Contents

PHYSICS

PHYSICAL QUANTITIES

The quantities like length, mass, time, temperature, area, volume and density, etc. which can be measured, are known as physical quantities. Physical quantities are speed and velocity, acceleration, pressure, energy, work, power, electric current, luminous intensity, amount of substance, force, momentum, etc.

A physical quantity is represented by a number, followed by a unit. The 'number plus unit' is known as the 'magnitude' of the physical quantity.

PHYSICAL QUANTITIES ARE OF TWO TYPES:

(i) Basic physical quantities, and

(ii) Derived physical quantities.

BASIC PHYSICAL QUANTITIES:

There are a total of 7 basic physical quantities. Length, mass, time, electric current, temperature, luminous intensity and amount of substance. All other quantities of physics can be expressed in terms of these physical quantities.

DERIVED PHYSICAL QUANTITIES

A physical quantity obtained by multiplying or dividing one basic physical quantity with another basic physical quantity, is known as a derived quantity.

The basic quantities are also known as base quantities. Basic quantities are fundamental quantities.

A unit is a quantity of dimension used as a standard of measurement.

(i) There should be a standard unit of measurement,

(ii) A comparison should be made between the standard unit of measurement and the quantity to be measured.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

The international system of units is called SI units in short. Actually, SI units is the short form of the French name 'Systeme International d'Units' which means 'International System of Units'.

THE SEVEN BASE UNITS OF THE INTERNATIONAL SYSTEM OF MEASUREMENT:

Basic quantity	Name of the base SI unit	Symbol of SI unit
1. Length	metre	m
2. Mass	kilogram	kg
3. Time	second	s
4. Electric current	ampere	A
5. Temperature	kelvin	K
6. Luminous intensity	candela	cd
7. Amount of substance	mole	mol

The speed of light in vacuum is 299 792 458 m/s.

METRE

Metre is the SI unit of length. A metre is the length of path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.

1 kilometre = 1000 metres
1 centimetre = $\frac{1}{100}$ metre
1 millimetre = $\frac{1}{1000}$ metre

2. KILOGRAM

Kilogram is the SI unit of mass.

1 quintal = 100 kg
1 tonne = 1000 kg
1 gram = $\frac{1}{1000}$ kg
1 milligram = $\frac{1}{1000}$ gram

Kilogram is denoted by the symbol kg, gram by g and milligram by mg.

3. SECOND

Second is the SI unit of time.

60 seconds = 1 minute
60 minutes = 1 hour
24 hours = 1 day

4. AMPERE

Ampere is the SI unit of electric current. The ampere is the constant current which, if maintained in two straight parallel conductors of infinite length and of negligible circular cross-section placed 1 metre apart in vacuum, would produce between them a force of 2×10^{-7} newtons per metre of length.

5. KELVIN

Kelvin is the SI unit of temperature. The triple point of water is temperature at which all the three phases of water (ice, liquid and water vapour) co-exist in dynamic equilibrium. The triple point of water has been assigned a temperature of 273.16 kelvin. The Kelvin is 1/273.16 of the thermodynamic temperature of the triple Point of water.

6. MOLE

Mole is the SI unit of the amount of substance. A mole is the amount of substance which contains as many elementary particles (atoms, molecules or ions) as there are in 12 grams of carbon-12.

7. CANDELA

Candela is the SI unit of luminous intensity (luminous intensity means brightness of light).

PREFIXES FOR USE WITH SI UNITS:

Value	prefix	symbol
10^{18}	exa-	E
10^{15}	peta-	P
10^{12}	tera-	T
10^{9}	giga-	G
10^{6}	mega-	M
10^{3}	kilo-	K
10^{2}	hecto-	h
10^{1}	deca-	da
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
10^{-18}	atto-	a

DERIVED UNITS (OR DERIVED SI UNITS)

A unit obtained by multiplying or dividing one base unit by another base unit is called a derived unit.

The derived physical quantities like area, volume, density, pressure, force, energy, speed, velocity, acceleration, power, momentum etc, all are derived SI units which have been derived (obtained) from the base SI units.

The base SI unit of distance (which is a length) is metre (m) and that of time is second (s). So

$$\text{Unit of speed} = \frac{\text{unit of distance(or length)}}{\text{unit of time}} = m/s \text{ or } ms^{-1}$$

Thus, the SI unit of speed is metre per second which is written as m/s or ms^{-1}.

SOME DERIVED SI UNITS:

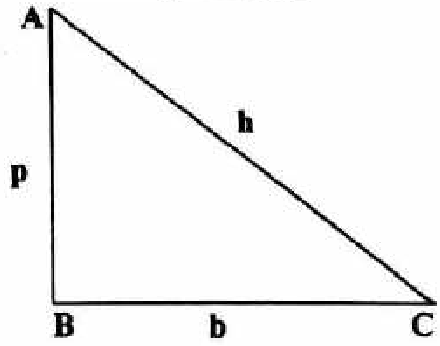
Name of the derived quantity	Name of the derived SI unit	Symbol of the derived SI unit
Area	square metre	m^2
Volume	cubic metre	m^3
Density	kilogram per cubic metre	kg/m^3 or $kg\text{-}m^{-3}$
Speed (and velocity)	metres per second	m/s or ms^{-1}
Acceleration	metre per second square	m/s^2 or ms^{-2}
Momentum	kilogram-metre per second	kg.m/s or $kg.ms^{-1}$
Force (and weight)	newton	N
Work (and energy)	joule	J
Power	watt	W
Pressure	pascal	Pa

MOTION, DISTANCE AND DISPLACEMENT

A body is said to be in motion (or moving) when its position changes continuously with respect to a stationary object taken as a reference point.

The distance travelled by a body is the actual length of the path covered by a moving body irrespective of the direction in which the body travels.

When a body moves from one point to another, the distance travelled refers to the actual length of the indirect path whereas displacement refers to the straight line path between the initial and the final positions. So, whatever be the actual length of the path followed by a moving body, displacement of the body is always represented by the shortest distance between the initial and final positions of the body. Thus, when a body moves from one position to another, the shortest (straight line) distance between the initial position and final position of the body, along with direction, is known as its displacement.



When a body travels from A to B and then to C

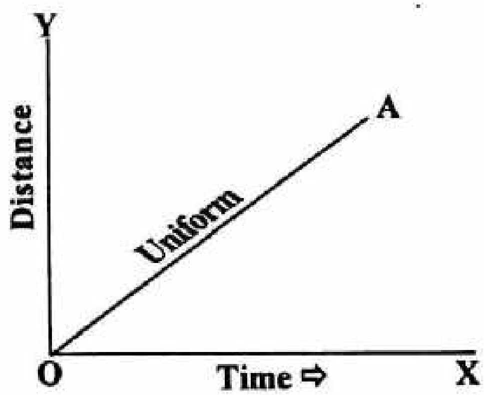
the distance travelled = p + b

and displacement = h

Distance is a scalar quantity (because it has magnitude only) but displacement is a vector quantity because it has magnitude as well as a direction.

UNIFORM MOTION

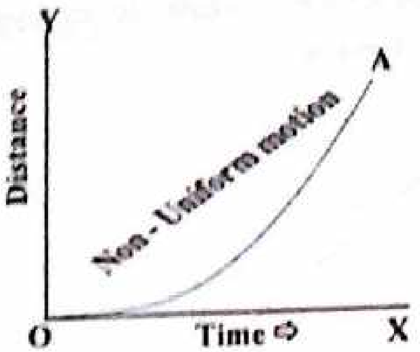
A body has a uniform motion if it travels equal distances in equal intervals of time, no matter how small these time intervals may be. The distanace-time graph for uniform motion is a straight line.



NON – UNIFORM MOTION

A body has a non-uniform motion if it travels unequal distances in equal intervals of time.

The motion of a freely falling body is an example of non uniform motion. The distance-time graph for a body having non-uniform motion is a curved line.



If the distance – time graph is a curved line, the motion will be non-uniform. It should be noted that non-uniform motion is also called accelerated motion.

SPEED, VELOCITY AND ACCELERATION

The motion of a body can be described by three terms: speed, velocity and acceleration.

SPEED

Speed of a body is the distance travelled by it per unit time.

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

If a body travels a distance 's' in time 't', then its speed 'v' is given by:

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

Where

v = speed

s = distance travelled

t = time taken (to travel that distance)

The SI unit of distance is metre (m) and that of time is second (s), therefore, the SI unit of speed is metres per second which is written as m/s or ms^{-1}.

Speed has magnitude only, it has no specified direction, therefore, speed is a scalar quantity.

AVERAGE SPEED

The average speed of a body is the total distance travelled divided by the total time taken to cover this distance.

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

UNIFORM SPEED (OR CONSTANT SPEED)

A body has a uniform speed if it travels equal distances in equal intervals of time, no matter how small these time intervals may be. For example, a car is said to have uniform speed of say, 60 km per hour, if it travels 30 kms every half hour, 15 kms every quarter of an hour, 1 km every minute, and 1/60 km every second.

VELOCITY

Velocity of a body is the distance travelled by it per unit time in a given direction. Velocity of a body is its speed in a specified direction.

Velocity = Distance travelled in a given direction/Time taken

$v = s/t$

v = velocity of the body

s = distance travelled (in the given direction)

t = time taken (to travel that distance)

The unit of velocity is the same as that of speed, namely, metres per second (m/s or ms^{-1})

Speed has only magnitude. So speed is a scalar quantity but velocity has magnitude as well as direction. Velocity is a vector quantity.

$v = s/t$

$s = v \times t$

Distance travelled = average velocity × time

UNIFORM VELOCITY (OR CONSTANT VELOCITY)

A body has a uniform velocity if it travels in a straight line and moves over equal distances in equal intervals of time, no matter how small these time intervals may be.

THE VELOCITY OF A BODY CAN BE CHANGED IN TWO WAYS:

(i) by changing the speed of the body, and

(ii) by keeping the speed constant but by changing the direction.

ACCELERATION

Acceleration of a body is defined as the rate of change of its velocity with time.

Acceleration = change in velocity/ time taken for change
Change in velocity = final velocity – initial velocity

$$\text{Acceleration} = \frac{\text{final velocity} - \text{initial velocity}}{\text{time taken}}$$

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

a = Acceleration of the body
v = Final velocity of the body
u = Initial velocity of the body
t = Time taken for the change in velocity

The S.I. unit of acceleration is 'meters per second per second' or 'metres per second square' which is written as m/s^2 or ms^{-2}.

Acceleration is a vector quantity and when a body is moving with uniform velocity, its acceleration will be zero.

UNIFORM ACCELERATION

A body is said to be accelerated if it travels in a straight line and its velocity increases by equal amounts in equal intervals of time. A body has a uniform acceleration if its velocity changes at a uniform rate.

Here are some examples of the uniformly accelerated motion.

