Bar Magnet: | N S |

- It is a rectangular steel bar, at the ends of which are marked letter N and S.
- The N stands for "Geographic North" and S stands for "Geographic South".
- If this magnet is suspended freely, then the end marked with N points towards geographic north and the end marked with S points towards geographic south.

2. Horse shoe magnet etc..

General properties of a Bar magnet:

1. It attracts small pieces of iron toward itself.
2. A freely suspended magnet points in north-south direction.
3. Like poles of the magnets repel each other and the unlike poles attract each other.
4. It can magnetise another piece of iron when rubbed several times in one direction.
5. Magnetic poles exist in pairs (dipole). These cannot be a monopole.



Types of Magnetic Substances

Ferromagnetic Substances	Paramagnetic Substances	Diamagnetic Substances
Substances which are strongly attracted by magnetare Feromagnetic substances. Ex: Iron Steel, Nickel, Cobalt etc.,	Substances which are weakly attracted by a magnet are called Paramagnetic substances. Ex: Aluminium, Manganese, Chromium, Platinum etc.,	Substances that are repelled by a magnet are lcalled Diamagnetic substances. Ex: Copper, bismuth, phosphorus, water, gold, antimony etc.,

WORK SHEET - 1

Single Answer Type

1. Which of the following is a magnetic material
   1) wood 2) Plastic 3) Iron 4) Paper
2. Which of the following is a not magnetic material
   1) Nickel 2) Cobalt 3) Bismuth 4) Wood
3. Which of the following cannot be magnetised?
   1) Iron 2) Nickel 3) Cobalt 4) Stainless steel
4. One of the following is an artificial magnet
   1) Horse shoe magnet 2) Magnetic needle
   3) Magnetic compasses & electro magnet 4) Above all
5. Copper, Gold are the examples of the following magnetic materials
   1) Ferro 2) Dia 3) Para 4) Both A and B

Multi Answer Type

6. Choose the correct example/s for the Ferro magnetic material.
   1) Aluminum 2) Copper 3) Steel 4) cobalt
7. Choose the correct statement/s from the following:
   1) A freely suspended magnet points in N-S direction
   2) Magnetic poles exist in pairs(dipole)
   3) A freely suspended magnet points in E-W direction
   4) Magnetic poles does not exist in pairs
8. Choose the correct statement/s from the following:
   1) magnetite can be called as lode stone
   2) Natural magnets possess attractive property only
   3) natural magnets possess attractive and directional properties
   4) Natural magnets possess directional property only
9. Choose the correct option's
   1) Magnetic poles exist in pairs.
   2) Every molecule of a magnet is complete magnet by itself.
   3) Overall attractive power of a magnet is equal to the sum total of atttractive powers of molecular magnets 4) Overall attractive power of a magnet is unequal to the sum total of atttractive powers of molecular magnets
10. Which of the following are diamagnetic substances
    1) phospheres 2) water 3) antimony 4) platinum

Reasoning Answer Type

11. Statement I : A freely suspended bar magnet always comes to lie in North-South direction.
    Statement II : Magnetic poles have the property of directionality
    1) Both Statements are true, Statement - II is the correct explanation of Statement - I.
    2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
    3) Statement - I is true, Statement - II is false.
    4) Statement - I is false, Statement - II is true.

Comprehension Type

A piece AB of the magnetite is dipped in a leap of small iron filings. It is observed that a cluster of iron filings stick to the ends A and B while there is practically no iron filing stick to its central region.

12. The central region or called
    1) Neutral Region 2) Pole 3) Equator 4) none of these
13. End A is called
    1) Neutral Region 2) Pole 3) Equator 4) none of these
14. End B is called.
    1) Neutral Region 2) Pole 3) Equator 4) none of these

Matrix Matching Type

15.

Column-I	**Column-II**
a) The rest position of a magnet is along N-S when suspended	1) Ferromagnetic substance
b) Magnetic poles exist in pairs	2) diamagnetic substance
c) Iron is strongly attracted by magnet so it is	3) directive property
d) Gold is repelled by a magnet so it is	4) Dipole
	5) paramagnetic substance

Integer Answer Type

16. All Substances can be divided into ________ classes on the basis of their magnetic properties

SYNOPSIS - 2

SGeneral Definitions of Bar Magnet:

1. **Pole:** Each end of a bar magnet is called its pole.
2. **Geometric pole:** The geometric end of a bar magnet is called its geometric pole.

A, B ⟶ Geometric poles

3. **Magnetic pole:** The point situated slightly inside a bar magnet, where most of its magnetic power is concentrated is called its magnetic pole.

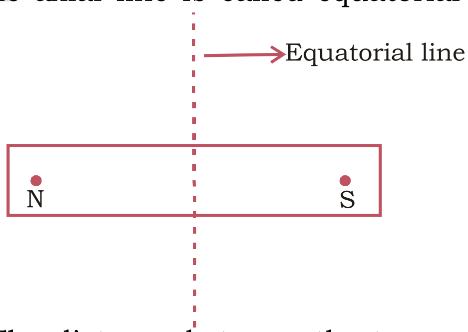
N, S ⟶ Magnetic poles

Magnetic North pole
The pole of a freely suspended bar magnet which point towards geographic north is called its magnetic north pole (N).

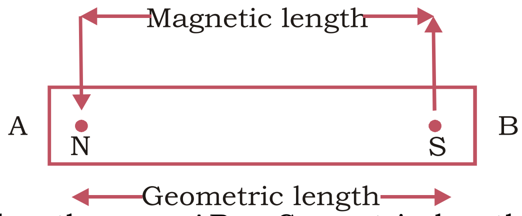
Magnetic South pole
The pole of a freely suspended bar magnet which points towards geographic south is called its magnetic south pole (S).

Magnetic axis: An imaginary line joining the magnetic north and south poles of a bar magnetic is called its magnetic axis (or) axial line. (XY = magnetic axis)

Equatorial line: The line passing through the centre of magnet and perpendicular to the axial line is called equatorial line.



Magnetic length: The distance between the two poles of a magnet is called magnetic length of magnet.



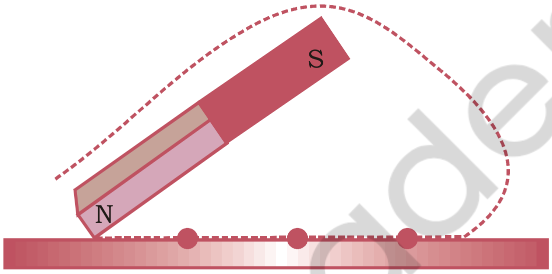
NS $\rightarrow$ Magnetic length   AB = Geometric length

The relation between magnetic length and geometric length is

$$\text{MAGNETIC LENGTH} = \frac{5}{6} \times \text{GEOMETRIC LENGTH}$$

A piece of iron can be magnetized by the following ways.

a) **Single touch method:** A piece of iron can be magnetized by rubbing it with a magnet from one end to another as shown in the figure.

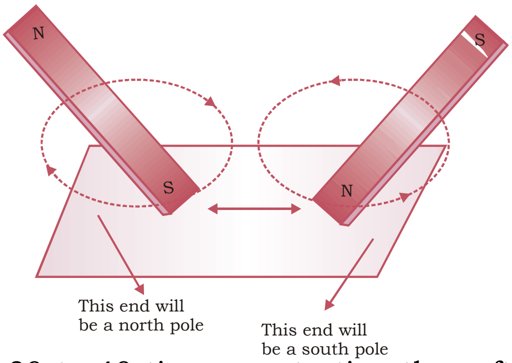


b) **Electric method:** Strong magnets are nowadays made by the electrical method. The principle used in it is that a wire carrying electric current behaves like a magnet. Magnetism can be induced in a steel bar by winding a coil of wire around it and passing current through the coil. Then the steel bar magnet becomes an electromagnet.

A steel piece which becomes a magnet when electric current passes through the wire wound round it is called **electromagnet.**

Application of Electromagnets: Electromagnets are used in electric bells.

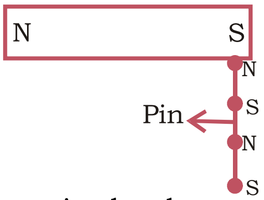
Double touch method : In this double touch method, two strong magnets are placed at the centre of the soft iron piece to be magnetised, keeping the opposite poles of the magnets facing each other. Move the magnets simultaneously over the surface of the soft iron piece taking them away from one another. Lift the magnets on reaching the ends of the piece and place them again at the centre.



Repeat this exercise 30 to 40 times, on testing the soft iron piece, it would be found to have become a magnet.

A piece of iron can be strongly magnetised by double touch method than the single touch method.

Magnetic induction : The phenomenon due to which magnetism is produced in a magnetic substance by the mere presence of a magnet, which is not actually in physically contact with magnet is called magnetic induction.



Note: The end of an unmagnetised substance nearer to the pole of inducing magnet acquires opposite polarity, whereas the further end from inducing magnet acquires similar polarity. Magnetic induction precedes magnetic attraction.

Temporary magnets: The magnets which lose their magnetism as soon as the cause producing them is removed, are called temporary magnets.

Examples: Electromagnets and the magnets made from soft iron are temporary magnets.

ii) Permanent magnets: The magnets which do not lose their magnetism, when the cause producing them is removed, are called permanent magnets.

Examples: The magnets made from steel,cobalt etc., are permanent magnets.

Note : Soft iron is a temporary magnet whereas Steel is a permanent magnet.

Demagnetisation : The loss of magnetic property of a magnet is called demagnetisation. By heating or by hammering or by rough handling, a magnet loses its property.

WORK SHEET - 2

Single Answer Type

1. The magnets which do not lose their magnetism , when the cause producing them is removed are called
   1) demagnetisation 2) permanent magnets
   3) temporary magnets 4) none of these
2. A vertical plane passing through the magnetic axis of a freely suspended magnet
   1) Magnetic Meridian 2) Magnetic equator
   3) Equitorial Meridian 4) Magnetic Pole
3. A vertical plane passing through the magnetic equator of a freely suspended barmagnet is called
   1) Magnetic Pole 2) Magnetic equator
   3) Equatorial Meridian 4) Magnetic Meridian
4. A piece of iron rubbed with magnetite is called a
   1) magnet 2) Natural magnet 3) Artifical magnet 4) iron ore
5. One of the following is not a property of a magnet
   1) Attraction 2) Repulsion 3) Induction 4) Reflection

Multi Answer Type

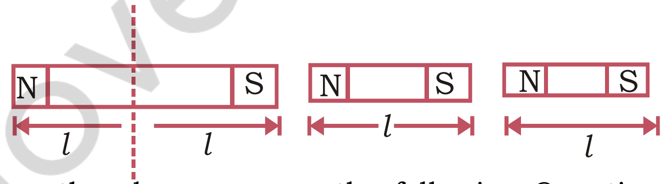
6. A magnet can be demagnetisa by
   1) Heating 2) Hammering 3) rough handling 4) induction
7. Which of the following are made as permanent magnets
   1) steel 2) cobolt 3) soft iron 4) iron
8. An imaginary line joining the magnetic north and south pole of a bar magnet is its
   1)magnetic axis 2) axial line 3) equitorial line 4)pole

Reasoning Answer Type

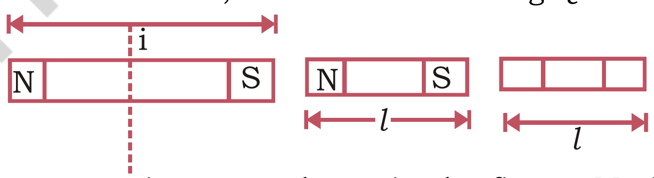
9. Statement I : Soft iron is a temporary magnet where as steel is a parmanet magnets
   Statement II : Electro magnets are used in electric bells
   1) Both Statements are true, Statement - II is the correct explanation of Statement - I.
   2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
   3) Statement - I is true, Statement - II is false.
   4) Statement - I is false, Statement - II is true.
10. Statement I : A piece of iron can be strongly magnetised by double touch method than the single touch method.
   Statement II : Electromagnets and the magnets made from soft iron are temporary magnets.
   1) Both Statements are true, Statement - II is the correct explanation of Statement - I.
   2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
   3) Statement - I is true, Statement - II is false.
   4) Statement - I is false, Statement - II is true.

Comprehension Type

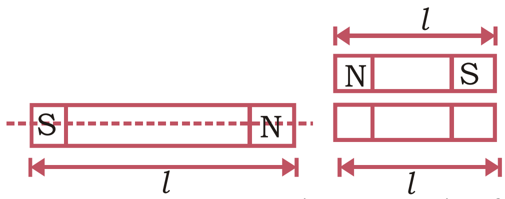
Magnetic poles exist in pair. We can not get a magnetic monopole. When we cut a magnet, each piece will behave like a magnet with two poles.