(i) The motion of a freely falling body is an example of uniformly accelerated motion.

(ii) The motion of a bicycle going down the slope of a road when the rider is not pedalling and wind resistance is negligible, is also an example of uniformly accelerated motion.

(iii) The motion of a ball rolling down an inclined plane is an example of uniformly accelerated motion.

NON – UNIFORM ACCELERATION

A body has a non-uniform acceleration if its velocity increases by unequal amounts in equal intervals of time. In other words, a body has non-uniform acceleration if its velocity changes at a non-uniform rate.

RETARDATION (OR DEACCELERATION OR NEGATIVE ACCELERATION)

A body is said to be retarded if its velocity is decreasing. Retardation is measured in the same way as acceleration, that is, retardation is equal to change in velocity / time taken and has the same unit of 'meters per second' (m/s^2 or ms^{-2}). Retardation in actually acceleration with the negative sign.

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Average velocity

$$\text{Average velocity} = \frac{(\text{initial velocity} + \text{final velocity})}{2}$$

EQUATIONS OF UNIFORMLY ACCELERATED MOTION

There are three equations for the motion of those bodies which travel with a uniform acceleration. These equations give relationship between initial velocity, final velocity, time taken, acceleration and distance travelled by the bodies.

1. FIRST EQUATION OF MOTION

The first equation of motion is : $v = u + at$. It gives the velocity acquired by a body in time 't'.

Consider a body having initial velocity 'u'. Suppose it is subjected to a uniform acceleration 'a' so that after time 't' its final velocity becomes 'v'. Now, from the definition of acceleration we know that:

Acceleration = change in velocity/ time taken

$$\text{Acceleration} = \frac{\text{final velocity} - \text{initial velocity}}{\text{time taken}}$$

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

v = final velocity of the body
u = initial velocity of the body
a = acceleration
t = time taken

2. SECOND EQUATION OF MOTION

The second equation of motion is : $s = ut + \frac{1}{2}at^2$. It gives the distance travelled by a body in time 't'.

$$\text{Average velocity} = \frac{(\text{initial velocity} + \text{final velocity})}{2}$$

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

where s = distance travelled by the body in time 't'

u = initial velocity of the body

a = acceleration

3. THIRD EQUATION OF MOTION

The third equation of motion is:

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

where v = Final velocity

u = Initial velocity

a = Acceleration

s = Distance travelled

CIRCULAR MOTION

When a body moves in a circular path with uniform speed (constant speed), its motion is called uniform circular motion. Circular motion is accelerated even though the speed of the body remains constant. The motion in a circle with constant speed is an example of accelerated motion. Though the speed may not change, the direction of motion changes continuously. We, therefore, conclude that when a satellite (like the moon) goes round the earth with constant speed, its velocity is not uniform because the direction of motion of the satellite changes continuously. Thus, the motion of a satellite is accelerated.

In uniform linear motion, the direction of motion is fixed. So, uniform linear motion is not accelerated. In uniform circular motion, the direction of motion changes continuously. So, uniform circular motion is accelerated.

RADIAN

An angle in radians is equal to the length of the arc (which subtends the angle) divided by the radius of the circle.

Angle in radians = length of the arc of the circle/radius of the circle

One radian is that angle which is subtended at the centre of a circle by an arc having a length equal to the radius of the circle.

LINEAR SPEED AND ANGULAR VELOCITY

$$\text{Linear speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

The angular velocity of a body is the angular displacement per unit time.

$$\text{Angular velocity} = \frac{\text{Angular displacement}}{\text{Time taken}}$$

RELATION BETWEEN LINEAR SPEED AND ANGULAR VELOCITY

$$\text{Angular velocity} = \frac{\text{Angular displacement}}{\text{Time taken}}$$

or $\omega = \frac{\theta}{t}$

where ω = Angular velocity,

v = linear speed,

and t = Time taken

Linear speed

= Angular velocity × Radius of the circular path

$v = \omega \times r$

where v = linear speed,

ω = angular velocty ,

and r = radius of the circular path

FORCE

A force can produce three effects :

(1) A force can change the speed of a body. It can make a stationary body move from rest or increase or decrease the speed of a moving body.

(2) A force can change the direction of motion of a body.

(3) A force can change the shape of a body.

Hence

A force is an influence which tends to set a stationary body into motion or which tends to change the speed and direction of a moving body or which tends to change the shape of a body.

NEWTON'S FIRST LAW OF MOTION

A body at rest will remain at rest, and a body in motion will continue to remain in motion in a straight line with a uniform speed, unless it is compelled by an external force to change its state of rest or of uniform motion.

Inertia is that property of a body due to which it resists a change in its state of rest or of uniform motion. Greater the inertia of a body, greater will be the force required to bring a change in its state of rest or of uniform motion. In fact, mass is a measure of the inertia of a body. If a body has more mass, it has more inertia. When a bus starts suddenly, the passengers fall backward. This is due to the fact that because of their inertia, the passengers tend to remain in their state of rest (or stationary state) even when the bus has started moving.

When a running car or bus stops suddenly, the passengers are jerked forward because due to inertia the passengers tend to remain in their state of moving (which they possessed in a moving car or bus) even though the car or bus has come to rest.

It is dangerous to jump out of moving bus because the jumping man, who is moving with the high speed from the bus, would tend to remain in motion (due to inertia) even on falling to the ground and get hurt due to the resistance offered by ground. Thus, Newton's first law of motion is the law of inertia of matter. Neuton's first law of motion says that a force is something which changes or tends to change the state of rest or of uniform motion of a body.

NEWTON'S SECOND LAW OF MOTION

The force acting on a body is directly proportional to the product of the 'mass' of the body and the 'acceleration' produced in the body by the action of the force, and it acts in the direction of the acceleration.

$$\text{Force} = \text{mass} \times \text{acceleration}$$

$$F = m \times a$$

So $$a = F / m$$

The acceleration produced in a body is directly proportional to the force acting on it and inversely proportional to the mass of the body.

UNITS OF FORCE

The S.I. unit of force is newton which is denoted by N.
A Newton is that force which when acting on a body of mass 1kg produces an acceleration of $1 m/s^2$ in it.

$$F = m \times a$$

The first law of motion is, in fact, a special case of the second law, because when the applied force F is zero, then the acceleration 'a' is also zero and the body remains in its state of rest or of uniform motion. It is obvious that Newton's second law gives us a relationship between the force applied to a body and the acceleration produced in the body.

SOME APPLICATIONS OF NEWTON'S SECOND LAW OF MOTION

We have all seen that a cricket player lowers his hands while catching a ball to stop it. He never stops a cricket ball suddenly keeping his hands stationary. This observation can be explained on the basis of Newton's second law of motion as follows:

If a cricket player stops fast moving cricket ball suddenly, then the change in the velocity of the ball from high value to zero value will be in a very short time. Due to the very short time taken to stop the ball, the acceleration (or rather retardation) of the ball will be very large. And due to large acceleration of the ball, the player will have to apply a large force to stop it (because force = mass x acceleration). Since the ball also exerts an equal force on the hand of the player, the player's hand may get hurt when he stops the fast ball suddenly.

When the cricket player stops the same ball gradually by lowering his hands alongwith ball, he takes a longer time to stop the ball. The same change in velocity of the ball is now brought about in a longer time and the acceleration (or rather retardation) of the ball becomes comparatively small. And because of smaller acceleration, the player will have to apply smaller force to stop the ball gradually. It is also a known fact that when a man falls from a height to a concrete floor, he receives greater injuries than one who falls on a sandy floor from the same height. This is also due to the same reason.

MOMENTUM

The momentum of a body is defined as the product of its mass and velocity.

Momentum = mass × velocity

$P = m \times v$

where P = momentum

m = mass of the body

v = velocity (or speed) of the body

If a body is at rest, its velocity is zero and hence its momentum is also zero. Thus, the total momentum is a vector quantity and takes place in the direction of velocity. The S.I. unit of momentum is 'kilogram metres per second' which is written as kg.m/s or $kg.ms^{-1}$.

A karate player can break a pile of tiles or a slab of ice with a single blow of his hand. This is because a karate player strikes the pile of tiles or the slab of ice with his hand very, very fast. In doing so, the entire momentum of the fast moving hand is reduced to zero in a very, very short time. This exerts a very large force on the pile of tiles or the ice slab which is sufficient to break them apart. A cricket ball is not very heavy but when it is thrown with a high speed (or high velocity), it acquires a very large momentum and sometimes hurts the batsman. This is why a batsman often ducks to a bouncer. On the other hand, a car or bus may not be running at a high speed (or high velocity) but because of its high mass, it has a very high momentum which may hurt the person coming in its way.

Relationship between force and momentum:

Force = mass x acceleration

or $F = m \times a$

Acceleration = Change in velocity / Time taken

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

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

$$F = \frac{mv-mu}{t}$$

where (mv – mu) is the change in momentum of the body in time 't'.

Force = change in momentum / time taken

i.e Force = rate of change of momentum

This gives us another definition of Newton's second law of motion which can now be stated as:

The force applied to a body is directly proportional to the rate of change of momentum which is produced in the body.

Newtons's third law of motion

According to Newton's third law of motion: whenever one body exerts a force on another body there is an equal and opposite force on the first body. In other words to every action there is an equal and opposite reaction. Action and reaction act on two different bodies, but they act simultaneously.

SOME EXAMPLES TO ILLLUSTRATE NEWTON'S THIRD LAW OF MOTION

1. **HOW DO WE WALK :** when we walk on the ground, then our foot pushes the ground backward and, in return, the ground pushes our foot forward. The forward reaction exerted by the ground on our foot makes us walk forward. On the slippery ground or ice, the friction is much less, and we cannot exert a backward action force on slippery ground or ice which would produce a forward reaction force on us.
2. **WHY THE GUN RECOILS :** when a bullet is fired from a gun, the force sending the bullet forward is equal to the force sending the gun backward. But due to high mass of the gun, it moves only a little distance backward and gives a backward jerk or kick to the shoulder of the gunman. The gun is said to have recoiled.
3. **THE CASE OF JET AEROPLANES AND ROCKETS:** Jet aeroplanes utilize the principle of action and reaction. In the modern jet aircraft, the hot gases obtained by the rapid burning of fuel rush out of a jet at the rear end of the aircraft at a great speed. The equal and opposite reaction of backward going gases pushes the aircraft forward at a great speed. The rockets also work on the principle of action and reaction. In a rocket, the hot gases produced by the rapid burning of fuel rush out of a jet at the bottom of the rocket at a very high speed. The equal and opposite reaction force of the downward going gases pushes the rocket upward with a great speed.

4. **THE CASE OF A BOAT AND THE SHIP**
During the rowing of a boat, the boatman pushes the water backwards with the oars. The water exerts an equal and opposite push on the boat which makes the boat move forward. In fact, harder the boatman pushes back the water with oars, greater is the reaction force exerted by water and faster the boat moves forward. When a man jumps out of a boat to the bank of the river, the boat moves backwards, away from him. This is due to the fact that to step out of the boat, the man presses the boat with his foot in the backward direction. The push of the man on the boat is the action. The boat exerts an equal force on the man in the forward direction which enables him to move forward. This force exerted by the boat on the man is reaction. Since the boat is floating on water and not fixed, it moves backward due to the action force exerted by man.

5. **THE CASE OF HOSE PIPE:** When firemen are directing a powerful stream of water on fire from a hose pipe, they have to hold the hose pipe strongly because of its tendency to go backward. The backward movement of the hose pipe is due to the backward reaction of water rushing through it in the forward direction at a great speed.

6. **THE CASE OF HORSE PULLING A CART:** According to the third law of motion, the horse exerts some force on the cart, and the cart exerts an equal and opposite force on the horse. So, at first glance it seems that the force being equal and opposite cancel out and hence the cart would not move. But it should be noted that it is only the force on the cart which determines whether the cart will move or not, and the force exerted by the cart on the horse affects the horse alone. Thus, if the horse is able to apply enough force to overcome the frictional forces present, the cart will move. So, to make the cart move the horse bends forward and pushes the ground with its feet. When the forward reaction to the backward push of the horse is greater than the opposing frictional force of the wheels, the cart moves.

THE LAW OF CONSERVATION OF MOMENTUM

When two bodies act upon one another, their total momentum remains constant provided no external forces are acting. The law of conservation of momentum means that whenever one body gains momentum, then some other body must lose an equal amount of momentum. This law can also be stated as: momentum is neither created nor destroyed. The law of conservation of momentum is also known as the principle of conservation of momentum. The principle of conservation of momentum is in accord with Newton's third law of motion which says that action and reaction are equal and opposite.

The total momentum of the bodies before and after the collision is the same. This means that the momentum of the two bodies remains constant.

APPLICATIONS OF THE LAW OF CONSERVATION OF MOMENTUM

The working of rockets and jet aeroplanes is based on law of conservation of momentum.

The chemicals inside the rocket burn and produce high velocity blast of hot gases. These gases pass out through the tail nozzle of the rocket in the downward direction with tremendous speed or velocity, and the rocket moves up to balance the momentum of the gasses. Although the mass of gases emitted is comparatively small, but they have a very high velocity and hence a very large momentum. An equal momentum is imparted to the rocket in the opposite direction, so that, inspite of its large mass, the rocket goes up with a high velocity. In jet aeroplanes, a large volume of gases produced by the combustion of fuel is allowed to escape through a jet in the backward direction. Due to the very high speed or velocity, the backward rushing gases have a large momentum. They impart an equal and opposite momentum to the jet aeroplane due to which the jet aeroplane moves forward with a great speed. Thus, the rockets and jet aeroplanes work on the principle of conservation of momentum.

The momentum is also conserved when a bullet is fired from a gun. Initially, before a bullet is fired from a gun, both, the bullet and the gun, are at rest. So, before a bullet is fired, the initial momentum of the bullet and the gun is zero.

Now, when a bullet is fired from a gun, then the bullet has the momentum given by: mass of bullet and velocity of bullet. The bullet imparts an equal and opposite momentum to the gun due to which the gun jerks backwards. The gun is said to recoil. The momentum acquired by the gun is : mass of gun × recoil velocity of gun. According to the law of conservation of momentum.

Mass of bullet × Velocity of bullet

= Mass of gun × Recoil velocity of gun

Since mass of gun is large the recoil velocity is less.

FRICTION

When we push an object with only a small amount of force, it does not move at all. It means that the surface on which the object is resting, exerts some force on the object and this force must be acting in a direction opposite to the force of our push. In other words, some force is acting on the stationary object which opposes its motion. This opposing force is friction. A ball moving on the ground also slows down or stops due to the friction between the ball and the ground. Thus, we conclude that: the force which always opposes the motion of one body over another body in contact with it is called the force of friction or just friction.

CAUSE OF FRICTION

Every object has a rough surface, though the surface may appear to be smooth to the naked eye. When we see through a microscope, it is found that the surfaces of all the bodies are rough – some are rough and others are less. Some of the particles on the surface are in the form of tiny hills and the others form grooves. These tiny hills and grooves get entangled with one another. The interlocking of the two surfaces opposes the motion of one body over another and gives rise to frictional force. We can say that: friction is due to the roughness of surfaces.

Friction is of three types: Static friction, Dynamic friction and Rolling friction. Static friction is also known as limiting friction whereas dynamic friction is also known as sliding friction or kinetic friction.

STATIC FRICTION AND DYNAMIC FRICTION

The static friction is the friction between any two bodies when one of the bodies just tends to move or slip over the surface of another body. There is no actual movement of the body in static friction. If, however, one body moves slowly or slides over another body, then the frictional force is called dynamic friction.

The maximum frictional force present when a body just tends to slip over the surface of another body is called static friction or limiting friction.

The force required to keep the block sliding, once it has started sliding, is less than the static friction or limiting friction. In other words, when a body starts sliding the friction is less.

LAWS OF FRICTION

The four important laws of friction are given below:

1. Friction opposes the motion.
2. Friction depends on the nature of the two surfaces in contact. In other words, friction depends on the kind of materials; smoothness; and degree of lubrication.
3. Friction is independent of the area of contact between the two surfaces.
4. Frictional force is directly proportional to the weight of the body which tends to move. This is why it is difficult to move heavier objects.

ROLLING FRICTION

When a body (like a roller or wheel) rolls over the surface of another body, the friction is called rolling friction.

The rolling friction is due to two reasons:

(i) The rolling body deforms the surface a little bit on which it rolls, and

(ii) The rolling body itself gets deformed at its points of contact with the surface.

As the wheels of the car roll along continuously, the various parts of the tyres and the road are successively deformed, and cause rolling friction, and some force has to be applied by the car engine to overcome this rolling friction. It is obvious that if the wheel is hard and the road is also hard, then the deformations will be less and hence the rolling friction will also be less. So, we should have sufficient air pressure in the car tyres to reduce the rolling friction.

The rolling friction can never be zero. Rolling friction is much less than sliding friction. Since the rolling friction is much less than the sliding friction, therefore, it is easier to roll a heavy drum than to drag it.

Most of the suitcases these days are fitted with small wheel due to which it becomes very convenient to pull them from one place to another.

FRICTION EXERTED BY LIQUIDS AND GASES

The liquids and gases, however, exert much less friction as compared to solid surfaces. The friction due to air is still smaller. This can further be reduced by giving a streamlined shape to the body. The special shape of a body (or object) around which a fluid (air or water) can flow past easily, is called streamlined shape. The shape of boats and ships are made 'streamlined' so that they experience the minimum friction while moving in water. Even the shapes of fishes and other marine animals are such that they face the minimum friction while in water.

Air exerts the force of friction on all the bodies which move through it and opposes their motion.

The most interesting example of the friction of air is the case of a meteor (or shooting star). Meteors are the stone like objects which enter into the earth's atmosphere from the outer space and are at a very, very high speed. When the meteors fall through the earth's atmosphere, their motion is opposed by the friction of air. Due to the very high speed of meteors through air, the heat is produced by the friction of air. Due to the very high speed of meteors through air, the heat is seen by us as shooting stars coming down the sky during night. Most of the meteors falling from the sky are small and burn up completely before reaching the surface of earth. Only the very large meteors burn partially and reach the earth's surface. The meteors which land on earth's surface are called meteorites. Friction is a necessary evil.

WHERE FRICTION IS USEFUL

We are able to walk because friction prevents us from slipping. Walking on slippery ground is difficult because the friction force is not great enough to prevent slipping.

Without friction, belts could not drive machines and the brakes could not be applied. Without friction, nails and screws cannot be used to hold things together and knots cannot be tied.

Friction also enables us to write on paper. The lighting of a match stick is another useful application of friction. The surface of the head of a match-stick and the sides of the match – box are deliberately made rough to increase the friction.

The tyre surfaces are made corrugated and rough so that the friction between the tyres and road increases. Due to greater friction, the tyres get a better grip on the road which prevents skidding of the vehicle.

It is because of very small friction exerted by water on the ship that it requires much more time and force to stop a moving ship in water.

Spikes are provided in the shoes of players and athletes to increase friction and prevent slipping.

WHERE FRICTION IS HARMFUL

(i) Friction reduces the efficiency of machines.

(ii) Friction produces heat which could damage the machine.

(iii) Friction wears out the rubbing machine parts gradually.

METHODS OF REDUCHING FRICTION

Friction is due to the roughness of surfaces. Any process which makes the two surfaces smooth, will reduce the friction.

The Important methods of reducing friction are:

1. By polishing.
2. By applying lubricants (oil or grease) to surfaces.
3. By using ball-bearings:
   The ball – bearing reduces friction by converting sliding friction into rolling friction.
4. By using rollers and wheels.
5. By streamlining.

THRUST AND PRESSURE

Pressure is the force acting on a unit area of the object. The effect a force depends on the area of the object on which it acts.

The pressure depends on two factors:

1. Force applied, and
2. Area over which force acts.

The same force can produce different pressures depending on the area over which it acts. For example, when a force acts over a large area of an object, it produces a small pressure, but if the same acts over a small area of the object, it produces a large pressure.

We can now define pressure as follows: Pressure is the force acting perpendicularly on a unit area of the object.
Pressure = force / area

The SI unit of measuring pressure is 'newtons per square metre' which is also called pascal.

Pressure can also be defined in terms of another term called 'thrust'. The force acting on a body perpendicular to its surface is called thrust. Thrust is the total force acting on the surface of a body. So we can define pressure as follows: Thrust per unit area is called pressure.

Pressure = thrust / area

The SI unit of thrust is newton(N).

EXPLANATION OF SOME EVERY DAY OBSERVATIONS ON THE BASIS OF PRESSURE

1. **Why school bags have wide straps:**
   A school bag has wide strap made of thick cloth so that the weight of bag may fall over a large area of the shoulder of the child producing less pressure on the shoulder, if the school bag has a strap made of thin string, then the weight of school bag will be over a small area of the shoulder. This will produce a large pressure on the shoulder of the child and it will become very painful to carry the heavy school bag.

2. **Why a sharp knife cuts better than a blunt knife:**
   A sharp knife cuts objects better due to its very thin edge.

$$P \alpha \frac{1}{A}$$

i.e If Lesser is the area then high is the pressure.

3. **Why the pressure on ground is more when a man is walking than when he is standing:**
   When a man is walking, then at one time only one of his feet is on the ground. Due to this, the force or weight of man falls on a smaller area of the ground and produces more pressure on the ground.
   The tractors have wide tyres so that there is less pressure on the ground and the tyres do not sink into comparatively soft ground in the fields. Wooden

sleepers are kept below the railway line into the ground for the same reason.