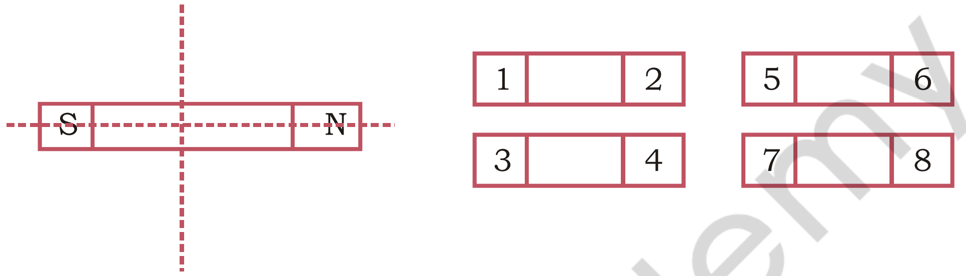
Based on the above, answer the following Questions.

11. 

A bar magnet is cut as shown in the figure. Mark the polarity of each pole (from left to right) for the polarity missed piece.
1) South, North 2) North, South
3) North, North 4) South, South

12. 

A bar magnet is cut as shown in the figure. Mark the polarity of each pole (from left to right) for polarity missed piece.
1) South, North 2) North, South 3) North, North 4) South, South

13. 

A bar magnet is cut as shown in the figure. choose the correct polarity.
1) 1 $\rightarrow$ south, 2 $\rightarrow$ north; 3 $\rightarrow$ south, 4 $\rightarrow$ north
2) 5 $\rightarrow$ south, 6 $\rightarrow$ north; 7 $\rightarrow$ south, 8 $\rightarrow$ north
3) Both (1) and (2) 4) neither (1) nor (2)

Matrix Matching Type

14.

Column-I	Column-II
a) Magnetization	1) Electro magnet
b) Temporary magnet	2) Heating a magnet
c) Demagnetisation	3) Double touch method
d) Electric bell	4) Single touch method
	5) Hammering on magnet

Integer Answer Type

15. The relation between magnetic length and geometric length is Magnetic length$=\frac{x}{6}\times$Geometric length ,then the value of x is ___

SYNOPSIS - 3

Magnetic field : Whenever a magnetic substance is placed at a distance from the magnet, it is affected by it. The magnetic substance is said to be in a field called magnetic field.

Magnetic field is a region (or space) around the magnet, in which its influence can be felt.

Representation of magnetic field:

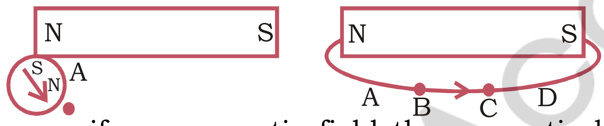
A magnetic field is represented by a set of lines (may be curved or straight) called lines of force. A line of force if it were free to move when placed on the field. The direction of arrow head gives the direction of motion of unit north pole. If the lines are spaced widely apart, it is a weak field. If the lines are situated close to each other, it represents a strong field.

Direction of magnetic field:

The direction of a magnetic field at a point in the field is the direction in which an isolated North pole would move, if free to do so. (An isolated north pole is a hypothetic assumption which is introduced for better understanding). Magnetic field can be understood properly through magnetic lines of forces.

Magnetic line of force:

Keep a small magnetic needle near the north pole of a magnet and it orients as itself shown below:



This curve is called magnetic line of force.

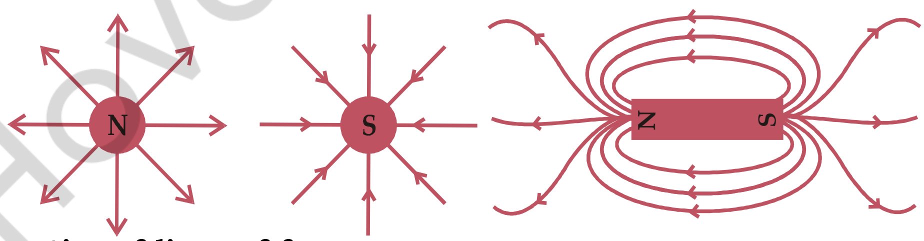
In a uniform magnetic field the magnetic lines of force are parallel to each other.

(A magnetic field is said to be uniform if it has same strength (in magnitude and direction at all points).

Ex: Earth's magnetic field is an uniform magnetic field in a given region. Hence the lines in it are parallel to each other.

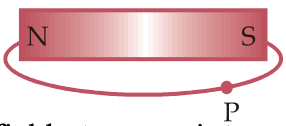
i) Magnetic lines of force due to an isolated

North pole — Isolated south pole — Bar magnet

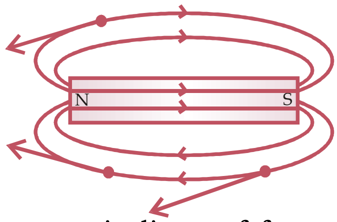


Properties of lines of force:

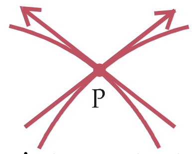
1. Lines of force are directed away from a north pole are directed towards a south pole. Externally they move from North pole of a magnet to its south pole.
2.



The direction of the field at any point on the magnetic line of force is obtained by drawing a tangent to it at that point.



Inside the magnet, the magnetic lines of force travel from south to north. Magnetic lines of force do not intersect.



Let us assume that two lines intersect at P. Let us get the direction of field at P by drawing tangents to the two curves.

We get two tangents at P as shown above indicating two directions for the same field at point P which is impossible. Hence they donot intersect.

- The density of magnetic line of force gives the intensity of magnetic field. More the density, the more is the intensity of the magnetic field.

WORK SHEET - 3

Single Answer Type

1. The space (or) region around the magnet is
   1) magnetic distance 2) magnetic field
   3) Both (1) and (2) 4) Neither (1) nor (2)
2. A magnetic field is represented by a sets of lines are called
   1) lines of force 2) lines of density 3) lines of mass 4)none of these
3. Which of the following is employed for tracing magnetic lines of force of a magnet.
   1) Load stone 2) Needle 3) Tracing compass 4) Bar magnet
4. The density of magnetic line of force gives the
   1) Intensity of the magnetic field 2) Intensity of the magnetic pole
   3) Both (1) and (2) 4) neither (1) nor (2)

Multi Answer Type

5. A magnetic field is said to be uniform if it has
   1) Same strength 2) Same in magnitude and direction at all points
   3) unequal strength 4) Different in magnitude and direction at all points
6. Choose the worng option's
   1) A magnetic field is said to be uniform if it field if it has same strength
   2) A magnetic field is said to be uniform if it field if it has unequal strength
   3) If density of magnetic lines more ,the intensity of the magnetic field is also more
   4) If density of magnetic lines more ,the intensity of the magnetic field is also less

7. The magnet have a general property(ies) if
   1) A freely suspended magnet points in east- west direction
   2) Magnetic poles always exists in pairs
   3) Like poles of a magnet attacts each other
   4) Inside the magnet , the magnetic lines of force travels from south to north

Reasoning Answer Type

8. Statement I : The direction of the magnetic lines of force out side the magnet is from north pole to south pole of a magnet
   Statement II : The direction of the magnetic lines of force in side the magnet is from north pole to south pole of a magnet
   1) Both Statements are true, Statement - II is the correct explanation of Statement - I.
   2) Both Statements are true, Statement - II is not correct explanation of Statement - I.
   3) Statement - I is true, Statement - II is false.
   4) Statement - I is false, Statement - II is true.

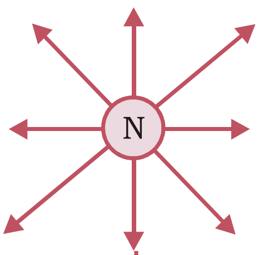
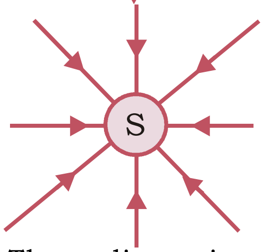
Comprehension Type

Magnetic filed can be understood properly through magnetic lines of forces.

9. Which of the following are the properties of magnetic lines of force
   1) They are closed continuous curves 2) They mutually repel each other
   3) They never interset with each other 4) All of these
10. In a uniform magnetic field the magnetic lines of force are
   1) Perpendicular to each other 2) parallel to each other
   3) Both (1) and (2) 4) Neither (1) nor (2)
11. A magnetic field is represented by a
   1) Set of lines 2) curved lines 3) straight lines 4) all of these

Matrix Matching Type :

12.

Column-I	Column-II
a) Magnetic field	1) 
b) a unit north pole	2) 
c) A unit south pole	3) Three dimensional
d) magnetic lines of force inside the magnet	4) travel from north pole to south pole
	5) travel from south pole to north pole

WORK SHEET – 1 (KEY)

1) 3	**2)** 4	**3)** 4	**4)** 4	**5)** 2
6) 3,4	**7)** 1,2	**8)** 1,3	**9)** 1,2,3	**10)** 2
11) 2	**12)** 1	**13)** 2	**14)** 4	**15)** 3,4,1,2
16) 3				

WORK SHEET – 2 (KEY)

1) 2	**2)** 1	**3)** 3	**4)** 3	**5)** 4
6) 1,2,3	**7)** 1,2	**8)** 1,2	**9)** 2	**10)** 2
11) 2	**12)** 1	**13)** 3	**14)** (3,4), 1, (2,5), 1	**15)** 5

WORK SHEET – 3 (KEY)

1) 2	**2)** 1	**3)** 3	**4)** 1	**5)** 1,2
6) 2,4	**7)** 2,4	**8)** 3	**9)** 4	**10)** 2
11) 4	**12)** (3,4), 1, 2, 5			

HEAT & THERMODYNAMICS

SYNOPSIS - 1

THERMOMETRY AND THERMAL EXPANSION

1. HEAT

It is a form of energy which causes in us the sensation of hotness or coldness.
For example, if we dip our finger in hot water we have a sensation of hotness. Similarly, if we touch a block of ice the sensation is that of coldness.
In the former case the heat energy has moved into the finger, while in the latter case it has moved out of finger.
Thus, hotness or coldness basically indicates whether heat energy is flowing into our body or out of it.

2. TEMPERATURE

It is the effect of heat energy which determines the thermal state of a given substance. In other words, it determines the degree of hotness or coldness of a substance.
If a body is at a higher temperature than its surroundings, it means that heat energy will flow out of the body. Similarly, if a body is at a lower temperature than its surroundings, it means that heat energy will flow into the body.

Differences between Heat Energy and Temperature:

1. Heat energy is the sum total of the potential and the kinetic energies of all the molecules of a body, whereas temperature is the measure which indicates the abilityof a body to give up heat to another body or absorb heat from another body.
2. The total quantity of heat energy in two different bodies with different masses may be equal but they may have different temperatures. Conversely, the total quantity of heat energy in two different bodies of different masses may not be equal while their temperature may be same.
3. The flow of heat energy from one body to another does not depend upon the amount of heat energy in them but upon their temperatures.
4. The fall in the temperature of a hot body may not be equal to the rise in the temperature of a cold body, but the amount of heat energy received by the cold body will always be equal to the amount of heat energy given out by the hot body, provided no amount of heat energy flows out into atmosphere or the surrounding medium in this process.
5. The temperature of a body will go on rising with the supply of heat energy, as long as the state of the body remains unchanged.

Heat	Temperature
1. Heat is a form of energy. Hence it has the capacity for doing work. 2. Heat is the cause. 3. Two bodies of same substance having different masses may have same amount of heat but different temperatures. 4. Heat contents of a body do not decide the direction of heat flow from the body. 5. S.I. unit of heat is joule (J) (energy unit)	1. Temperature indicates the thermal condition of a body which may be stated as how much hot or how-much cold the body is. 2. Temperature is the effect. 3. Two bodies of same substance having different masses may have same temperature but different amount of heat. 4. Temperature of a body decides the direction of heat flow from the body. 5. S.I. unit of temperature is Kelvin (K)

3. EFFECTS OF HEAT ENERGY

When a substance is heated there can occur a number of hcanges in it.

1. Heat energy brings about a change in temperature.
2. Heat energy changes dimensions, i.e., it increases or decreases the volume.
3. Heat energy can bring about a change in state, e.g., the solid may change into liquid and a liquid may change into gaseous state on heating and vice versa.
4. Heat energy brings about a chemical change. For example, limestone decomposes on heating, giving quicklime and carbon dioxide.
5. Heat energy changes into electric enegy, as in solar cells.

In this chapter we shall study the first two effects in detail.

4. MEASUREMENT OF TEMPERATURE

The instrument used for the measurement of temperature is called **Thermometer.**

All thermometers are based on the fact that matter expands on heating. Thus, we have solid thermometer, liquid thermometers and gas thermometers. The solid thermometers are less sensitive and the gas thermometers are most sensitive, because solids expand far less as compared to gases. However, for general purposes, we use liquid thermometers, using mercury or alcohol as thermometric liquids.

5. CHOICE OF THERMETRIC LIQUID

A thermometric liquid must have the following properties

i. It should have low specific heat capacity, so that it rapidly attains the temperature of a given substances, without absorbing any appreciable amount of heat energy from it.
ii. It should have a uniform rate of expansion, such that a linear scale can be easily marked.
iii. It should have large expansion for a unit degree rise in temperature, so that its expansion is visible to the unaided eye.
iv. It should have a high boiling point and low freezing point, so that a wide range of temperature changes could be recorded by a single thermometer.
v. It should be shiny and opaque so that it is clearly visible in glass.
vi. It should not stick to the sides of the glass tube.
vii. It should exert low vapour pressure.

viii. It should be a good conductor of heat.
ix. It should be easily available in pure state.

Reasons for Using Mercury as a Thermometric Liquid:

Mercury fulfils practically all the requisites of a thermometric liquid as under:
i) It has low specific heat capacity.
ii) Its expansion is uniform.
iii) It has a high b.p. (357^0C) and low m.p. $\left(-39^0C\right)$.
iv) It is opaque and shining.
v) It does not stick to the sides of the glass.
vi) It exerts very low vapour pressure.
vii) It is a good conductor of heat.
viii) It is easily available in pure state.

Disadvantages of Mercury as Thermometric Liquid:

i) Its expansion is not very large for 1^0C rise in temperautre, and hence, very small changes in temperature cannot be measured.
ii) It freezes below -39^0C, and hence, it cannot be used in very cold regions like Antarctic or Arctic.

WORK SHEET -1

Single Answer Type

1. Heat is a form of
1) matter 2) energy 3) fluid 4) none of these
2. The most important naturally occurring source of heat is
1) earth 2) sun 3) moon 4) none of these
3. Heat always flows from
1) higher temperature to lower temperature
2) lower temperature to higher temperature
3) sometimes higher to lower and lower to higher temperature
4) none of these
4. The degree of hotness or coldness of the body is called
1) heat 2) temperature 3) pressure 4) force
5. The heat of the _________ is a basic requirement for the existence of life
1) sun 2) moon 3) satellites 4) planet
6. The S.I. unit of heat is
1) calorie 2) joule 3) joule/kg 4) kg/joule
7. Thermometry is the branch of heat dealing with the measurement of
1) heat 2) temperature
3) density 4) none of these

Multi Answer Type

8. Choose the correct, regarding heat energy
   1) The S.I. unit of heat is joule
   2) The common unit of heat is calorie
   3) Heat is a vector quantity
   4) Heat is a scalar quantity
9. Choose the correct regarding effects of heat energy.
   1) Heat energy brings about a change in mass
   2) Heat energy brings about a change in temperature
   3) Heat energy changes dimensions
   4) Heat energy can change into electric energy
10. Mercury is choosen as thermometric liquid, because
    1) Its expansion is uniform
    2) It has a low boiling point
    3) It does not stick to the sides of glass
    4) It has high melting point

SYNOPSIS - 2

6. CONSTRUCTION OF MERCURY THERMOMETRE IN LABORATORY

Take a thermometer tube. It consists of a very thin capillary tube of uniform area of cross-section, on one end of which is provided a glass funnel and on the other end a very thing glass bulb. The capillary tube is protected by a thick glass stem.

Some mercury is poured in the funnel. It is seen that mercury does not flow down in to the bulb because the air gets trapped in side the bulb and the capillary tube. Now the thermometer tube is heated in boiling water. The air inside the bulb expands and bubbles come out of mercury. The tube is then taken out of boiling water. On cooling, the volume of the trapped air decrease, and hence, some amount of mercury enters the tube. In this way, by alternate heating and cooling, the bulb as well as the capillary tube are filled with mercury.

The thermometer tube is then transferred to boiling oil when the mercury expands, and some of it collects into the funnel. After heating it for a few minutes, the extra mercuryis taken out of the funnel. The funnel is then cut with a sharp file and its open end is sealed with a flame, which melts the glass. The tube is then allowed to cool.

7. MARKING OF STANDARD POINTS (FIXED POINTS)

Standard points are two supposed points with respect to which the temperature of various substances are compared.

The standard points chosen for thermometric scale are the melting point of pure ice (lower standard point) and boiling point of pure water (upper standard point) at normal pressure, i.e., 760 mm of mercury.

Water is chosen for the simple reason that it is the commonest liquid found all over the globe.

a) **Marking of the lower standard point:** Take a glass funnel and fix it in an iron stand. Place a beaker under the funnel and then clamp the thermometer as shown in figure. Surround the bulb of the thermometer completely with melting ice which is prepared from distilled water. The level of mercury will start falling.

When the level of mercury is stationary at some point for more than five minutes, mark that point. Give a sharp cut at the point with the help of a file. This point represents the lower standard point.

b) **Marking of the upper standard point:** The upper fixed point is marked with the help of hyposometer. It consists of a double walled copper vessel provided with a boiler. The thermometer is suspeded in the vessel as shown infigure taking care that it does not touch the side walls. The vessel is heated from below. When steam comes out of the spout freely for more than five minutes and the level of mercury is same in both the limbs of monometer, the point where the mercury stands in thermometer tube is marked with the help of a sharp file. This point represents the upper standard point.

c) Callibration of the stem: After marking the two standard points, the thermometer is dipped in the molten wax and then taken out, so that a thin layer of wax is deposited on it. With the help of a sharp needle the wax is removed from the standard points. The space in between the standard points is then equally divided into 100 equal parts and wax is scratched from those points. The thermometer is then placed in hydrofluoric acid for a few minutes. The acid reacts with the exposed glass surface and dissolves it. However, the part of stem covered with wax is not affected. The thermometer is then taken out of acid, washed with water and finally wax is scrubbed off. The itchings formed on the stem are filled with black paint. When the paint dries off, the thermometer is ready for use.

Thermometric Scales

a) Celsius or Centigrade Thermometer: As the name suggests, this scale has 100 divisions between the upper and lower standard points. This scale was introduced by a Swedish astronomer Celsius and is known after his name. Each division on this scale is called one degree centigrade or one degree celsius and is written as ^0C. More sensitive thermometers have 200 divisions between standard points and each division is equal to $1/2\,^0C$. Sometimes these thermometers are called half ^0C thermometers.

b) Fahrenheit Scale: This scale was introduced by Fahrenheit. On this scale 32^0F represents the melting point of ice and 212^0F the steam point. Zero is marked 32^0F below the ice point. The length in between the standard points is divided to 180 equal parts. Each division on this scale is called 1^0F. This scale is widely used for meteorological and clinical purposes.

8. RELATION BETWEEN CELSIUS AND FAHRENHEIT SCALES

As the length between the two standard points is same, we can say that 100 degrees Celsius (C) is equal to 180 degrees Fahrenheit (F-32).

$$C:(F-32)=100:180$$

or $$\frac{C}{100}=\frac{F-32}{180}$$

or $$\frac{C}{5}=\frac{F-32}{9}$$

The above relation is very useful for converting temperatures from one scale to another.

WORK SHEET - 2

Single Answer Type

1. A device used for the measurement of temperature is
   1) thermometer 2) barometer
   3) manometer 4) none of these
2. The liquid used in a laboratory thermometer is
   1) mercury 2) water 3) both (1) and (2) 4) none of these
3. The lower fixed point of a thermometer scale is the temperature of melting
   1) ice 2) water 3) mercury 4) alcohol
4. The boiling point of water is
   1) 180°C 2) 12°C 3) 40°C 4) 100°C
5. The melting point of ice is
   1) 0°C 2) 273°C 3) 40°C 4) 100°C
6. The S.I. unit of temperature is
   1) Celsius 2) Kelvin 3) Fahrenheit 4) Pascal
7. Mercury is the commonly used thermometric liquid because
   1) it can be easily obtained in pure state
   2) it does not stick to glass tube thermometer
   3) It has a very high density 4) all of the above
8. The lower fixed point of a temperature scale is also called
   1) ice point 2) water point 3) liquid point 4) steam point
9. If a body is at a temperature higher than the room temperature the level of mercury in the thermometer's stem
   1) falls 2) remain at the same position
   3) rises 4) may rise or fall

Multi Answer Type

10. 357^0C is equal to
    1) 357K 2) 630K 3) 630^0F 4) 674.6^0F
11. 233K is equal to
    1) 40^0C 2) 40^0F 3) -40^0C 4) -40^0F

Comprehension Type

Writeup-1

The mercury thread rises by 3/8 parts between the two standard points on Celsius scale, when thermometer is placed in warm milk. Then

12. Calculate the temperature in ^0C
    1) 35.7^0C 2) 35.5^0C 3) 41.2^0C 4) 43.2^0C
13. Calculate the temperature in K
    1) 300K 2) 298K 3) 410.5K 4) 3105K
14. Calculate the temperature in Fehrenheit scale.
    1) 32^0F 2) 79.5^0F 3) 99.5^0F 4) 102.5^0F

Writeup-2

The mercury thread falls by $\frac{7}{9}$ parts between two standard points on Fahrenheit scale, when boiling water at 76 cm pressure is cooled to room temperature. Then

15. Calculate the room temperature in Fahrenheit
    1) $72^0 F$ 2) $82^0 F$ 3) $102^0 F$ 4) $112^0 F$
16. Calculate the room temperature in Celsius
    1) $58^0 F$ 2) $38^0 F$ 3) $22.2^0 F$ 4) $24.4^0 F$
17. Calculate the room temperature in Kelvin scales.
    1) 373k 2) 295.2k 3) 373.2k 4) 222.2k

Subjective Answer Type

18. Convert $55^0 C$ into (i) Kelvin (ii) Fahrenheit scales.
19. Convert $108^0 F$ into (i) Celsius (ii) Kelvin scale.
20. Convert 198K into (i) Celsius (ii) Fahrenheit scale.

SYNOPSIS – 3&4

9. KELVIN SCALE (ABSOLUTE SCALE) OF TEMPERATURE

In case of Celsius scale or Fahrenheit scale the extent to which the highest or lowest temperature which can be recorded depends upon the thermal properties of the liquid used. For instance, if mercury is used as thermometric liquid, it can record lowest temperature as $-39^0 C$ and highest temperature as $+357^0 C$.

Lord Kelvin introduced a scale for the measurement of temperature, which was independent of thermal properties of a substance. He named this scale as absolute scale. However, to honour Lord Kelvin, it is now known as Kelvin scale of temperature or SI scale of temperature.

Lord Kelvin called this lowest limit of temperature as absolute zero. It is now called **Kelvin Zero**. By careful theoretical calculations, Lord Kelvin concluded that zero Kelvin corresponds to $-273^0 C$.

Kelvin scale of Temperature: The scale of measurement of temperature, in which lowest temperature is Zero Kelvin ($-273^0 C$) is called Kelvin scale. This is also called SI scale of temperature.

On this scale 273K represents the melting pointof ice and 373K represents the boiling pointof water.

10. CLINICAL THERMOMETER

It is a specially adapted Fahrenheit thermometer used by doctors to record the temperature of human body.

It consists of a large and very thin bulb containing mercury which is connected to a capillary tube. The capillary tube has a very fine constriction near the bulb and is well protected by means of a triangular stem. The scale on the thermometer is marked from $95^0 F$ to $110^0 F$. The normal temperature is shown by a red arrow and is $98.4^0 F$.

The large bulb as well as narrow capillary tube help to make the thermometer sensitive, i.e., responsive to small changes in the body temperature.

The constriction in the capillary tube does not allow the mercury to flow back into the bulb when the thermometer is taken out from the patient's mouth. The triangular stem helps us to see enlarged image of mercury thread when viewed from a proper angle.

The marking are from $95^0 F$ to $110^0 F$, because the temperature of human body does not fall below $95^0 F$ or rise above $110^0 F$, as in either case death occurs.

Some clinical thermometers have centingrade scale, marked between $35^0 C$ to $43^0 C$, the normal temperature being $37^0 C$.

Before using the thermometer it should be washed with water and then jerked so that the mercury flows back into the bulb.

In case a thermometer is to be sterilised, it should be done with formaldehyde, and not in boiling water which will break the bulb of the thermometer, because expanding mercury exerts a large force on the wall of the bulb.

Characteristics of Kelvin Scale:

1. There cannot be any temperature below zero Kelvin.
2. The temperature is expressed in (K), but not degree symbol is attached to it.
3. Rise in temp. of 1 K = Rise in temperature in $1^0 C$.