It is easier to walk on soft ground if we have flat shoes rather than shoes with pointed heels. This is because a flat shoe has greater area in contact with the soft sand due to which there is less pressure on the soft ground. Due to this the flat shoes do not sink much in soft sand and it is easy to walk on it.

ARCHIMEDES' PRINCIPLE

When a object is placed in a liquid, the liquid exerts an upward force on it. If we lift a stone lying at the bottom of a pond, it appears to be light as long as it is being lifted inside water. But as soon as the stone is lifted out of water into air, the same stone feels to be much heavier.

We conclude that the objects appear to be less heavy when submerged in water than when they are in air. The objects appear to be less heavy in water because the water exerts an upward force on them. In fact, every liquid exerts an upward force on the objects immersed in it. When an object is immersed in a liquid, it experiences an upward force. This upward force is called buoyant force. Thus, the upward force action on an object immersed in a liquid is called buoyant force or 'upthrust'.

The tendency of a liquid to exert an upward force on an object placed in it is called buoyancy.

The pressure exerted by a liquid increases with depth and acts in all directions (including upwards).

The maximum loss in weight of an object takes place when it is fully immersed in a liquid. As more and more volume of the object is immersed in a liquid, the upward buoyant force acting on it increases.

FACTORS AFFECTING BUOYANT FORCE

1. The buoyant force exerted by a liquid depends on the volume of the solid object immersed in the liquid. The magnitude of buoyant force acting on a solid object does not depend on the nature of the solid object.
2. The buoyant force exerted by a liquid depends on the density of the liquid in which the object is immersed. As the density of liquid increases, the buoyant force exerted by it also increases.

ARCHIMEDES' PRINCIPLE

Archimedes' principle states that when an object is wholly or partially immersed in a liquid, it experiences a buoyant force which is equal to the weight of liquid displaced by the object.

Buoyant force acting on an object

= weight of liquid displaced by that object

The magnitude of buoyant force is equal to the weight of liquid displaced by the immersed object.

APPLICATIONS OF ARCHIMEDES PRINCIPLE

1. The hydrometers used for determining the density of liquids are based on Archimedes principle.
2. The lactometers used for determining the purity of milk are based on Archimedes principle.
3. Archimedes principle is used in designing ships and submarines.

DENSITY

Some substances appear to be heavy whereas others are light. The density of a substance is defined as mass of the substance per unit volume.

$$\text{Density} = \frac{\text{mass of the substance}}{\text{volume of the substance}}$$

The SI unit of density is 'kilograms per cubic metre'.

DENSITIES OF SOME COMMON SUBSTANCES

Substance		Density	Density can also be written as
1	Ice	920 kg/m³	0.92×10^3 kg/m³
2	Water	1000 kg/m³	1.0×10^3 kg/m³
3	Glass	2500 kg/m³	2.5×10^3 kg/m³
4	Aluminium	2700 kg/m³	2.7×10^3 kg/m³
5	Iron	7800 kg/m³	7.8×10^3 kg/m³
6	Mercury	13600 kg/m³	13.6×10^3 kg/m³
7	Gold	19300 kg/m³	19.3×10^3 kg/m³

RELATIVE DENSITY

The relative density of a substance is the ratio of its density to that of water.

Relative density = density of the substance / density of water

relative density of a substance = weight of the substance / weight of an equal volume of water.

The relative density of a substance is the ratio of the weight of any volume of the substance to the weight of an equal volume of water.

GRAVITATION

According to Newton's law of gravitation (or universal law of gravitation), every body in the 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 them.

Gravitational force

$$F \alpha \frac{m_1 m_2}{R^2}$$

$$F = G\frac{m_1 m_2}{R^2}$$

Where G = gravitational Constant

NOTE: If we double the distance between two bodies, the gravitational force becomes one-fourth and if we halve the distance between two bodies, then the gravitational force become four times.

Value of gravitational constant (G) = $6.67 \times 10^{-11} Nm^2/kg^2$.

Unit of gravitational constant = $Nm^2 kg^{-2}$

It is the gravitational force between the sun and the earth which keeps the earth in uniform circular motion around the sun.

NEWTON'S THIRD LAW OF MOTION AND GRAVITATION

Newton's third law of motion says that: If an object exerts a force on another object, then the second object exerts an equal and opposite force on the first object. The Newton's third law of motion also holds good for the force of gravitation. This means that when earth exerts a force of attraction on an object, then the object also exerts an equal force on the earth, in the opposite direction. Thus, even a falling object attracts the earth towards itself.

The mass of a stone is very small, due to which the gravitational force produces a large acceleration in it. Due to large acceleration of stone, we can see the stone falling towards the earth. The mass of earth is, however, very, very large. Due to the very large mass of the earth, the same gravitational force produces very, very small acceleration in the earth.

FALLING OBJECTS

Earlier it was thought that the lighter objects fall slowly and the heavier objects fall more rapidly. This was later found to be wrong by Galileo. Galileo dropped two stones of different masses from the top of the leaning tower of pisa, and found that they hit the ground at the same time. From this Galileo concluded that the acceleration of an object falling freely towards the earth does not depend on the mass of the object. It was suggested by Galileo that the slow speed of feather, while falling, is due to the fact that its surface area is very large as compared to its mass, so the feather experiences much more resistance from air and its speed is slowed down. In vacuum, all the objects fall at the same rate.

ACCELERATION DUE TO GRAVITY

The uniform acceleration produced in a freely falling body due to the gravitational pull of the earth is known as acceleration due to gravity and it is denoted by the letter 'g'. The value of 'g' changes slightly from place to place but for most of the purposes it is taken as $9.8 m/s^2$. Thus, the acceleration due to gravity, $g = 9.8 m/s^2$.

The value of acceleration due to gravity 'g' is maximum on the surface of the earth. It decreases on going above the surface of earth or on going inside the surface of the earth. Since the acceleration due to gravity does not depend on the mass of the body, all the bodies (whether heavy or light) fall with the same acceleration towards the surface of the earth.

APPLICATIONS OF NEWTON'S LAW OF GRAVITATION

Newton's law of gravitation helps as-

1. to determine the mass of the earth accurately.
2. to determine the masses of the sun, the moon and the planets.
3. to estimate the masses of the double stars.(A double star is a pair of stars revolving around their common centre of mass). The two stars of a double star system which revolve around each other are held together by the gravitational force between them.
4. In discovering new stars and planets.

A large number of stars show a regular motion against the background of more remote stars. An irregularity (or unsteadiness) in the motion of a star indicates that it might have another star close to it, which is very faint and not visible, but exerts a large gravitational pull and makes the motion of original star irregular (or unsteady). The irregularity in the motion of a star is called 'wobbling'. And the star itself is said to 'wobble'.

The wobbling in the motion of stars indicates the presence of another star near it (whose gravitational pull causes the wobbling.)

General equations of motion		Equations of motion for freely falling bodies
(i) $v = u + at$	changes to	$v = u + gt$
(ii) $s = ut + 1/2at^2$	changes to	$h = ut + 1/2gt^2$
(iii) $v^2 = u^2 + 2as$	change to	$v^2 = u^2 + 2gh$

(a) when a body is falling vertically downwards, the acceleration due to gravity, g, is taken as positive. That is, acceleration due to gravity $= +9.8 m/s^2$

(b) when a body is thrown vertically upward, its velocity decreases, so the acceleration due to gravity, g, is taken as negative.
That is, acceleration due to gravity for a body thrown upwards $= -9.8 m/s^2$

(c) when a body is dropped freely from a height, its initial velocity 'u' becomes zero.

(d) When a body is thrown vertically upwards, its final velocity 'v' becomes zero.

MASS

The mass of a body is the quantity of matter (or material) contained in it. Mass is a scalar quantity and it is measured by an ordinary equal arm balance. The unit of mass is kilogram. The mass of a body is constant and does not change from place to place.

(If earth attracts two objects with equal force, they have equal masses)

WEIGHT

The earth attracts every body towards its centre with a certain force which depends on the mass of the body and the acceleration due to gravity at that place. The weight of a body is the force with which it is attracted toward the centre of the earth.

Force = mass x acceleration

The downward force acting on a body of mass 'm' is given by:

Force = mass x acceleration due to gravity

The SI unit of force and hence that of weight is Newton.

Another unit of weight is kilogram - weight

1 kg.wt = 9.8 Newton

Weight is a vector quantity and it can be measured with a spring balance.

The weight of a body is given by $W = m \times g$ and since the value of 'g' changes from place to place, therefore, the weight of a body also changes from place to place. Thus, the weight of a body is not constant.

We know that the value of acceleration due to gravity, 'g' decreases as we go down inside the earth and becomes zero at the centre of the earth. So, whatever be the weight of a body on the surface of the earth, its weight becomes zero when it is taken to the centre of the earth.

WEIGHT OF AN OBJECT ON THE MOON

The gravitational pull of the moon is about one-sixth of that of the earth, therefore, the weight of an object on the moon will be about one-sixth of what it is on the earth.

CENTRE OF MASS

The centre of mass of a body is that point where the whole mass of the body can be thought to be concentrated.

All the bodies are attracted towards the centre of the earth by a force which is directly proportional to their mass. This force is called the weight of the body. The whole weight of a body can be supposed to act at a point called the centre of gravity.

The centre of gravity of a regularly shaped body lies at the geometrical centre of the body.

The centre of gravity of a body can be inside the material of the body or outside it. If the body is solid throughout, then its centre of gravity lies inside the material of the body. If the body is hollow, then its centre of gravity lies outside the material of the body.

WEIGHTLESSNESS

The weight of a body is the force with which the earth attracts it. An object is said to be 'weightless' when it is falling freely under the action of gravity.

WEIGHTLESSNESS IN SPACE

An astronaut in a space–ship orbit the earth about 1000 kilometres above its surface. At that distance from the earth, the force of gravity of earth is still quite strong. Since the acceleration due to gravity, 'g' is not zero, therefore, the weight of astronauts in the space-ship certainly cannot be zero. But still we say that he is 'weightless'. It is because when the astronaut in the space-ship is orbiting the earth, then both, the astronaut and the space-ship, are in a continuing state of free fall toward the earth with the same acceleration due to gravity. Since the downward acceleration of the astronaut is the same as that of the space-ship, he does not exert any force on the sides of the astronaut to the space-ship and appears to be floating 'weightlessly'. Thus, the astronaut is weightless with respect to the space-ship and appears to be floating. A weighing machine kept in the space vehicle will show his weight to be zero. Though the free fall of a body produces a feeling of weightlessness but a true weightlessness can be experienced by a space-ship in a region of outer space where the acceleration due to gravity 'g' is zero.