For any scale

$$\frac{\text{Reading - lower standard point}}{\text{Upper standard point - lower standard point}} = \text{constant}$$

Parameters of different temperature scales :

Temperature scale	Lower fixed point (Ice point)	Upper fixed point (Steam point)	No. of division on fundamental interval
1. Celsius scale	0°C	100°C	100
2. Fahrenheit scale	32°F	212°F	180
3. Kelvin scale	273K	373K	100
4. Reaumer scale	0°R	80°R	80

$$\therefore \frac{C-O}{100-0} = \frac{K-273}{373.273} = \frac{F-32}{212-32} = \frac{R-0}{80-0}$$

$$\Rightarrow \frac{C}{100} = \frac{K-273}{100} = \frac{F-32}{180} = \frac{R}{80}$$

WORK SHEET -3&4

Single Answer Type

1. A 1K rise in temperature is
   1) the same as a 1°C rise in temperature
   2) the same as a 1°F rise in temperature
   3) more than a 1°C rise in temperature
   4) less than a 1°F rise in temperature

2. The relation between the Celsius and Fahrenheit temperature scales is
   1) $\frac{C-100}{212}=\frac{F-18}{32}$ 2) $\frac{C}{100}=\frac{F-32}{180}$
   3) $\frac{C}{9}=\frac{F-32}{5}$ 4) $\frac{C-32}{100}=\frac{F}{180}$

3. Normal temperature of the body of a healthy person is 98.4°F. Its equivalent in celsius scale is
   1) 37°C 2) 40°C 3) 50°C 4) 100°C

4. Absolute zero on Celsius scale is
   1) 100°C 2) 80°C 3) –273°C 4) –12°C

5. Ice point in Fahrenheit scale is
   1) 32°F 2) 0°F 3) 100°F 4) 212°F

6. Steam point in kelvin scale is
   1) 273K 2) 373K 3) 0K 4) 100K

7. The lower fixed point of each of the Celsius and the Fahrenheit scale of temperature is
   1) 4°C when the density of water is maximum
   2) the boiling point of water
   3) the freezing point of water 4) the freezing point of mercury

8. The boiling point of water on Fahrenheit scale is
   1) 100°F 2) 80°F 3) 212°F 4) 32°F

9. The melting point of ice in Kelvin scale is
   1) 0K 2) –273K 3) 273K 4) 373K

10. The temperature of a body rises through 1°C. What is the corresponding rise on Kelvin scale ?
    1) 1 K 2) 100 K 3) 273 K 4) 32 K

11. On the Fahrenheit scale, one division on the Celsius scale is equal to
    1) $\frac{100}{180}$ divisions 2) $\frac{273}{180}$ divisions 3) $\frac{180}{100}$ divisions 4) $\frac{100}{273}$ divisions

12. The lowest attainable temperature is
    1) 0°C 2) –10°C 3) –273°C 4) –100°C

13. Two bodies A and B are brought in contact with each other. A contains 50 cal of heat at 20°C while B contains 100 cal of heat at 10°C. Heat flows from
    1) A to B 2) B to A
    3) heat does not flow at all 4) none of these

14. A thermometer when put in a water bath at 27°C reads 300. The scale of the thermometer is in
    1) Fahrenheit 2) Kelvin
    3) Reaumur 4) none of these
15. Express 100 K in °C.
    1) –273°C 2) 100°C 3) 212°C 4) –173°C
16. Express 27°C in Kelvin.
    1) 100 K 2) 200 K 3) 300 K 4) 400 K
17. Express 100° F in degree celsius.
    1) 37.8°C 2) 40°C 3) 80°C 4) 32°C

Multi Answer Type

18. When a thermometer is taken from the melting ice to a warm liquid, the mercury level rises to two-fifth of the distance between the lower and the upper fixed points. Find the temperature of the liquid (i) in °C, and (ii) in K.
    1) 40°C, 313K 2) 30°C, 227K 3) 20°C, 273K 4) 0°C, 0K

Integer Answer Type

19. The temperature which has the same value on the Celsius and Fahrenheit scales is
    1) –40° 2) –60° 3) –100° 4) –32°

Comprehension Type

For any scale

$$\frac{\text{reading} - \text{lower standard point}}{\text{upper standard} - \text{lower standard point}} = \text{constant}$$

20. At what degree temperature both the Kelvin and Reaumer scale are equal ?
    1) 1000° 2) –1092° 3) 98.6° 4) 100°
21. At what temperature will the reading of a Fahrenheit thermometer be double that of a centigrade thermometer ?
    1) 160° 2) 150° 3) 170° 4) 180°
22. What is the temperature which has same numerical value on Fahrenheit and Reaumer scale ?
    1) –25.6° 2) –26.6° 3) –27.6° 4) –28.6°
23. A faulty centigrade thermometer is examined. The upper and lower points are found to be 99.5°C and 0.5°C respectively. What is the correct temperature if this faulty thermometer reads 15.5 ?
    1) 15.15°C 2) 16.16°C 3) 17.17°C 4) 18.18°C
24. Two thermometers A and B have fundamental interval of 45° and 100°. The lower points of A and B are 0° and 50° respectively. What will be the reading of A when B reads 110° ?
    1) 30° 2) 27° 3) 100° 4) 180°

25. A thermometer which has upper and lower point equal to 95° and 5° reads 59°. What is the temperature in centigrade scale ?
1) 60°C 2) 50°C 3) –40°C 4) 100°C

26. The lower point and upper point of a faulty thermometer are 5° and 99° respectively. If the reading of this thermometer be 52°, what will be the correct temperature in °F ?
1) 100°F 2) 120°F 3) 132°F 4) 122°F

SYNOPSIS – 5

11. EXPANSION OF SOLIDS

Whenever a solid is heated it generally expands in volume, i.e., it expands in all directions. This expansion of the solid is called cubical expansion or volume expansion.

However, if a solid is in the form of a plane, such that its thickness can be neglected as compared to its surface area, then the increase in area on heating is called superficial expansion.

Similarly, if the solid is in the form of a wire, such that its area of cross-section is too small as compared to its length, and hence, can be neglected, then the increqase in length on heating is called linear expansion.

12. EXPERIMENTS TO PROVE THAT SOLIDS EXPAND ON HEATING

(a) Grave sand's ring and ball experiment: Take a ring and ball apparatus. It consists of a metallic ring provided with a wooden handle, such that through the ring can pass a metallic ball which is suspended by a metallic chain, and connected to a wooden handle. At room temperature, the internal diameter of ring is equal to external diameter of the metallic ball.

Try to pass the ball through the ring. You will see ball just passes through the ring. Now heat the ball for five minutes over a Bunsen burner. Again try to pass the ball through ring. It is observed that balldoes not pass through ring.

On cooling the ball to room temperature it again passes through the ring. Thus, experiment proves that solids expand on heating and contact on cooling.

(b) Expansion in bimetallic strip:

Take a bimetallic strip, having equal strips of brass and iron, riveted together firmly and held in a wooden handle, such that the strip is flat.

Heat the one end of strip in Bunsen flame. It is observed that on heating, the strip bends with brass on the outer side of bent curve.

This shows that brass expands more than iron.

13. EXPERIMENT TO DETERMINE THE FACTORS ON WHICH LINEAR EXPANSION OF SOLID DEPENDS

Take a brass rod AB and clamp the end A in a metal stand. Place a cork under the end B, such that it is free to roll. In the cork fix a needle in the vertical position. Along the needle place a semi-circular scale. Heat the rod.

It is observed that the needle deflects towards right, thereby showing that metals expand on heating. Similarly, on cooling the metal rod with ice it is found that needle deflects towards left, thereby proving that metals contract on cooling.

1. If the experiment is repeated with rods of the same length and radius, but of different materials, and the rods are heated through the same range of temperature, then it is found that expansion for different rods of different materials is different.

Thus, we can conclude that increase in length depends upon the nature of material.

2. If the experiment is repeated with rods of different length, but of the same material, and the rods are heated through the same range of temperature it is found that the greater the original length of the rod, the greater is the increase in length.

Thus, it can be concluded that increase in length is directly proportional to the original length of the rod.

3. If the experiment is repeated with a rod of a fixed length and the same material, but the rod is heated through different ranges of temperature, it is found that the greater the rise in temperature, the greater is the increase in length.

Thus, it can be concluded that increase in length is directly porportional to the rise in temperature.

14. COEFFICIENT OF SUPERFICIAL EXPANSION (β)

Increase in area per unit of the original area, per degree Celsius rise in temperature is called coefficient of superficial expansion.

Mathematical Expression

Consider a thin plate of area of cross-section A_0 at 0^0C. Let the plate be heated through t^0C, such that its final area is A_t.

$\therefore$ Increase in area $= A_t - A_0$

Also, we know

Increase in area $\propto$ Initial area

$\therefore \; A_t - A_0 \propto A_0$ ....(i)

Similarly, increase in area $\propto$ rise in temperature

$\therefore A_t - A_0 \propto t$ .....(ii)

Combining (i) and (ii)

$A_t - A_0 \propto a_{0t}$

$\therefore A_t - A_0 = A_0\beta t$ {where, β is the coefficient of superficial expansion}

$$\therefore \beta = \frac{A_t - A_0}{A_0 \times t}$$

Coefficient of superficial expansion $= \dfrac{\text{Increase in area}}{\text{Initial area} \times \text{Rice in temp. } (^0C)}$

If A_0 is $1m^2$ and 1^0C is the rise in temperature, then shaded portion represents coefficient of superficial expansion β.

Unit of coefficient of superfical expansion

In CGS system, unit is ${}^0C^{-1}$. In SI system, unit is K^{-1}.

To Remember

1. $\beta = \dfrac{A_t - A_0}{A_0 \times t}$ 2. $A_t - A_0 = A_0 \times \beta \times t$ 3. $A_t = A_0(1+\beta t)$

15. COEFFICIENT OF CUBICAL EXPANSION (γ)

Increase in volume per unit of the original volume per degree Celsius rise in temperature is called coefficient of cubical expansion.

Mathematical expression

Consider a metal cube such that its volume is V_0 at 0^0C.

Let the metal cube be heated through t^0C, such that its final volume is V_t.

$\therefore$ Increase in volume $= V_t - V_0$

Also, we know : Increase in volume $\propto$ Initial volume

$\therefore V_t - V_0 \propto V_0$ .....(i)

Similarly, increase in volume $\propto$ rise in temperature

$\therefore V_t - V_0 \propto t$ .....(ii)

Combining (i) and (ii)

$V_t - V_0 \propto V_0 \times t$

$\therefore V_t - V_0 = V_0 \times \gamma \times t$ {where, γ is coefficient of cubical expansion.}

$$\therefore \gamma = \frac{V_t - V_0}{V_0 \times t}$$

$$\text{Coefficient of cubical expansion} = \frac{\text{Increase in volume}}{\text{Initial volume} \times \text{Rice in temp. } ({}^0C)}$$

Units of coefficient of cubical expansion

In CGS system, Unit is ${}^0C^{-1}$

In SI system, Unit is K^{-1}.

To Remember

1. $\gamma = \dfrac{V_t - V_0}{V_0 \times t}$ 2. $V_t - V_0 = V_0 \gamma t$ 3. $V_t = V_0(1+\gamma t)$

16. RELATION BETWEEN COEFFICIENTS OF LINEAR, SUPERFICIAL; CUBIUCAL EXPANSION

Following relations can be proved mathematically. However, mathematical deductions are beyond the scope of syllabus:

1) Coefficient of superficial expansion $= 2\times$ Coefficient of linear expansion

$$\beta = 2\alpha$$

2) Coefficient of cubical expansion $= 3 \times$ Coefficient of linear expansion

$$\gamma = 3\alpha$$

3) Coefficient of cubical expansion $= \frac{3}{2} \times$ Coefficient of superficial expansion.

$$\gamma = \frac{3}{2}\beta$$

17. APPLICATIONS OF THERMAL EXPANSION

As discussed above, most of solids expand on heating and contract on cooling. If there is any obstruction to their free movement while expanding or contracting, a very large force is set up in them which may bend, deform or break the solid. This knowledge is made use of in many constructive devices or in overcoming their shortcomings.

Constructive Applications:

(i) **Iron tyres of cart wheels** are made a little smaller than the wooden wheels. When iron tyres are heated, they expand and their radius becomes larger than the wooden wheels. They are then placed around the wooden wheels and cold water is poured on them. On cooling they contract and hold the wooden wheel very tightly.

It is precisely for the same reason that tonga drivers pour cold water over iron rims in summer, to prevent the loosening of the tyre grip.

(ii) **Riveting:** A rivet is a small steel cylinder used for fastening two metal places.

A hole is made in the metal plates to be joined. A rivet is so chosen that its length is slightly smaller than thickness of metal plates.

The rivet is then heated to red hot temperature when its length becomes slightly more than the plates. It is then slipped into the hole in the metal plates and hammered, when its ends flatten. On cooling the rivet contracts and holds the plates very tightly. Riveting is generally employed in making boilers for ships and locomotives.

(iii) **Bimetallic strips:** Plates of two different metals which are riverted together at a number of points in such a way that they cannot slide on being heated or cooled, form a bimetallic strip.

WORK SHEET - 5

Single Answer Type

1. Increase in length of a rod on heating is called
   1) linear expansion 2) superficial expansion
   3) cubical expansion 4) none of these
2. Increase in surface area of a sheet on heating is called
   1) linear expansion 2) superficial expansion
   3) cubical expansion 4) none of these
3. Increase in volume of a body on heating is called
   1) linear expansion 2) superficial expansion
   3) cubical expansion 4) none of these
4. A brass ring is tightly fitted over an iron cylinder. To loosen the ring, the system must be
   1) heated 2) cooled
   3) at first heated then cooled 4) none of these
5. An iron ring is tightly fitted over an brass cylinder. To loosen the ring, the system must be
   1) heated 2) cooled
   3) at first heated then cooled 4) none of these
6. While lying a railway line, a small gap is left in between the two rails at their joints to allow
   1) expansion during summer 2) contraction during winter
   3) both expansion and contraction 4) none of these
7. While laying telephone or electric wires a little sag is left during summer because
   1) to expand in summer 2) to contract in winter
   3) for both expansion and constraction
   4) none of these
8. In summer, clocks becomes
   1) slow 2) fast
   3) more accurate 4) neither slow nor fast
9. In winter, clocks becomes
   1) slow 2) fast
   3) more accurate 4) neither slow nor fast
10. Bridges are mounted on _____ to prevent their collapse
    1) stones 2) rollers
    3) bricks 4) none of these

Multi Answer Type

11. Choose the correct option(s)

    1) $\alpha = 3x$ 2) $\beta = 2x$ 3) $\alpha = \frac{3}{2}\beta$ 4) $\beta = 3x$

12. Per kelvin(K^{-1}) is the unit of
1) coefficient of linear expansion
2) coefficient of superficial expansion
3) coefficient of cubical expansion
4) None

Comprehension Type

A metal cube of side 5 cm at 20^0C is heated, when its each side becomes 5.05 cm at 820^0C.

13. Calculate the value of coefficient of linear expansion
1) $1.25 \times 10^{-5}/^0C$ 2) $2.25 \times 10^{-5}/^0C$
3) $1.25 \times 10^{-6}/^0C$ 4) $2.25 \times 10^{-6}/^0C$
14. Calculate the value of coefficient of superficial expansion
1) $1.25 \times 10^{-5}/^0C$ 2) $2.25 \times 10^{-5}/^0C$
3) $1.25 \times 10^{-6}/^0C$ 4) $2.25 \times 10^{-6}/^0C$
15. Calculate the value of coefficient of cubical expansion
1) $1.25 \times 10^{-5}/^0C$ 2) $2.75 \times 10^{-5}/^0C$
3) $3.75 \times 10^{-5}/^0C$ 4) $4.75 \times 10^{-6}/^0C$

Subjective Answer Type

16. Calculate the increase in length of brass rod, which measure 200 cm at 20^0C, when it is heated to 880^0C. [α for brass = 0.000018/^0C]. Also calculate the overall length at 880^0C.
17. An iron plate of dimensions $20cm \times 50cm \therefore 10^0C$ is heated in a furnace, when the final area of plate is $1006 cm^2$. If the coefficient of linear expansion of iron is $0.000012/^0C$, find the temperature of the furnace.
18. Calculate the length of brass rod, which will have same expansion as 1.8 m of iron rod. Coefficient of linear expansion for iron and brass are $12 \times 10^{-6}/^0C$ and $18 \times 10^{-6}/^0C$ respectively.

SYNOPSIS – 6

Factors influencing the quantity of heat :

When a cold body is heated, it absorbs heat and its temperature rises, but when a hot body is cooled, it gives out heat and its temperature falls. It has been found that the heat absorbed (or given out) by a body is directly proportional to

(i) mass of the body i.e., $Q \propto m$ --------------- (i)

(ii) change in temperature of the body i.e., $Q \propto (T_2 - T_1)$ --------------- (ii)

(iii) the nature of the material of the body.

combining (i) and (ii), we get, $Q \propto m\Delta t$ [where $\Delta t = T_2 - T_1$]

$\Rightarrow Q = m.C.\Delta t$ ---------------- (iii)

Where C is constant called specific heat of the body and its value depends on the nature of the material of the body.

$\therefore$ **Heat absorbed (or given out) = mass × specific heat × change in temperature.**

Note : The above formula should be used whenever there is a rise (or fall) in temperature).

Specific heat capacity or specific heat :

As $Q = m.C.\Delta t$. If m = 1 unit ; Δt = 1°C then Q = C, hence specific heat is the amount of heat required to raise the temperature of unit mass of the substance through 1°C or 1K.

Mathematically,

Specific heat =

$$\frac{\text{quantity of heat}}{\text{mass of the substance} \times \text{change in temperature}} \Rightarrow C = \frac{Q}{m.\ \Delta t}$$

[as $Q = m.C.\Delta t$]

Note :

1. Of all known substances water has the highest specific heat capacity. It can absorb a lot of heat without its temperature going up very much. It also cools down slower than other substances, as it has to lose more heat to cool down.
2. Because of its high specific heat capacity, water is used as a coolant in automobile radiators. It is also used in hot water bottles as it cools down slowly.

Units of specific heat :

S.I. unit of specific heat = J kg^{-1} K^{-1}

CGS unit of specific heat is cal g^{-1} $°C^{-1}$

Since 1cal = 4.18 J therefore 1 cal g^{-1} $°C^{-1}$ = 4180 J kg^{-1} K^{-1}

Note :

Water is a liquid having highest specific heat capacity i.e.,4180 J $kg^{-1}K^{-1}$.

Heat capacity or Thermal capacity :

Heat capacity of a body is defined as the amount of heat required to raise the temperature of the (whole) body through 1°C or 1K.

Heat capacity = heat required to rise the temperature of the body through 1°C

Mathematically, heat capacity

$$= \frac{\text{amount of heat}}{\text{Rise in temperature}} = \frac{Q}{\Delta t} \Rightarrow H = \frac{Q}{\Delta t} = m \times C.$$

Hence **Thermal Capacity = mass × specific heat.**

Units of heat capacity :

S.I. unit of heat capacity is $J\ K^{-1}$ CGS unit of heat capacity is cal $°C^{-1}$

Note : Thermal capacity depends on mass of the substance whereas specific heat does not depend upon the mass of the substance.

1. Heat absorbed (or given out) by a body = Mass × Specific heat × Change in temperature

   i.e., $Q = m\,C\,\Delta T$.

2. $1\text{cal}\ g^{-1}\,°C^{-1} = 4180\ J\ kg^{-1}\,K^{-1}$.

3. Heat capacity = mass × Specific heat.

   Note : Specific heat of water = $1\text{cal}\ g^{-1}\,°C^{-1} = 4180\ J\ kg^{-1}\,K^{-1}$.

WORK SHEET - 6

Single Answer Type

1. The S.I. unit of specific heat capacity is

   1) $J\ kg^{-1}$ 2) $J\ kg\ K^{-1}$ 3) $J\ kg^{-1}\ K$ 4) $J\ kg^{-1}\ K^{-1}$

2. If Q is the amount of heat absorbed, m is the mass of the substance, C is the specific heat of the substance and ΔT is the rise in temperature then choose the correct relation:

   1) $C = \frac{Q}{m\Delta T}$ 2) $C = \frac{m}{Q\Delta T}$ 3) $C = \frac{\Delta T}{Qm}$ 4) $C = \frac{Qm}{\Delta T}$

3. If 1cal = 4.2J then 0.2 cal $g^{-1}\,°C^{-1}$ = ______ $Jkg^{-1}K^{-1}$.

   1) 0.2 2) 840 3) 420 4) 42

4. The correct relation between specific heat and thermal capacity is

   1) specific heat = mass × thermal capacity
   2) thermal capacity = mass × specific heat
   3) specific heat = mass / thermal capacity
   4) thermal capacity = mass + specific heat

5. Which of the following is a unit of thermal capacity?

   1) J-K 2) $J\ K^{-1}$ 3) $J^{-1}K$ 4) $J^{-1}K^{-1}$

6. How much heat is required to raise the temperature of 150 g of iron from 20°C to 25°C ? (Specific heat of iron = 480 $J\ kg^{-1}\ °C^{-1}$)

   1) 350 J 2) 345 J 3) 360 J 4) 330 J

7. 2000 cal of heat is supplied to 200g of water. Find the rise in temperature. (Specific heat of water = 1 cal $g^{-1}\ °C^{-1}$)

   1) 10° C 2) 20° C 3) 30° C 4) 40° C

8. How much amount of heat required to raise the temperature of 100 g of water from 30°C to 100°C ? The specific heat of water = 4.2 $J\ g^{-1}\ °C^{-1}$.

   1) 25.5 kJ 2) 29.4 kJ 3) 30 kJ 4) 40 kJ

9. 500g of hot water at 60°C is kept in the open till its temperature falls to 40°C. Calculate the heat energy lost to the surroundings by the water. (Sp. heat of water = 4200 J/kg°C)

   1) 2400 J 2) 5000 J 3) 40000 J 4) 42000 J

10. Find the heat lost by a copper cube of mass 400 g when it cools from 100°C to 30°C. (Specific of heat of copper = 390 J/kg °C).
    1) 50000 J 2) 10000 J 3) 10920 J 4) 10900 J
11. What quantity of heat would be given out by 200gm of copper in cooling from 80 °C to 20 °C (Sp. heat of copper = 0.09 cal/g °C)
    1) 1080 cal 2) 1000 cal 3) 1500 cal 4) 1100 cal

Comprehension Type

The amount of heat energy, requied to raise the temperature by ΔT is given by $Q = m.c.\ \Delta T \Rightarrow \frac{Q}{\Delta T} = m.c =$ Heat capacity

12. How much heat is required to raise the temperature of 100 g of water from 5°C to 95°C ?
    1) 900 k.cal 2) 90 k.cal 3) 10 k.cal 4) 9 k.ca
13. 500 g of oil has a specific heat capacity of 1.8 J g^{-1} $°C^{-1}$. What is the heat capacity of the oil ?
    1) 850 J/°C 2) 900 J/°C 3) 915 J/°C 4) 950 J/°C
14. 48.75 J of heat energy is supplied to 75 g of metal when its temperature rises by 1°C, Calculate specific heat capacity of the metal.
    1) 2.65 Jg^{-1} $°C^{-1}$ 2) 2.5 Jg^{-1} $°C^{-1}$ 3) 1.6 Jg^{-1} $°C^{-1}$ 4) 0.65 Jg^{-1} $°C^{-1}$
15. 400g of vegetable oil of specific heat capacity 1.98 J g^{-1} $°C^{-1}$ is cooled from 100°C. Find the final temperature, if the heat energy given out by oil is 47376 J.
    1) 30.2 °C 2) 40.2 °C 3) 50.2 °C 4) 43.2 °C

SYNOPSIS – 7

Principle of Calorimetry : (or Law of Mixtures)

When two bodies at different temperatures are brought in contact with each other the heat flows from the body at higher temperature to that at lower temperature until the temperatures of both bodies become equal. Then as there is no change of state and no heat is lost/gained to/ from the surroundings, the heat lost by the hot body must be equal to the heat gained by the cold body. Thus, during transfer of heat from a hot body to the cold body, heat energy must be conserved. This is the principle of calorimetry.

Mathematically

Heat lost by the hot body = Heat gained by the cold body. (provided there is no loss of heat to the external surroundings)

Note : Heat lost = heat gained, will hold good only if there is no change of state and no heat is lost/gained to / from the surroundings.

Thermal Equilibrium :

Two bodies in contact will be in thermal equilibrium only when they are at the same temperature.

WORK SHEET - 7

Single Answer Type

1. When an unknown amount of water at 70°C is added to 175g of water at 30°C, the equilibrium temperature becomes 42°C. Find the mass of water added.
   1) 10 g 2) 25 g 3) 75 g 4) 100 g
2. 5kg of water at 80°C is taken in a bucket of negligible heat capacity, 15kg of water at 20°C is added to it. What is the temperature of the mixture?
   1) 45 ^{0}C 2) 65 ^{0}C 3) 85 ^{0}C 4) 35 ^{0}C
3. 10kg of hot water in a bucket at 70°C is cooled for taking a bath adding to it 20kg water at 20°C. What is the temperature of the mixture? (Neglect the thermal capacity of the bucket)
   1) 30.67 ^{0}C 2) 36.67 ^{0}C 3) 60.67 ^{0}C 4) 46.67 ^{0}C
4. 500g of water at 100°C is mixed with 300g at 30°C. Find the temperature of the mixture. Specific heat of water = 4.2J g^{-1} °C^{-1}.
   1) 73.8 ^{0}C 2) 53.8 ^{0}C 3) 40 ^{0}C 4) 60 ^{0}C
5. A piece of copper weighing 500g is heated to 100°C and dropped into 200g of water at 25°C. Find the temperature of the mixture. The specific heat of Cu is 0.42J g^{-1} °C^{-1}.
   1) 20 ^{0}C 2) 80 ^{0}C 3) 40 ^{0}C 4) 60 ^{0}C
6. When 0.4kg of brass of 100°C is dropped into 1kg of water at 20°C, the final temperature is 23°C. Find the specific heat of brass.
   1) 470 J/kg ^{0}C 2) 47 J/kg ^{0}C 3) 407 J/kg ^{0}C 4) 427 J/kg ^{0}C
7. A piece of iron of mass 0.05kg is heated to a temperature of 200°C and dropped into a beaker containing 0.4kg of water at 20°C. If the final temperature of water and iron is 22.4°C, find the specific heat capacity of iron.
   1) 454.05 J kg^{-1} K^{-1} 2) 554.05 J kg^{-1} K^{-1}
   3) 445.00 J kg^{-1} K^{-1} 4) 54 J $kg^{-1}K^{-1}$

Integer Answer Type

8. 75g of water at 10^{0}C is heated by supplying 25200J of heat energy. If specific heat capacity of water is 4.2 Jg^{-1}, Then the final temperature of water ____________ × 10^{0}C

Comprehension Type

Principal of calorimetry is expressed mathematically as follows
Heat lost = Heat gained by cold body provided there is no loss of heat to the eneternal surroundings.