PROJECTILES

A falling object having a horizontal velocity , is called a projectile and it moves in a curved path called parabola. In other words, an object having uniform horizontal motion and a uniform vertical acceleration simultaneously, is called a projectile.

Thus, a projectile possesses two motions simultaneously:

(i) It possesses a horizontal motion with a constant velocity, and

(ii) It possesses a vertical motion downwards with a constant acceleration.

Two coins,one dropped vertically and the other thrown horizontally from the same height, take same amount of time to travel the vertical distance from the table to the ground. This means that the horizontal velocity of the projectile has no effect on its vertical acceleration. In any given time interval, the vertical distance travelled by an object thrown parallel to the surface of earth is the same as that travelled by an object dropped directly from the same height.

Thus, the vertical motion a projectile is independent of its horizontal motion. The vertical distance 'h' travelled by a projectile thrown horizontal parallel to the ground, in time 't' is give by $1/2\ gt^2$, which is the same as that for an object dropped vertically downwards from the same position.

The vertical distance travelled by a projectile does not depend on the speed with which it is thrown horizontally.

The horizontal distance travelled by a projectile depends on the speed with which it is thrown horizontally. It has been found that larger the initial speed with which it is thrown horizontally, greater will be the horizontal distance travelled by it.

PLANETS AND SATELLITES ARE A SORT OF PROJECTILES

It is the gravitational attraction of the sun which keeps the planets revolving round it in their orbits, and it is the gravitational attraction of the earth which makes the moon (or artificial satellite) go round the earth repeatedly.

WORK, ENERGY AND POWER

Work is done when a force produces motion. The work done by a force on a body depends on two factors:

1. Magnitude of the force, and
2. Distance through which the body moves.

Work is said to be done when the point of application of a force moves. Work done in moving a body is equal to the product of force exerted on the body and the distance moved by the body in the direction of force.

$W = F \times S$

UNIT OF WORK

The unit of work is 'Newton metre' which is written a as Nm.

1 joule = 1 Newton x 1 metre

The SI unit of work is joule.

WORK DONE AGAINST GRAVITY

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.

FORMULA FOR WORK DONE WHEN A BODY MOVES AT AN ANGLE TO THE DIRECTION OF FORCE

$W = F \cos\theta \times S$

where W = work done, F = force applied, S = distance moved and θ = angle between the direction of motion of body and the direction of force applied.

WHEN THE FORCE ACTS AT RIGHT ANGLES TO THE DIRECTION OF MOTION

$\cos 90^0 = 0$

$W = F \times 0 \times S = 0$

This means that when the displacement of the body is perpendicular to the direction of force, no work is done. Thus, the work done in the case of earth moving round the sun is zero, and the work done in the case of a satellite moving round the earth is also zero.

POWER

Power is defined as the rate of doing work.

Power = work done / time taken

Being a fraction of two scalar quantities, work and time, power is a scalar quantity.

UNIT OF POWER

The unit of power is "joules per second". The SI unit of power is watt and it is the rate of doing work at 1 joule per second.

ENERGY

Energy is the ability to do work. The amount of energy possessed by a body is equal to the amount of work it can do when its energy is released. The S.I. unit of energy is joule. Energy is a scalar quantity.

KINETIC ENERGY

The energy of a body due to its motion is called kinetic energy.

Kinetic energy = $F \times S$ and also

Kinetic energy = $\frac{1}{2}mv^2$

From this formula, it is clear that:

(i) The kinetic energy of a body is directly proportional to the mass of the body, and
(ii) The kinetic energy of a body is directly proportional to the square of velocity of the body (or square of the speed of the body).

Since the kinetic energy of a body is directly proportional to its mass, therefore, if the mass of a body is doubled, its kinetic energy also gets doubled and if the mass of a body is halved, its kinetic energy also gets halved. Again, since the kinetic energy of a body is directly proportional to the square of its velocity, therefore, if the velocity of a body is doubled, its kinetic energy becomes four times, and if the velocity of a body is halved, then its kinetic energy becomes one-fourth.

POTENTIAL ENERGY

The energy of a body due to its position or change in shape is known as potential energy.

P. E = mgh

Where, m = mass of the body

g = acceleration due to gravity

h = height of the body above a reference point

The sum of the potential and kinetic energies of a body is called its mechanical energy.

TRANSFORMATION OF ENERGY

The change of one form of energy into another form of energy is known as transformation of energy. When a body is released from a height then the potential energy of the body is gradually transformed into kinetic energy. When a body is thrown upwards, the kinetic energy of body is gradually transformed into potential energy.

ENERGY FROM THE SUN (OR SOLAR ENERGY)

All the energy comes or has come from the sun.

(i) **Transformation of sun's energy into wind energy:** The sun's heat causes uneven heating of land and produces different air pressures at different places. These different air pressures produce wind having kinetic energy.

(ii) **Transformation of sun's energy into electrical energy:** The sun's heat evaporates the water from seas and lifts the water vapour high into the sky (and gives it potential energy). When this water falls back to the earth in the form of rain, then some of it is stored behind high dams. When this water is allowed to fall from dam, its potential energy is converted into kinetic energy. The kinetic energy of flowing water turns the turbines which drive the generators to produce electrical energy. This is done at a hydroelectric power plant.

(iii) **Transformation of sun's energy into food energy:** The plants use sun's energy to prepare food by the process of photosynthesis. The food stores sun's energy in the form of chemical energy.

(iv) **Transformation of sun's energy into energy of fossil fuels:** The dead plants and animals buried under the earth long, long ago have been converted into fossil fuels like coal, petroleum oil and natural gas. The energy stored in fossil fuels came originally from the sun.

LAW OF CONSERVATION OF ENERGY

Energy can neither be created nor destroyed. It can only be converted from one form to another form.

ESCAPE VELOCITY

The earth pulls every object towards it. Due to the gravitational pull of the earth, all the slow moving objects fall back to the earth. So, if an object like a rocket is to escape into the space, then it must be given a high velocity which an object should have in order to overcome the earth's gravity and enter into space. This velocity is called escape velocity. The escape velocity for all the objects from the earth has been found to be 11.16 kilometres per second. The escape velocity does not depend on the mass of the object. The escape velocity from the earth depends only on the mass of the earth and radius of the earth. The escape velocity from the moon is only one-fifth of that from the earth.

HEAT

Heat is a form of energy. Heat is measured by the temperature effect which it produces. When heat is given to a substance its temperature rises.

Temperature is the degree of hotness of a substance. Temperature is measured in the unit of degrees Celsius or Kelvin (k).

There are two temperature scale which are commonly used in the measurement of temperature these days. These are:

(i) Celsius scale of temperature, and

(ii) Kelvin scale of temperature.

The Kelvin temperature scale is also called absolute temperature scale.

CELSIUS SCALE OF TEMPERATUE

On Celsius scale of temperature, the melting point of ice is given value of 0^0 (zero degree), and the temperature of boiling water is given the value of 100^0. Thus the lower fixed point is 0^0c and the upper fixed point is 100^0. There are 100-0 = 100 equal divisions or 100 degrees between the two fixed temperatures.

KELVIN SCALE OF TEMPERATURE

It has been found that the lowest temperature which can be attained in a laboratory is minus 273°c. This lowest possible temperature is called 'absolute zero'. The Kelvin scale has its 'zero' at 'absolute zero'. Thus: the temperature of -273°c is taken as the 0 of the Kelvin scale.

The lower fixed point on the Kelvin scale is also the temperature of pure melting ice under standard atmospheric pressure and its value is -273k.

The upper fixed point on the Kelvin scale is also the temperature of boiling water under standard atmospheric pressure and its value is 373k.

RELATION BETWEEN CELSIUS SCALE AND KELVIN SCALE

Temp. on Kelvin scale = temp. on Celsius scale + 273

$$K = C + 273$$

MESUREMENT OF TEMPERATURE

The temperature of a body is measured by an instrument called thermometer.

GALILEO'S GAS THERMOMETER (OR AIR THERMOMETER)

Galileo used air as the gas in his thermometer, so it was called an air thermometer.

LABORATORY THERMOMETER

It is a mercury thermometer. A common laboratory thermometer can measure temperatures from -10° C to 110° C.

CLINICAL THERMOMETER

The normal temperature of a human body is 37°C. When a person gets fever, his body temperature rises. The thermometer used for measuring the temperature of human body is called clinical thermometer.

1. A clinical thermometer has a very short range of temperature from 35°c to 42°c. This is due to the fact that the temperature of a human body never goes beyond these temperatures.
2. A clinical thermometer has a constriction in its glass tube just above the bulb containing mercury. This constriction is to prevent the back flow of mercury into the thermometer bulb when the thermometer is removed from the mouth of the patient.

THERMAL EQUILIBRIUM

When two bodies are in contact with each other but no heat flows from one body to another, they are said to be in a state of thermal equilibrium.

UNITS OF HEAT

The S.I. unit of energy is joule, therefore, the S.I. unit of heat is joule which is denoted by the letter J. The old unit of measuring heat is, however, calorie.

1 calorie = 4.18 joules.

THE QUANTITY OF HEAT ABSORBED (OR GIVEN OUT) BY A BODY

The quantity of heat required to heat a substance depends on three factors:

(i) Mass of the substance
(ii) Specific heat of substance
(iii) Rise in temperature of substance

$Q = mst$

SPECIFIC HEAT

The specific heat of a substance is the amount of heat which is required to raise the temperature of a unit mass of the substance by 1 degree C.

The S.I. unit of specific heat is "joules per kilogram per degree Celsius".

THERMAL EXPANSION

One of the important effects of heat is the thermal expansion. 'thermal expansion' means 'increase in size on heating'.

EXPANSION OF SOLIDS

A solid substance can undergo three types of expansion: expansion in length; expansion in area and expansion in volume. Expansion in length is known as linear expansion; expansion in area is known as superficial expansion whereas expansion in volume is called cubical expansion.

LINEAR EXPANSION OF SOLIDS

The increase in length of a solid, on heating, is directly proportional to:

(i) Rise in temperature, and

(ii) The nature of the material of the rod.