9. 15kg of water at 90^{0}C is mixed with 20kg of water at 30^{0}C is a bucket of negligible heat capacity, what is the equilibrium temeprature
   1) 45^{0}C 2) 55.7^{0}C 3) 58.7^{0}C 4) 54^{0}C

10. A copper rod o mass 800g is heated to 90^0C and dropped into 300g of water at 10^0C. Find the temperature of mixture
1) 30^0C 2) 25^0C 3) 27^0C 4) 32^0C

SYNOPSIS – 8

CHANGE OF STATE:

Matter can exist in three physical states viz, solid, liquid and vapour (or gaseous) states. The physical state of a substance can be changed by heating or cooling.

Change of substance from one physical state to another is called change of state.

For example, water can exist in three different physical states: solid (ice), liquid (water), and gas (water vapour). Ice (solid) can be converted into water (liquid) and water can be converted into vapours (steam) by heating. On the other hand, water vapours when cooled give water (liquid), which on further cooling gives ice (solid).

The transformation of various physical states of water may be described as follows.

$$\underset{(solid)}{\text{Ice}} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{Water} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \underset{(gas)}{\text{Steam}}(\text{water vapours})$$

Note : During a change of state, the temperature remains constant.

Terms associated with change of state :

(i) Fusion or Melting:

Definition : The *process* during which a solid changes to liquid state at some fixed temperature by the absorption of heat energy (or heating) is called fusion or melting.

Example: Conversion of ice into water is fusion.

$$\underset{(solid)}{\text{Ice}} \xrightarrow[\text{(melting)}]{\text{fusion}} \underset{(liquid)}{\text{water}}$$

Melting point : The *fixed temperature* at which a solid substance gets converted into a liquid is called its **fusion point** or **melting point**.

Example: The melting point of ice is 0^0C.

(ii) Vaporization or Boiling:

Definition : The *process* during which a liquid on heating changes to vapour state at some fixed temperature is called **vaporization** or **boiling**.

Example:Conversion of water into steam is vaporization.

$$\underset{(liquid)}{\text{Water}} \xrightarrow[\text{(boiling)}]{\text{vaporization}} \underset{(gas)}{\text{steam}}$$

Boiling point : The *fixed temperature* at which a liquid gets converted into vapour state is called its **vaporization point** or **boiling point**.

Example: The boiling point of water is 100^0C.

(iii) Condensation or Liquefaction:

Definition : The *process* during which vapours on cooling change into liquid state at some fixed temperature is called condensation.

Example: Conversion of steam into water is condensation.

$$\underset{(\text{gas})}{\text{steam}} \xrightarrow[\text{(cooling)}]{\text{condensation}} \underset{(\text{liquid})}{\text{water}}$$

Condensation point : The fixed temperature at which the vapour state of substance gets converted into liquid state is called its **condensation point** or **liquefaction point**.

(iv) Freezing or Solidification:

Definition : The process during which a liquid changes to solid state at some fixed temperature with the liberation of heat energy (or cooling) is called **solidification** or **freezing**.

Example: Conversion of water into ice is solidification.

$$\underset{(\text{liquid})}{\text{water}} \xrightarrow[\text{(solidification)}]{\text{freezing}} \underset{(\text{solid})}{\text{ice}}$$

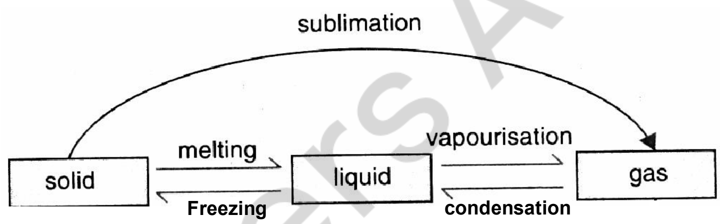
Freezing point : The fixed temperature at which a liquid substance gets converted into a solid is called its **freezing point**.

(v) Evaporation and sublimation:

The conversion of a liquid into vapour, at temperatures below the boiling point is called evaporation.

A few substances change directly from solid to gas on heating and gas to solid on cooling. This process is called **sublimation** and such substances are called **sublimates**. Iodine, camphor, ammonium chloride and naphthalene are some examples of sublimates.

Diagram for change of state:



Note :

It must be remembered that solidification point and melting point have same numerical value.

For example, if melting point of ice is 0°C, then solidification point of water is also 0°C. The only difference is that during melting the heat energy is absorbed, whereas during solidification, the heat energy is liberated.

Similarly the numerical value of the boiling point and liquefaction point is the same. For example, if the boiling point of water is 100°C, then liquefaction point of steam is also 100°C.

WORK SHEET - 8

Single Answer Type

1. The temperature at which a liquid is converted into vapour (gas) is called
   1) freezing point 2) melting point
   3) boiling point 4) condensation point
2. The temperature at which a solid is converted into liquid, is called its
   1) freezing point 2) melting point
   3) boiling point 4) condensation point
3. The temperature at which a gas is converted into a liquid is called its
   1) freezing point 2) melting point
   3) boiling point 4) condensation point
4. The temperature at which a liquid is converted into a solid is called its
   1) freezing point 2) melting point
   3) boiling point 4) condensation point
5. During change of state ________ remains constant
   1) heat 2) temperature 3) pressure 4) volume
6. The process during which a liquid on heating changes to vapour state is called
   1) freezing 2) melting 3) boiling 4) sublimation
7. Which among the following is a sublimate?
   1) iodine 2) ice 3) water 4) salt
8. The melting point of ice is
   1) 0 °C 2) 100 °C 3) 80 °C 4) 32 °C
9. During solidification the heat energy is
   1) absorbed 2) liberated 3) both 1 and 2 4) none of these

Reasoning Answer Type

10. Statement - A : If melting point of ice is 0°C, then solidification point of water is also 0°C.
    Statement - B : If the boiling point of water is 100°C, then liquefaction point of steam is also 100°C.
    1) Statement A is true whereas Statement B is false.
    2) Statement A is false whereas Statement B is true.
    3) Both the statements are true.
    4) Both the statements are false.

SYNOPSIS – 9

Whenever a substance undergoes a change in state, whether from solid to liquid or from liquid to gas, it absorbs some quantity of heat without any rise of temperature. This heat is called latent heat. The word 'latent' means 'hidden' since there is no rise of temperature as the heat is being absorbed, the name 'latent heat' is assigned to it.

Latent heat :

The amount of heat needed to change the state of a given substance without any change in its temperature is called the latent heat.

We know that more is the mass(m) of the substance is the quantity of heat(Q) required, i.e., $Q \propto m$ or $Q = mL$ where L is the latent heat of substance.

Unit of Latent heat : We know $Q = mL \Rightarrow L = \frac{Q}{m} = \frac{J}{kg} = Jkg^{-1}$.

Hence the S.I. unit of latent heat is Jkg^{-1}.

Similarly the CGS unit of latent heat is cal g^{-1}.

Types of Latent heat :

Depending upon the nature of the process, there are two kinds of specific latent heat.

(1) The specific latent heat of fusion.

(2) The specific latent heat of vapourisation.

Specific Latent heat of fusion (L_f) :

Specific latent heat of fusion of a substance is the quantity of heat required to convert unit mass of the substance from solid to liquid state without change of temperature.

Example : The specific latent heat of fusion of ice is 80cal/g. This statement means that for 1gram of ice at 0°C to convert to water at 0°C amount of heat required is 80cal.

Specific latent heat of vapourisation : Specific latent heat of vapourisation of a substance is the quantity of heat required to convert unit mass of the substance from liquid to vapour state without changing of temperature.

Example : The specific latent heat of vapourisation of water is 540cal/g. This statement means that for 1gram of water at 100°C to convert to steam at 100°C amount of heat required is 540cal.

Change of state sequence :

When we supply heat to ice at 0°C it converts to water at 0°C. (change of state)

On supplying heat further, water at 0°C converts to water at 100°C. (rise of temp.)

On supplying heat further, water at 100°C converts to stem at 100°C. (change of state).

CONCLUSIONS

1) During change of state, heat absorbed or evolved (given out) is given by $Q = m \times L$ where L is the latent heat of substance.
2) During rise (or fall) of temperature heat absorbed or evolved (given out) is given by $Q = m \times C \times \Delta T$ where C is the specific heat of the substance.
2) The latent heat of fusion of ice is 3.36×10^5 J/kg, which is the same as 80 cal/g.
3) The latent heat of vapourisation of water is 2.26×10^6J/kg, which is same as 540 cal/g
4) Specific heat of water = $1 \text{calg}^{-1 0}\text{C}^{-1}$.
5) Change of state sequence :
When we supply heat to ice at 0^0C it converts to water at 0^0C. (change of state)
On supplying heat further, water at 0^0C converts to water at 100^0C. (rise of temp.)
On supplying heat further, water at 100^0C converts to stem at 100^0C. (change of state).

WORK SHEET - 9

Single Answer Type

1. The S.I. unit of latent heat is
1) kJ/kg 2) cal/g 3) J/kg 4) J/g
2. The heat absorbed when 1 kg of a liquid is converted to its vapour at the boiling point is called
1) latent heat of fusion 2) latent heat of vapourisation
3) specific heat 4) none of these
3. If m is mass of the body and Q is quantity of heat then, Latent heat of vapourisation is given by the formula
1) Q/m 2) m/Q 3) $Q \times m$ 4) $Q - m$
4. The latent heat of fusion of ice value in CGS system is 80cal/g. Its value in S.I. system is ___. (Take 1cal = 4.2J).
1) 3.36×10^5 J/kg 2) 336×10^5 J/kg 3) 33.6×10^5 J/kg 4) 0.336×10^5 J/kg
5. The latent heat of vapourisation of water value in CGS system is 540cal/g. Its value in S.I.system is ___. (Take 1cal = 4.2J).
1) 2.26×10^6 J/kg 2) 226×10^6 J/kg 3) 22.6×10^6 J/kg 4) 0.226×10^6 J/kg
6. Calculate the amount of ice that will be melted by a heat of 16.8×10^5 J. Latent heat of fusion of ice is 3.36×10^5 J/kg
1) 2 kg 2) 5 kg 3) 3 kg 4) 4 kg
7. Find the heat needed to convert 10g of ice into water. ($L_{ice} = 3.35 \times 10^5$ J/kg).
1) 3450 J 2) 3350 J 3) 3250 J 4) 3345 J
8. How much heat is required to melt 500 kg of aluminium ? $L_{aluminium} = 38 \times 10^4$J/kg
1) 18×10^7 J 2) 17×10^7 J 3) 20×10^7 J 4) 19×10^7 J

9. Calculate the amount of heat required to convert 500g of ice into water without change of temperature (L_{ice} = 3.34×10^5 J/kg)

1) 1.67×10^5 J 2) 1.50×10^5 J 3) 1.26×10^5 J 4) 1×10^5 J

10. What will be the amount of heat required to convert 50g of ice at 0°C to water at 0°C ?

1) 400 cal 2) 4000 cal 3) 3000 cal 4) 300 cal

11. What amount of ice that can be melted by 4000 calories of heat? Latent heat of fusion of ice = 80 cal g^{-1}

1) 20 g 2) 30 g 3) 50 g 4) 40 g

Comprehension Type

During the chane of state heat absorbed (or) evolved is given by $Q = M \times L$ where L is catent heat of substance.

12. Find the heat needed to convert 10g of water into vapour (Latent heat of vapourisation of water = 2.24×10^6 J/kg)

1) 2.20×10^6 J 2) 2.30×10^6 J 3) 2.29×10^6 J 4) 2.24×10^6 J

13. Calculate the amount of heat required to convert 5kg of ice at 0°C to vapour at 100°C.

1) 1.5×10^7 J 2) 2.5×10^7 J 3) 3.5×10^7 J 4) 4.5×10^7 J

14. Calculate the quantity of heat required to convert 1.5kg of ice at 0 °C to water at 15 °C. (L_{ice} = 3.34×10^5 J/kg, C_{water} = 4180 J/kg ° C)

1) 5.85×10^5 J 2) 5.95×10^5 J 3) 3.95×10^5 J 4) 4.95×10^5 J

WORK SHEET – 1 (KEY)

1) 2	**2)** 2	**3)** 1	**4)** 2	**5)** 1
6) 2	**7)** 2	**8)** 1,2,4	**9)** 2,3,4	**10)** 1,3

1. Heat is a form of energy.
2. The most important naturally occurring source of heat is sun.
3. Heat always flows from higher temperature to lower temperature.
4. The degree of hotness or coldness of the body is called temperature.
5. The heat of the sun is a basic requirement for the existence of life.
6. The S.I. unit of heat is joule.

WORK SHEET – 2 (KEY)

1) 1	**2)** 1	**3)** 1	**4)** 4	**5)** 1
6) 2	**7)** 4	**8)** 1	**9)** 3	**10)** 2,4
11) 3,4	**12)** 1	**13)** 4	**14)** 3	**15)** 1
16) 3	**17)** 2			

1. A device used for the measurement of temperature is thermometer.
2. The liquid used in a laboratory thermometer is mercury.
3. The lower fixed point of a thermometer scale is the temperature of melting ice .
4. The boiling point of water is 100°C.
5. The melting point of ice is 0°C.
6. The S.I. unit of temperature is Kelvin.
7. Mercury is the commonly used thermometric liquid because
   1) it can be easily obtained in pure state
   2) it does not stick to glass tube thermometer
   3) It has a very high density.
8. The lower fixed point of a temperature scale is also called ice point.
9. If a body is at a temperature higher than the room temperature the level of mercury in the thermometer's stem rises.
10. Temperature in Kelvin = 273 + temp. in ${}^0C$

$$= 273 + 357$$
$$= 630K$$

Also $\frac{F-32}{9}=\frac{C}{5}$

$\frac{F-32}{9}=\frac{357}{5}$

$F-32=\frac{9}{5}\times 357$

$\therefore F=\left(\frac{9}{5}\times 357\right)+32=674.6^0 F$

11. Temp. in (K) = 273 + temp in $\left({}^0C\right)$

233 = 273 + temp. in ${}^0C$

$\therefore$ temp in ${}^0C=233-273$

$=-40^0 C$

12 $\frac{3}{8}$ of Celsius scale $=\frac{3}{8}\times 100^0 C=37.5^0 C$

13. Temp. on Kelvin scale $=37.5+273=310.5K$

14. Temp. on Fahrenheit scale, $\frac{F-32}{9}=\frac{C}{5}$

$\therefore\ F=\frac{9}{5}C+32=\frac{9}{5}\times 37.5+32=99.5^0 F$

15. $\frac{7}{9}$ parts on Fahrenheit scale $=\frac{7}{9}\times 180=140^0 F$

$\therefore$ Room temp. on Fahrenheit = $(180-140)+32=72^0 F$

16. $\frac{C}{5}=\frac{F-32}{9}$

$\therefore C=\frac{5}{9}(F-32)=\frac{5}{9}(72-32)=22.22^0 C$

17. Temperaure in $K=C+273=22.22+273=295.22$ K.

18. (i) Temperature in Kelvin = $273+$ temp in $\left({}^0C\right)$

$=273+55=328K$

(ii) $\frac{F-32}{9}=\frac{C}{5}$

$\therefore F-32=\frac{9}{5}C=\frac{9}{5}\times 55$

$\therefore F-32=99$

$\therefore F=99+32=131^0 F$

19. (i) $\frac{C}{5}=\frac{F-32}{9}$

$\therefore C=\frac{5}{9}(F-32)=\frac{5}{9}(108-32)=\frac{5}{9}\times 76=42.22^0 C$

(ii) Temperaure in Kelvin = 273 + temp. in $\left({}^0C\right)$

$=273+42.22=315.22K$

20. (i) Temp. in $(K)=273+$ temp. in $\left({}^0C\right)$ or 198 = 273 + temp. in $\left({}^0C\right)$

$\therefore$ Temp. on Celsius scale = 198 - 273 = $-75^0 C$

(ii) $\frac{F-32}{9}=\frac{C}{5}$

$\therefore F=\frac{9}{5}C+32=\left(\frac{9}{5}\times -75\right)+32=-135+32=-103^0 F$

WORK SHEET – 3 & 4 (KEY)

1) 1	**2)** 2	**3)** 1	**4)** 3	**5)** 1
6) 2	**7)** 3	**8)** 3	**9)** 3	**10)** 1
11) 3	**12)** 3	**13)** 1	**14)** 2	**15)** 4
16) 3	**17)** 1	**18)** 1	**19)** 1	**20)** 2
21) 1	**22)** 1	**23)** 1	**24)** 2	**25)** 1
26) 4				

1. A 1K rise in temperature is the same as a 1°C rise in temperature. sice the number of divisions in both the scales is same.
2. The relation between the celsius and Fahrenheit temperature scales is
3. Normal temperature of the body of a healthy person is 37°C.
4. Absolute zero on celsius scale is –273°C.
5. Ice point in Fahrenheit scale is 32°F.
6. Steam point in kelvin scale is 373K.
7. The lower fixed point of each the celsius and the Fahrenheit scale of

temperature is the freezing point of water.

8. The boiling point of water on Fahrenheit scale is 212°F.
9. The melting point of ice in Kelvin scale is 273K
10. Since a 1K rise in temperature is the same as a 1°C rise in temperature. as the number of divisions in both the scales is same.
11. On the Fahrenheit scale, one division on the celsius scale is equal to divisions.
12. The lowest attainable temperature is –273°C.
13. Heat flows from A to B. Because heat always flows from a body of higher temperature to lower temperature.
14. A thermometer when put in a water bath at 27°C reads 300. The scale of the thermometer is in Kelvin.
15. We know that $\frac{C}{100} = \frac{K-273}{100}$

$\Rightarrow$ C = K – 273 $\Rightarrow$ C = 100 – 273

$\therefore$ C = – 173^{0}C.

16. We know that, $\frac{C}{100} = \frac{K-273}{100}$

$\therefore$ K + 273 = 300

$\therefore$ 27^{0}C = 300 K

17. From relation $\frac{C}{100} = \frac{F-32}{180}$

$\frac{C}{5} = \frac{F-32}{9} \Rightarrow \frac{C}{5} = \frac{100-32}{9}$

$\therefore\ C = \frac{5}{9} \times 68 = 37.8$

18. On Celsius scale, the interval between L.S.P and U.S.P is 100^{0}C

$\therefore$ Reading on cessius scale is $\left(\frac{2}{5}\right)$ 100^{0}C

$= \frac{2}{5} \times 100 = 40^0 C$

Now $\frac{C}{100} = \frac{K-273}{100}$

$\Rightarrow$ C = K – 273

$\therefore$ 40 = K – 273 $\Rightarrow$ K = 40 + 273 = 313 K

19. We know that $\frac{C}{100} = \frac{F-32}{180}$

$\therefore\ \frac{C}{5} = \frac{F-32}{9}$

Let the common reading be ‘x’

$\therefore \frac{x}{5}-\frac{x-32}{9}$

$9x = 5x - 160$

$4x = -160$

$\therefore\ x = -40$

20. We know that $\frac{K-273}{100}=\frac{R}{80}$

$\therefore \frac{K-273}{5}=\frac{R}{4}$

Let the common reading be 'x'

$\therefore \frac{x-273}{5}=\frac{x}{4}$

$4x - 1092 = 5x$

$\therefore\ x = -\ 1092$

21. We know that $\frac{F-32}{180}=\frac{C}{100}$

$\therefore \frac{F-32}{9}=\frac{C}{5}$

$\frac{2x-32}{9}=\frac{x}{5}$

$\Rightarrow\ 10x - 160 = 9x$

$\therefore x = 160$

22. We know that

$\frac{F-32}{180}=\frac{R}{80}$

$\frac{x-32}{9}=\frac{x}{4}$

$\Rightarrow\ 4x - 128 = 9x$

$\Rightarrow\ 5x = -\ 128$

$\therefore\ x = -25.6$

23. We know that for any scale

$\frac{\text{Reading}-\text{L.S.P}}{\text{U.S.P}-\text{L.S.P}}=\text{constant}$

$\therefore \frac{15.5-0.5}{99.5-0.5}=\frac{C-0}{100-0}$

$\frac{15}{99}=\frac{C}{100}$

$\Rightarrow\ C=\frac{15}{99}\times 100=15.15^{0}C$

24. Let the reading of A = x

$$\therefore \frac{x-0}{450} = \frac{110-50}{100}$$

$$\frac{x}{9} = \frac{60}{20}$$

$\therefore$ x = 27

$\therefore$ Reading of A will be 27^0 when B reads 110^0

25. Let the temperature on centigrade scale be 'x'

$$\therefore \frac{59-5}{95-5} = \frac{x-0}{100-0}$$

$$\therefore \frac{54}{90} = \frac{x}{100}$$

$\therefore$ x = 60^0C

26. Let the correct reading in of = x

$$\therefore \frac{x-32}{180} = \frac{52-5}{99-5}$$

$$\frac{x-32}{180} = \frac{47}{94}$$

$$\frac{x-32}{180} = \frac{1}{2}$$

$\therefore$ 2(x – 32) = 180

x – 32 = 90

$\therefore$ x = 122^0F

WORK SHEET – 5 (KEY)				
1) 1	**2)** 2	**3)** 3	**4)** 1	**5)** 2
6) 1	**7)** 2	**8)** 1	**9)** 2	**10)** 2
11) 1,2,3	**12)** 1,2,3	**13)** 1	**14)** 2	**15)** 3

1. Increase in length of a rod on heating is called linear expansion.
2. Increase in surface area of a sheet on heating is called superficial expansion.
3. Increase in volume of a body on heating is called cubical expansion.
4. A brass ring is tightly fitted over an iron cylinder. To loosen the ring, the system must be heated.
5. An iron ring is tightly fitted over an brass cylinder. To loosen the ring, the system must be cooled.
6. While lying a railway line, a small gap is left in between the two rails at their joints to allow expansion during summer.

7. While laying telephone or electric wires a little sag is left during summer because to contract in winter.
8. As in summer, due to increase in atmospheric temperature, the **effective length of pendulum increases** and thus the time taken for each oscillation increases and the **clock loses time** (i.e. it goes slow).
9. As in winter, clocks becomes fast In winter, due to decrease in atmospheric temperature, the **effective length of pendulum decreases** and thus the time taken for each oscillation decreases and the **clock gains time** (i.e. it becomes fast).
10. Bridges are mounted on rollers to prevent their collapse

13,14 &15

$$L_0 = 5cm; L_t = 5.05cm; t = (820-20) = 800^0 C$$

$$\therefore \alpha = \frac{L_t - L_0}{L_0 \times t} = \frac{(5.05-5)}{5\times 800} = \frac{0.05}{4000} = 0.0000125 /^0 C$$

$$\therefore \beta = 2\alpha = 2\times 0.0000125 /^0 C = 0.0000250 /^0 C$$

$$\gamma = 3\alpha = 3\times 0.0000125 /^0 C = 0.0000375 /^0 C$$

16. $L_0 = 200cm; \alpha = 0.000018 /^0 C; t = (880-20) = 860^0 C$

Increase in length $(L_t - L_0) = L_0 \times \alpha \times t = 200\times 0.000018 \times 860 = 3.096$ cm

$\therefore$ Length at $880^0 C = 200 + 3.096 = 203.096cm$

17. Initial area of plate, $A_0 = 20\times 50cm^2 = 1000cm^2$

Final area of plate, $A_t = 1006cm^2$

Coefficient of linear expansion $(\alpha) = 0.000012 /^0 C$

$\therefore$ Coefficient of superficial expansion $(\beta) = 2\times\alpha = 0.000024 /^0 C$.

We know, $A_t - A_0 = A_0 \beta t$

$$\therefore t = \frac{A_t - A_0}{A_0 \times \beta} = \frac{1006-1000}{1000\times 0.000024} = \frac{6}{0.024} = 250^0 C$$

$\therefore$ Temp. of furnace = Initial temperature + Rise in temperature

$$= 10 + 250 = 260^0 C$$

18. Increase in length of brass = Increase in length of iron

$(L_t - L_0)$ for brass $= (L_t - L_0)$ for iron.

$$L_{Brass} \times \alpha_{brass} \times t = L_{Iron} \times \alpha_{Iron} \times t$$

$$L_{Brass} \times 18\times 10^{-6} = 1.8\times 12\times 10^{-6}$$

$\therefore L_{Brass} = \frac{1.8 \times 12}{18} = 1.2m$.