Coefficient of linear expansion

$$\alpha = \frac{\text{increase in lenght}}{\text{original lenght}} \times \text{rise in temperature}$$

SUPERFICIAL EXPANSION OF SOLID

The increase in area of a solid, on heating, is directly proportional to:

(i) Original area of the solid, and

(ii) Rise in temperature

The coefficient of superficial expansion of a solid is given by the following formula:

Coefficient of superficial expansion

$$\beta = \frac{\text{increase in area}}{\text{original area}} \times \text{rise in temperature}$$

Coeff. of superficial expansion

= 2 × coeff. of linear expantion.

i.e $\beta = 2\alpha$

CUBICAL EXPANSION OF SOLIDS

The increase in volume of a solid, on heating, is directly proportional to:

(i) Original volume of the solid, and

(ii) Rise in temperature

Coefficient of cubical expansion

$$= \frac{\text{increase in volume}}{\text{original volume}} \times \text{rise in temperature}$$

Coefficient of cubical expansion

= 3 × coeff. of linear expansion

i.e $\gamma = 3\alpha$

CONSEQUENCES OF THE EXPANSION OF SOLIDS

1. Gaps are left between the rail joints to allow for expansion: if the gaps are not left between the rails, the rails (which are made of steel) expand in summer and get distorted because there will be no space to accommodate the increase in length of the rails.
2. Loops are provided in metal pipelines to allow for expansion.
3. Telephone wires sag more in summer due to expansion.
4. If we put boiling water in a tumbler made of thick glass walls, it cracks immediately. This is due to the fact that glass is a poor conductor of heat, so when boiling water is put in the glass tumbler, the inside portion of the glass walls becomes hot and expands while the outside portion of the glass walls remains cold and does not expand quickly. Due to the rapid expansion of the inside glass wall but slow expansion of the outside portion, it cracks.

APPLICATIONS OF EXPANSION OF SOLIDS

1. Fixing of iron tyre to a cart wheel: the wooden wheels of 'tongas' and 'bullock carts' have iron tyres around them. The iron tyre is made slightly smaller than the wooden wheel by a blacksmith. It is heated uniformly when it expands and its size increases. This hot iron tyre is now easily put around the wooden wheel and water is poured over it to cool it. On cooling, the iron tyre contracts and fits tightly to the wheel.
2. To remove a tight glass stopper from a bottle: the neck of the bottle is dipped in warm water. The neck of bottle expands, the stopper becomes loose and can be removed.
3. Riveting of metal plates: to get a tight joint, metal plates are riveted with red hot rivets. When the hot rivets are cooled, they contract and hold the two plates very tightly.

4. To make thermo-switches: a thermo-switch is a temperature-controlled switch which switches off current automatically when an electrical appliance gets heated to a certain pre-set temperature. It also switches on the current when the temperature of the appliance tends to fall too much.

EXPANSION OF LIQUIDS

Like solids, liquids also expand on heating and contract on cooling.

CUBICAL EXPANSION OF LIQUIDS (OR VOLUME EXPANSION OF LIQUIDS)

Coefficient of cubical expansion,

$$\gamma = \frac{V_1 - V_2}{V_1 \times (T_2 - T_1)}$$

Coefficient of cubical expansion =

$$\frac{\text{increase in volume}}{\text{original volume} \times \text{Rise in temperature}}$$

The coefficient of cubical expansion of a liquid is the increase in its volume per unit volume of the liquid when its temperature is raised by 1° C.

NOTE

1. Benzene has a low boiling point of 80°C, so a benzene thermometer cannot be used to measure high temperatures. On the other hand, mercury has boiling point of 357 °C, so a mercury thermometer can be used to measure high temperature.
2. Benzene sticks to the glass tube of the thermometer whereas mercury does not stick to the glass tube.

WHY DO SUBSTANCES EXPAND ON HEATING

All the substance (solids, liquids and gases) expand on heating. When a substance is heated, the kinetic energy of its molecules increases. Due to increase in kinetic energy, the molecules move more rapidly, the distance between the molecules of the substance increases and hence it expands.

CHANGE OF STATE: FUSION AND VAPORIZATION

The process in which a solid changes into a liquid on heating is called fusion or melting. A change of state takes place during melting.

The process in which a solid changes into a liquid on heating is called vaporization. A change of state takes place during vaporization. The reverse of this is also true. That is, a vapour changes into a liquid on cooling. This is known as condensation.

LATENT HEAT

When heat is supplied to change the state of a substance, there is no rise in temperature of the substance. The latent heat of a substance is the amount of heat absorbed by a unit mass of the substance to change its state without change of temperature. The S.I. unit of latent heat is 'joules per kilogram'. The latent heat is used up in overcoming the force of attraction between the molecules of the substance.

1. **LATENT HEAT OF FUSION (SOLID TO LIQUID CHANGE)**

The latent heat of fusion of a substance is the amount of heat required to convert a unit mass of the substance from the solid state to the liquid state without change of temperature. Ice at 0°C is more effective in cooling a substance than water at 0°C. This is due to the fact that for melting, each kilogram of ice takes in latent heat of 3.34×10^5 joules from the substance and hence cools the substance more effectively. On the other hand, water at 0°C cannot take any such latent heat from the substance.

2. **LATENT HEAT OF VAPORIZATION (OR LIQUID TO VAPOUR CHANGE)**

The heat required to convert a liquid into the vapour state is called latent heat of vaporization. The latent heat of vaporization of a substance is the amount of heat required to change a unit mass of the substance from the liquid state to vapour state without change of temperature. When water changes into steam, it absorbs latent heat, but when steam condenses to form water, an equal amount of latent heat is given out. The burns caused by steam are much more severe than those caused by boiling water though both of them are at the same temperature of 100° C. This is due to the fact that steam contains more heat, in the form of latent heat, than boiling water.

EVAPORATION

The process of a liquid changing into its vapour even below its boiling point is called evaporation.

COOLING CAUSED BY EVAPORATION

During hot summer days, water is usually kept in earthern pots to keep it cold. The earthern pot has a large number of extremely small pores in its walls. Some of the water continuously keeps seeping through these pores to the outside of the pot. This water evaporates continuously and takes the heat required for vaporization from the earthen pot and the remaining water. In this way, the remaining water loses heat and gets cooled.

Perspiration is our body's method of maintaining a constant temperature. When moisture evaporates, it takes the latent heat of vaporization from our body. This keeps our body cool. A fan increases the rate of evaporation of moisture from our skin and makes us feel cool and comfortable. Similarly, water vaporizing from the leaves of the trees cools the surrounding air.

SATURATED VAPOUR PRESSURE OF A LIQUID

The saturated vapour pressure is the pressure of the vapour above the liquid surface when the vapour is in a state of dynamic equilibrium with the liquid. The saturated vapour pressure of a liquid increases with temperature.

BOILING OF A LIQUID

The boiling point of a liquid is defined as the temperature at which its saturated vapour pressure is equal to the atmospheric pressure acting on the surface of liquid.

Reducing the pressure on the surface of water lowers its boiling point. The atmospheric pressure on high altitudes like high mountains is less than the atmospheric pressure at the sea-level. So, in mountainous places, water boils at a temperature lower than 100°C.

EFFECT OF INCREASED PRESSURE ON THE BOILING POINT OF WATER

An increase in pressure on the surface of water raises its boiling points.

WATER VAPOUR IN THE AIR (OR ATMOSPHERE): HUMIDITY

The presence of water vapour in the air is known as its humidity. The air containing maximum possible amount of water vapour in it is said to be saturated. Thus, the formation of mist or dew on a glass containing ice-cold water shows that the air around us contains water vapour.

RELATIVE HUMIDITY

The relative humidity of air at a given temperature is the ratio of mass of water vapour actually present in a certain volume of air to the mass of water vapour required to saturate the same volume of air at the same temperature, multiplied by 100.

PERIODIC MOTION

Motion which repeats itself after a fixed interval of time is known as periodic motion. The periodic motion in which a body moves back and forth continuously is called vibratory motion. In physics, the motion of a simple pendulum is an example of vibratory motion.

MOTION OF A SIMPLE PENDULUM

A simple pendulum consists of a small metal ball suspended by a long thread from a rigid support, in such a way that the bob is free to swing back and forth. A simple pendulum completes every swing in exactly the same time, provided its length is kept constant. Whether the amplitude of oscillations a pendulum is large or small, the time taken for one complete oscillation remains the same.

Simple harmonic motion is oscillating motion of an object in which the acceleration of the object is:

(i) Always in the opposite direction to the displacement from equilibrium.

(ii) Proportional to the displacement from equilibrium.

The motion of a simple pendulum is an example of simple harmonic motion.

WHAT KEEPS THE SIMPLE PENDULUM OSCILLATING

Once the pendulum bob is pulled to one side and released, it is the restoring force exerted by gravity and tension in the thread which tends to bring the bob back to its mean position and keeps it oscillating.

1. LENGTH OF PENDULUM

The length of thread from the point of suspension to the centre of bob, is called length of the pendulum.

2. OSCILLATIONS

One complete to-and-fro movement of the pendulum bob is called oscillation.

3. TIME-PERIOD

The time taken by the pendulum bob to make one complete oscillation is called time-period of the pendulum.

The time-period of a simple pendulum depends on:

(i) Length of the pendulum, and

(ii) Acceleration due to gravity.

The time-period of a simple pendulum does not depend on:

(i) Mass of the bob,

(ii) Nature of material of the bob, and

(iii) Amplitude of oscillations

FORMULA FOR THE TIME-PERIOD OF A SIMPLE PENDULUM

$$T = 2\pi\sqrt{\frac{l}{g}}$$

(i) The time-period of a simple pendulum is directly proportional to the square root of its length. As the length of a pendulum is increased, its time-period also increases.

(ii) The time-period of a simple pendulum is inversely proportional to the square root of the acceleration due to gravity at that place.

4. AMPLITUDE

As the pendulum swings to and fro,the maximum displacement of the bob from its central position on either side is called the amplitude of pendulum.

5. FREQUENCY OF OSCILLATIONS

The number of complete oscillations made by a simple pendulum in one second is called its frequency. The SI unit of frequency is 'hertz'.

The number of oscillation made in one second is called frequency. This means that the frequency of a pendulum of time-period T will be 1/T. So, we can now say that the 'frequency is the reciprocal of time-period'.

Frequency = 1 / time period

WAVE MOTION

Wave motion is a vibratory disturbance travelling through a medium in which energy is transferred from one point to another without there being a direct contact between the two points. Only energy is transferred by wave motion, matter is not transferred from one place to another by wave motion.

Sound is also an example of wave motion.

A wave is a vibratory disturbance in a medium which carries energy from one point to another without there being a direct contact between the two points.

MECHANICAL WAVES (OR ELASTIC WAVES)

Those waves which need a material medium for their propagation, are called mechanical waves or elastic waves. Sound waves and water waves are mechanical waves or elastic waves.

ELECTROMAGNETIC WAVES

Those waves which do not need a material medium for their propagation and can travel even through vacuum, are called electromagnetic waves.

DIFFERENCES BETWEEN ELASTIC WAVES AND ELECTROMAGNETIC WAVES

ELASTIC WAVES	ELECTROMAGNETIC WAVES
1. Elastic waves require a material medium like solids, liquids or gases, for their propagation.	1. Electromagnetic waves can be transmitted even through vacuum.
2. Elastic waves are due to the vibrations of the particles of the medium through which they pass	2. Electromagnetic waves are due to the varying electric and magnetic fields in space.
3. Elastic waves have a low speed.	3. All the electromagnetic waves have a very high speed of 3×10^8 m/s.
4. Elastic waves have very high frequency and large wavelength.	4. Electromagnetic waves have very high frequency and extremely short wavelength.
5. Elastic waves can be transverse waves or longitudinal waves.	5. Electromagnetic waves are only transverse waves.

DIFFERENCE BETWEEN SOUND WAVES AND LIGHT WAVES (OR RADIO WAVES)

SOUND WAVES	LIGHT WAVES (RADIO WAVES)
1. Sound waves are longitudinal waves in which the vibrations are parallel to the direction in which the wave travels.	1. Light waves are transverse waves in which the vibrations are perpendicular to the direction in which the wave travels.
2. Sound waves cannot travel through vacuum. They require a material medium like solid, liquid or gas, for their propagation.	2. Light waves can travel even through vacuum.
3. Sound waves have a small speed in air, which is about 330 m/s.	3. The speed of light waves in air is very, very large. It is 3×10^8 m/s.
4. Sound waves are due to the vibrations of the particles of the medium concerned.	4. Light wave are due to the varying electric and magnetic fields.
5. Sound wave have low frequency and high wavelength.	5. Light waves have very high frequencies and small wavelengths.

TRANSVERSE WAVES

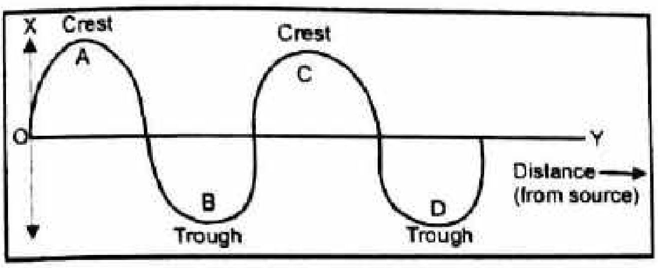
A wave in which the particles of the medium vibrate up and down 'at right angles' to the direction in which the wave is moving, is called a transverse wave.

EXAMPLES OF TRANSVERSE WAVES

The water waves formed on the surface of water in a pond are also transverse waves.

CRESTS AND TROUGHS OF A TRANSVERSE WAVE

The 'elevation' or 'hump' in a transverse wave is called crest. A crest is that part of the wave which is above the line of zero disturbance of the medium. The 'depression' or 'hollow' in a transverse wave is called trough. A trough is that part of the transverse wave which is below the line of zero disturbance. A transverse wave consists of crests and troughs.



LONGITUDINAL WAVES

A waves which the particles of the medium vibrate back and forth in the 'same direction' in which the wave is moving, is called a longitudinal wave.

EXAMPLE OF LONGITUDINAL WAVES

1. The waves which travel along a spring when it is pushed and pulled, are longitudinal waves.
2. The sound waves in air are longitudinal waves.

COMPERSSIONS AND RAREFACTIONS OF A LONGITUDINAL WAVE

A compression is that part of a longitudinal wave in which the particles of the medium are closer to one another then they normally are, and there is a monementary reduction in volume of the medium.

A rerefaction is the part of a longitudinal wave in which the particles of the medium are farther apart than normal, and there is a momentary increase in the volume of the medium. A longitudinal wave consists of compressions and rarefactions travelling through a medium.

Compression Rarefaction Compression Rarefaction

Greater denstiy **Less denstiy** **Greater denstiy** **Less denstiy**

DIFFERENCES BETWEEN TRANSVERSE WAVES AND LONGITUDINAL WAVES

PULSE	PERIODIC WAVE
1. A pulse is a wave of short duration.	1. A periodic wave is a continuous wave of long duration.
2. A pulse is not repetitive.	2. A periodic wave is repetitive. A periodic wave has a basic pattern which repeats itself after a fixed interval.
3. A pulse is set up by a single disturbance in the medium.	3. A periodic wave is set up by a continuous disturbance in the medium.
4. When a pulse is formed, the medium oscillates for a short while and then returns to its original undisturbed position.	4. When a periodic wave is formed, the medium oscillates for a long time after it is disturbed.
5. A pulse is formed in a small part of the medium. so, in the formation of a pulse, only a part of the medium is displaced from its original undisturbed position.	5. A periodic wave stretches over the entire length of the medium. So, in the formation of a periodic wave, every point of the medium is displaced.

PULSES AND PERIODIC WAVES

1. The waves set up by a single disturbance in the medium are called pulses.

(i) The formation of water waves on the surface of water when a stone is dropped into it is an example of wave pulses.

(ii) The sound waves produced by the clapping of hands is also an example of wave pulses.

(iii) The "shock wave" caused by supersonic plane or that resulting from an explosion, also consists of a single pulse or a few pulses.

2. The waves set up by continuous disturbance in the medium occurring due to regular vibrations are called periodic waves.

DIFFERENCES BETWEEN A PULSE AND PERIODIC WAVE

TRANSVERSE WAVES	LONGITUDINAL WAVES
1. In transverse waves, the particles of the medium vibrate at right angles to the direction of wave.	1. In longitudinal waves, the particles of the medium vibrate parallel to the direction of wave.
2. Transverse waves consist of crests and troughs.	2. Longitudinal waves consist of compressions and rarefactions.
3. Transverse waves can be propagated only through a solid or over the surface of a liquid, but not in a gas.	3. Longitudinal waves can be propagated through solids, liquids as well as gases.
4. Transverse waves can be polarized.	4. Longitudinal waves cannot be polarized.

PHASE

All the points on a wave which are in the same state of vibration are said to be in the same phase with respect to one another. Those points on a wave which are in different states of vibration are said to be out of phase.

WAVELENGTH

The distance between two nearest points in a wave whichare in the same phase of vibration is called the wavelength. The distance between two consecutive crests of a transverse wave is called the wavelength. The distance between two consecutive troughs of a transverse wave is also called the wavelength.The distance between a crest and an adjacent trough is equal to half the wavelength.

2. AMPLITUDE

The maximum displacement of the particles of the medium from their original undisturbed positions, when a wave passes through the medium, is called amplitude of the wave.

3. TIME-PERIOD

The time required to produce one complete wave is called time-period of the wave. The time taken to complete one vibration is called time-period.

4. FREQUENCY

The number of complete waves produced in one second is called frequency of the wave. The number of vibrations per second is called frequency of the wave. The number of vibrations per second is called frequency.

5. VELOCITY OF WAVE

The distance travelled by a wave in one second is called velocity of the wave. The S.I. unit for measuring the velocity of a wave is metres per second.

Velocity of a wave = frequency wavelength

SOUND

Sound is a form of energy. Sound is that form of energy which makes us hear.

HOW SOUND IS PRODUCED

Sound is produced when an object vibrates.

PROPAGATION OF SOUND (OR TRANSMISSION OF SOUND)

When an object vibrates, then the air layers around it also start vibrating in exactly the same way and carry sound waves from the sound producing object to our ears. In the transmission of sound through air, there is no actual movement of air from the sound-producing body to our ear. The air layers only vibrate back and forth, and transfer the sound energy from one layer to the next layer till it reaches our ear.

PHYSICS - 2

SOUND WAVES REQUIRE A MATERIAL MEDIUM

Sound needs a material medium like solid, liquid or gas to travel and be heard. Sound cannot travel through vacuum.

THE CASE OF MOON AND OUTER SPACE

Sound cannot be heard on the surface of moon because there is no air on the moon to carry the sound waves. The astronauts who land on moon talk to one another through wire-less sets using radio waves. This is because radio waves can travel even through vaccum (though sound waves cannot travel through vacuum).

THE SPEED OF SOUND

The speed of sound depends on

1. The nature of material through which it travels.
2. The temperature. (The speed of sound in air will be more on a hot day than on a cold day.)
3. The humidity of air. (The speed of sound is less in dry air but more in humid air. Sound travels about 5 times faster in water than in air. Sound travels about 15 times faster in iron than in air.)

THE RACE BETWEEN SOUND AND LIGHT

(i) On a rainy day season, the flash of lightning is seen first and the sound thunder is heard a little later. It is due to the very high speed of light that we see the flash of lightning first and it is due to comparatively low speed of sound that the thunder is heard a little later.

(ii) In the game of cricket, the ball is seen to hit the bat first and the sound of hitting is heard a little later.

(iii) If a gun is fired from a distance, we see the flash of gun first and the sound of gun shot is heard a little later.

REFLECTION OF SOUND

The bouncing back of sound when it strikes a hard surface, is called reflection of sound. The reflection of sound is utilized in the working of three devices: megaphone, sound boards and ear trumpet. The reflection of sound causes echoes.

ECHOES

The repetition of sound caused by the reflection of sound waves is called an echo. An echo is simply a reflected sound.

THE FREQUENCY RANGE OF HEARING IN HUMANS

The range of frequency from 20 Hz to 20,000Hz is known as the frequency range of hearing in humans. It is the audible range of frequencies for human ears.

(i) The sound of frequencies lower than 20 Hz are known as infrasonic sounds. The earthquakes, volcanic eruptions, simple pendulum and some animals like whales and elephants produce infrasonic sounds. Infrasonic sound cannot be heard by human beings.

(ii) The sounds of frequencies higher than 20,000 hertz are known as ultrasonic sounds. Both sonic and ultra sonig sound are inaudile.

Dogs can hear ultrasonic sounds of frequency upto 50,000Hz. This is the reason why dogs are used for detective work by the police. Monkeys, deer, cats, porpoises and leopard can also hear ultrasonic sounds. Bats can hear ultrasonic sounds having frequencies upto 1,20,000Hz. In fact, bats can also produce ultrasonic sounds while screaming. We cannot hear the screams of a bat because its screams consists of ultrasonic sound having a frequency much higher than 20,000Hz. The ultrasonic sounds produced by bats are reflected back by other objects in their path, and the echoes thus formed are detected by bats. It is due to this 'echolocation' of objects around them that bats can fly at night without colliding with other objects.

ULTRASOUND

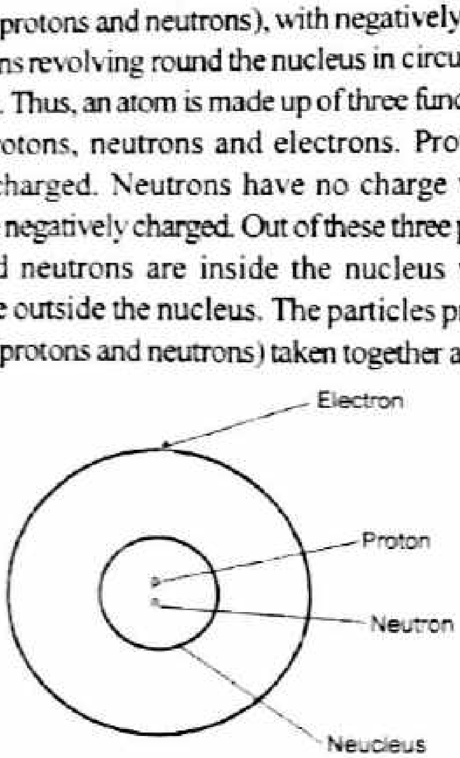
The sound having too high frequency which cannot be heard by human beings are called ultrasonic sound or ultrasound.