WORK SHEET – 6 (KEY)

1) 4	**2)** 1	**3)** 2	**4)** 2	**5)** 2
6) 3	**7)** 1	**8)** 2	**9)** 4	**10)** 3
11) 1	**12)** 4	**13)** 2	**14)** 4	**15)** 2

1. We know Q = m C
2. We know Q = m C
4. The correct relation between specific heat and thermal capacity is thermal capacity = mass × specific heat.
5. We know, thermal capacity = mass × specific heat = kg ×
6. Given m = 150 g =
   Specific heat of iron C = 480 J kg^{-1} $°C^{-1}$
   = (25 – 20)°C = 5°C
   Q = m × C ×
   = 0.15 kg × 480 J kg^{-1} $°C^{-1}$ × 5°C
   = 360 J
7. Quantity of heat supplied Q = 2000 cal
   mass of water, m = 200 g
   specific heat of water, C = 1 cal g^{-1} $°C^{-1}$
   Rise in temperature = ?
   From relation, Q = m C

   So, the temperature of water rises by 10°C.
8. mass of water, m = 100 g
   Rise in temperature = (100°C – 30°C)
   = 70 °C
   Specific heat of water C = 4.2 J g^{-1} $°C^{-1}$
   Then Q = m. C.
   = 100 g × 4.2 J g^{-1} $°C^{-1}$ × 70°C
   = 29400 J = 29.4 kJ.
9. m = 500 g = 0.5 kg = 60 – 40 = 20°C
   C = 4200 J/kg °C Q = ?
   using the formula, Q = m C
   = 0.5 × 4200 × 20 = 42000 J
   Heat lost = 42,000 J
10. m = 400 g = 0.4 kg C = 390 J kg^{-1} $°C^{-1}$
    T_1 = 100°C, T_2 = 30°C = 70°C
    Heat lost = mC ($T_1 - T_2$)
    = 0.4 × 390 × 70 J = 10, 920 J

11. $m = 200g$, $C_{copper} = 0.09$ cal/g °C
$T = T_1 - T_2 = 80 - 20 = 60$ °C
$Q = mC T = 200 \times 0.09 \times 60 = 1080$ cal.

12. $m = 100$ g, $C = 1$ cal/g °C
= 90°C
$Q = mC = 100 \text{ g} \times 1 \text{ cal g}^{-1}°C^{-1} \times 90°C$
$= 100 \times 1 \times 90$ cal
$= 9000$ cal = 9 k.cal

13. $m = 500$ g, $c = 1.8 \text{ Jg}^{-1} °C^{-1}$
Heat capacity = mass × Specific heat
$= 500 \text{ g} \times 1.8 \text{ J g}^{-1} °C^{-1} = 900 \text{ J } °C^{-1}$

14. The amount of heat required to raise the temperature of 75 g of metal through 1°C = heat capacity.
Now, heat capacity = mass × Specific heat capacity
48.75 J/°C = 75 g × sp.heat capacity
sp. heat capacity =
$= 0.65 \text{ J g}^{-1} °C^{-1}$

15. $m = 400$ g , $C = 1.98 \text{ J g}^{-1} °C^{-1}$
$T_1 = 100°C$, $T_2 = ?$
fall in temperature = (100 – x)
Heat energy given out by oil = 47376 J
according to formula $Q = m.C. \Delta T$
$47376 = 400 \times 1.98 \ (100 - x)$
$100 - x =$
$x = 100 - 59.8 = 40.2$ °C
Final temperature of oil = 40.2°C

WORK SHEET – 7 (KEY)				
1) 3	**2)** 4	**3)** 2	**4)** 1	**5)** 3
6) 3	**7)** 1	**8)**	**9)** 2	**10)** 3

1. Suppose m gram of water at 70°C is added. Then
Heat lost by water at 70°C
$= m \times C \times (70 - 42) = m \times C \times 28$
Heat gained by water at 30°C
$= 175 \times C \times (42 - 30) = 175 \times C \times 12$
As Heat lost = Heat gained
$m \times C \times 28 = 175 \times C \times 12$
or $\Rightarrow m = \frac{175 \times 12}{28} = 75g$

2. Hot water, m_h = 5kg, T_h = 80°C
Cold water, m_c = 15kg, T_c = 20°C, T = ?
If the temperature of mixture is T
Heat lost by hot water = 5 × C × (80 – T)
Heat gained by cold water
= 15 × C × (T – 20)
According to the principle of calorimetry, Heat lost = Heat gained
5 × C × (80 – T) = 15 × C × (T – 20)
80 – T = 3 (T – 20) T = 35°C

3. m (hot water) = 10kg,
T (hot water) = 70°C
m (cold water) = 20kg
T (cold water) = 20°C T (final) = ?
Using the formula Q = mC t
We get heat lost by hot water
= 10 × C × (70 – T_f)
Where T_f is the final temperature
Heat gained by cold water = 20 × C × (T_f – 20)
Using the principle of calorimetry
Heat lost = Heat gained
We get 10 × C × (70 – T_f) = 20 × C × (T_f – 20)
700 – 10T_f = 20T_f – 400
or 30 T_f = 1100 T_f = 36.67°C

4. Mass of hot water, m_1 = 500g
Mass of cold water, m_2 = 300g
Temp. of hot water, t_1 = 100°C
Temp. of cold water, t_2 = 30°C
Sp. heat of water, C = 4.2J g^{-1} °C^{-1}
Let temp. of mixture be t°C. Then,
Heat gained by cold water
= m_2 × C × (t – t_2)
According to the principle of calorimetry, Heat lost = Heat gained
500 × 4.2 × (100 – t) = 300 × 4.2 × (t – 30)
5 (100 – t) = 3(t – 30)
–3t – 5t = –90 – 500 –8t = –590

So, the final temperature of the mixture is 73.8°C.

5. Given, Mass of copper, m_1 = 500g
Mass of water, m_2 = 200g
Initial temperature of copper, t_1 = 100°C
Initial temperature of water, t_2 = 25°C
Sp. heat of copper, C_1 = 0.42J g^{-1}°C^{-1}
Sp. heat of water, C_2 = 4.2J g^{-1} °C^{-1}

Final temperature of the mixture = t°C
Then,
Heat lost by the copper piece
$= m_1C_1(t_1 - t)$
Heat gained by water = $m_2C_2\ (t - t_2)$
We know, Heat lost = Heat gained
$m_1C_1\ (t_1 - t) \quad = m_2C_2(t - t_2)$
$500 \times 0.42 \times (100 - t) = 200 \times 4.2 \times (t - 25)$
$(100 - t) \times (t - 25)$
$= 4\ (t - 25)$
This given, 5t= 200
Thus, the final temperature of the mixture is 40°C.

6. Here, Mass of brass, m_1 = 0.4kg
Temperature of brass, T_1 = 100°C
Mass of water, m_2 = 1kg
Temperature of water, T_2 = 20°C
Final temperature, T = 23°C
Specific heat of brass, C_1 =?
Specific heat of water, C_2 = 4180J/kg°C
From relation, Heat lost = Heat gained
$m_1C_1\ (T_1 - T) = m_2C_2\ (T - T_2)$
Putting values we get,
$0.4 \times C_1 \times (100 - 23) = 1 \times 4180 \times (23 - 20)$
$J/kg^0\,C$
Specific heat of brass = 407J/kg°C.

7. Mass of iron, M = 0.05kg
Initial temperature of iron, t_1 = 200°C
Final temperature of iron, t_2 = 22.4°C
Mass of water, m = 0.4kg
Initial temperature of water, t_3 = 20 °C
Final temperature of water, t_2 = 22.4°C
Specific heat capacity of water
$= 4200J\ kg^{-1}\ K^{-1}$
Let specific heat capacity of iron = C
Heat lost by iron = $MC\ (t_1 - t_2)$
$= 0.05 \times C \times (200 - 22.4)$
$= 0.05 \times C \times 177.6 = 8.88C\ J$
Heat gained by water = $m \times 4200 \times (t_2 - t_1)$
$= 0.4 \times 4200 \times (22.4 - 20)$
$= 0.4 \times 4200 \times 2.4 = 4032J$
Equating heat lost and heat gained
$8.88C = 4032$
Therefore, $C = 4032/8.88 = 454.05J\ kg^{-1}\ K^{-1}$

8. We know that, $Q = M.C\ \Delta T$

$\therefore\ 25200\ J = \left(\frac{75}{100}kg\right)\times 4200\frac{J}{kg^0C}\times(x-10)$

$80 = x - 10$

$\therefore\ x = 90^0C = 9 \times 10^0C$

9. Heat loss = Heat gained

$M_1C_1\ \Delta T_1 = m_2\ c_2\ \Delta T_2$

$\Rightarrow\ 15 \times C \times (90^0 - T) = 20 \times C \times (T - 30^0)$

$3(90 - T) = 4(T - 30)$

$270 - 3T = 4T - 120$

$7T = 390$

$\therefore\ T = 55.7^0C$

10. Heat lost by Cu = Heat gained by water

$800 \times 420\times (90 - T) = 300 \times 4200 \times (T - 10)$

$4(90 - T) = 15(T - 10)$

$360 - 4T = 15T - 150$

$360 + 150 = 15T + 4T$

$\therefore\ 19T = 510$

$T = \frac{510}{19} = 27^0C$

WORK SHEET – 8 (KEY)

1) 3	**2)** 2	**3)** 4	**4)** 1	**5)** 2
6) 3	**7)** 1	**8)** 1	**9)** 2	**10)** 3

1. The temperature at which a liquid is converted into vapour (gas) is called boiling point
2. The temperature at which a solid is converted into liquid, is called its melting point
3. The temperature at which a gas is converted into a liquid is called its condensation point
4. The temperature at which a liquid is converted into a solid is called its freezing point.
5. During change of state temperature remains constant
6. The process during which a liquid on heating changes to vapour state is called boiling
7. Which are among them is sublimates iodine
8. The melting point of ice is 0 °C
9. During solidification the heat energy is liberated.
10. Both the statements are true.

WORK SHEET – 9 (KEY)

1) 3	**2)** 2	**3)** 1	**4)** 1	**5)** 1
6) 2	**7)** 2	**8)** 4	**9)** 1	**10)** 2
11) 3	**12)** 4	**13)** 1	**14)** 2	

1. The S.I. unit of latent heat is J/kg
2. The heat absorbed when 1 kg of a liquid is converted to its vapour at the boiling point is called latent heat of vapourisation
3. Latent heat of vapourisation is given by Q/m [Q = mL].
6. Given $Q = 16.8 \times 10^5$ J
   $L = 3.36 \times 10^5$ J/kg Then m = ?
   We know that Q = mL
7. Given, m = 10 g = 0.01 kg
   $L = 3.35 \times 10^5$ J/kg
   We know Q = mL
   $= 0.01 \times 3.35 \times 10^5$ J/kg= 3350 J
8. m = 500kg $L = 38 \times 10^4$ J/kg
   We know Q = mL
   $= 500 \times 38 \times 10^4 \text{ J} = 19000 \times 10^4$ J
   $= 19 \times 10^7$ J
9. $L = 3.34 \times 10^5$ J/kg Q = ?
   We know Q = mL $= 0.5 \times 3.34 \times 10^5$ J
   $= 1.67 \times 10^5$ J
10. m = 50 g L = 80 cal/g
    We know Q = mL
    $= 50 \times 80$ cal = 4000 cal.
    = 4 Kcal
11. Given Q = 4000 cal L = 80 cal/g
    We know that Q = mL
    $= 50 \text{ g} = 5 \times 10$g
12. m = 10g = 0.01 kg
    $L = 2.24 \times 10^6$ J/kg
    We know Q = mL
    $= 0.01 \times 2.24 \times 10^6 \text{ J/kg} = 2.24 \times 10^4$ J
13. m = 5 kg $L_f = 3.36 \times 10^5$ J/kg
    $L_v = 2.25 \times 10^6$ J/kg
    s = 4200 J/kg/°C   Then Q = ?

Q = Heat required to convert ice at °C to water at 0°C + Heat required to convert water at 100°C to vapour at 100°C

$= mL_f + ms\,(100 - 0) + mL$

$= 5 \times 3.36 \times 10^5 + 5 \times 4200 \times (100 - 0) + 5 \times 2.25 \times 10^6$

$= 16.8 \times 10^5 + 21 \times 10^5 + 112.5 \times 10^5$

$= 1.5 \times 10^7$ J

14. m = 1.5 kg

$L = 3.34 \times 10^5$ J/kg C = 4180 J/kg °C

$t_1 = 0$ °C $t_2 = 15$ °C

quantity of heat required ,Q = ?

From relation heat required to current ice into water at 0°C

$Q_1 = mL = 1.5\times3.34\times 10^5 = 5.01 \times 10^5$ J

Heat required to rise the temperature of water from 0°C to 15°C

$Q_2 = mCt = 1.5 \times 4180 \times (15 - 0)$ J

$= 1.5 \times 4180 \times 15$ J = 94050 J

$= 0.94 \times 10^5$ J

Total heat required $Q = Q_1 + Q_2$

$= 5.01\times10^5 + 0.94 \times 10^5$ J $= 5.95 \times 10^5$ J