SONAR

The word 'SONAR' stands for 'sound navigation and raging'. Sonar is an apparatus which is used to find the depth of a sea or to locate the underwater things like shoals of fish, shipwrecks, and enemy submarines.

STRUCTURE OF ATOM

An atom consists of a small positively charged heavy nucleus (containing protons and neutrons), with negatively charged light electrons revolving round the nucleus in circular paths called orbits. Thus, an atom is made up of three fundamental particles-protons, neutrons and electrons. Protons are positively charged. Neutrons have no charge whereas electrons are negatively charged. Out of these three particles. Protons and neutrons are inside the nucleus whereas electrons are outside the nucleus. The particles present in the nucleus (protons and neutrons) taken together are called nucleons.



PROTON

Proton is a positively charged particle having an absolute charge of $+1.6 \times 10^{-19}$ coulombs. Since this is the smallest positive charge carried by a particle, so this is taken as the unit of positive charge and we say that the relative charge of a proton is +1. The mass of a proton is about 1836 electrons. The relative mass of a proton is 1 a.m.u. (1 atomic mass unit) which is the same as that of a hydrogen atom, the atom of lowest mass.

ELECTRON

Electron is a negatively charged particle having an absolute charge of -1.6×10^{-19} Coulombs. Since that is the smallest negative charge carried by a particle, so that is taken as the unit of negative charge, and we say that the relative charge of an electron is -1. The charge of an electron is equal in magnitude but opposite in sign to the charge of a proton. A normal atom has an equal number of protons and electrons and since a proton and an electron have equal and opposite charge, an atom on the whole is electrically neutral. Electron is the lightest of the three atomic particles. The mass of an electron is about 1 / 1836 of the mass of a hydrogen atom (which is the atom of lowest mass). Since the mass of a hydrogen atom is 1 amu, we can say that the relative mass of an electron is 1 / 1836 amu. The absolute mass of an electron is, however 9×10^{-28} gram.

NEUTRON

Neutron is an uncharged particle or neutral particle which is present in the nucleus of an atom. The mass of a neutron is the same as that of a proton i.e.1 amu. The relative charge of a neutron is zero.

ATOMIC NUMBER

The number of protons present in the nucleus of an atom of an element is called its atomic number. For example, if an element has 2 protons in the nucleus of its atom, then its atomic number will be 2.

MASS NUMBER The total number of protons and neutrons present in the nucleus of one atom of an element is called its mass number. That is:

mass number = no. of protons + no. of neutrons

For example , If an element has 2 protons and 2 neutrons then mass number = 2 + 2 = 4

ISOTOPES

All the atoms of an element contain the same number of protons but they may have different number of neutrons. For example, all the uranium atoms contain 92 protons and 92 electrons each, but all the uranium atoms do not contain the same number of neutrons. The atoms of an element having the same atomic number but different mass numbers are called isotopes and the isotopes of an element differ in the number of neutrons in their nuclei.

RADIOACTIVITY

The heavy elements like uranium, thorium, radium and polonium emit some invisible rays which affect a photographic plate just like ordinary light rays. These substances which emit such invisible rays are called radioactive elements and the property of emitting the invisible radiations is called radioactivity. The spontaneous and uncontrollable disintegration of certain heavy atoms with the emission of alpha or beta particles and gamma rays is called radioactivity. Example - A uranium -238 atom disintegrates on its own and forms a new element thorium -234 by emitting an alpha particle, and energy in the form of gamma radiations.

$_{92}U^{238} - {}_{2}He^{4} \rightarrow {}_{90}Th^{234} + \gamma$ (Energy)

This is an example of natural radioactivity.

Some Particles are emited in Radioactivity. They are given below:

SN.	Name of Particle	Charged	Symbol
1.	Alpha	positive	$_{2}He^{4}$ or $_{2}\alpha^{4}$
2.	Beta	negative	$_{-1}\beta^{0}$
3.	Gamma rays	no charge	γ

CHEMICAL REACTIONS

In chemical reactions, only the outermost electrons of the atoms take part, the nuclei of the atoms remain unaffected. For example, when charcoal is burned in the oxygen of air, a chemical reaction takes place to form carbon dioxide gas, and a lot of heat is released in this chemical reaction.

NUCLEAR REACTIONS

In nuclear reactions, the nucleus of an atom undergoes a change forming new atoms and releasing a tremendous amount of energy. New atoms can be produced in a nuclear reaction, which is not possible in the case of a chemical reaction.

The first ever nuclear reaction in which one element was changed into another element was carried out by Rutherford in 1919.

Rutherford showed by his experiments that it is possible to change one element into another element by artificial methods also. This process is called a nuclear reaction or transmutation. Thus the changing of a stable element artificially by changing the number of protons in its nucleus is called transmutation of element.

Artificial transmutation is brought about by bombarding the nuclei of stable elements with particles such as alpha particles, protons, neutrons and deuterons. Though the number of protons changes during artificial transmutation there may or may not be a change in the number of neutrons during the artificial transmutation of elements. The new element produced by artificial transmutation can either be stable (non-radioactive) or unstable (radioactive).

The particles which are used to bombard the nuclei of atoms for causing nuclear reactions are called projectiles.

A major success in carrying out nuclear reactions came in 1932 with the discovery of another particle called neutron. Neutrons are the best projectiles for carrying out nuclear reactions because they are neutral, having no electric charge. Since the neutron is an electrically neutral particle, therefore it can penetrate the nucleus of an atom easily without facing much repulsion. In this way, neutrons can bring about the nuclear reactions more easily. Neutrons of different energies can cause different nuclear reactions.

TRANSURANIC ELEMENTS

The elements upto uranium (atomic number 92), have been found in nature. They have been isolated and investigated. The elements having atomic number higher than 92 do not occur in nature. The elements having atomic number higher than that of uranium are called transuranic elements.

FORCES WHICH OPERATE INSIDE THE NUCLEUS

It has been found that the nuclei of small atoms are quite stable but the nuclei of big atoms are quite unstable. Various forces operate inside the nucleus of an atom where we have positive protons and neutral neutrons.

There are two types of forces operating inside the nucleus of an atom. These are: electrostatic force and nuclear force.

1. ELECTROSTATIC FORCE

The force which a charged particle exerts on another charged particle is called electrostatic force. The electrostatic force may cause attraction or repulsion depending upon the nature of charges on the particles. If the two particles have opposite charges then the electrostatic force will cause attraction between them but if the particles have similar charges then the electrostatic force will be repulsive and will cause repulsion between the similarly charged particles.

2. NUCLEAR FORCE

The force with which two protons, two neutrons or a proton and a neutron attract one another in the nucleus is called nuclear force (or strong force).

One important characteristic of nuclear force is that it is effective only when the particles like protons and neutrons are very, very close together. If the nuclear particles (protons and neutrons) are separated by comparatively larger distances then the nuclear force of attraction between them becomes very weak. And then the nuclear particles cannot attract one another very much.

OCCURRENCE OF URANIUM

In nature uranium element occurs mainly in the form of two isotopes uranium-235 and uranium-238. Both these isotopes of uranium have the same number of protons (92 each) in their nuclei but they contain different number of neutrons in their nuclei. The uranium-238 isotope is more abundant in nature. Thus most of the uranium occurring in nature is in the form of uranium-238 isotope and a small percentage of uranium-235 isotope occurs in nature.

A SPECIAL PROPERTY OF U-235 ISOTOPE

A special property of uranium-235 isotope is that its nucleus is very unstable due to which it can be fissioned (broken) very easily. So even when a slow moving neutron (having low energy) collides with a uranium-235 nucleus the nucleus gets ruptured (breaks) to form smaller nuclei with the emission of neutrons and an enormous amount of energy.

NUCLEAR FISSION

The nucleus of uranium-235 atom is highly unstable. So when a neutron from outside is made to collide with a uranium-235 nucleus then this nucleus breaks up or gets fissioned to form smaller atoms with the liberation of a large amount of energy. This splitting up of the nucleus is called nuclear fission. The process in which an unstable nucleus of a heavy atom (like uranium-235) splits up into two medium weight nuclei with the liberation of an enormous amount of energy is called nuclear fission. The low energy (slow moving) neutrons which can produce nuclear fission are called thermal neutrons. The importance of a nuclear fission process is that it is accompanied by the release of an enormous amount of energy. The controlled fission of uranium-235 was first carried out by Fermi in 1942. In a nuclear fission reaction neutrons are used up as well as produced. For example, in the nuclear fission of uranium-235 described above one neutron is consumed and three neutrons are produced in each fission process. These neutrons lead to further fission. The nuclear fission process also emits radiations or rays of very short wavelength which is called gamma radiation or gamma rays. Uranium-235 is one of the elements which can undergo fission easily by the action of slow moving neutrons. Another element the nucleus of whose atom is unstable and which can fission easily is plutonium-239 (or pu-239). Plutonium-239 is an artificial element which does not exist in nature it is however a radioactive element. Plutonium-239 required for nuclear fission can be made artificially from uranium-238 isotope by a series of nuclear reactions and can be fissioned only if it is bombarded with neutrons having exceptionally high speeds or exceptionally high energy (a condition quite difficult to achieve). The easily fissionable materials (which can be fissioned even with slow moving neutrons or low energy neutrons) are called fissile. Thus fissile means easily fissionable.

TYPES OF FISSION REACTIONS

1) Spontaneous fission
2) Prompt fission and
3) Delayed fission.

When a nucleus undergoes fission on its own (without being hit by a projectile like neutron) it is called spontaneous fission.

When a nucleus splits up into smaller nuclei instantaneously as soon as it is bombarded with a projectile (like neutrons) it is called prompt fission.

When a projectile like neutron enters a nucleus and causes an instability which leads to the fission of the nucleus after a short while, it is called delayed fission.

ENERGY

Energy is the ability to do work. The amount of energy possessed by a body is equal to the amount of work it can do when its energy is released.* **(see page no. 17 for work and power)**

Types of energy

1. Mechanical energy
2. Heat energy
3. Chemical energy
4. Electrical energy
5. Nuclear energy
6. Solar energy

VARIOUS WAYS OF ENERGY

There are varionns ways in which man controlled and made use of energy to make his work easier and life better, more comfortable and pleasant.

1. ENERGY OF THE MUSCLES

The energy present in the muscles of man came from the chemical energy of the food which he eats.

THE USE OF SIMPLE MACHINES

A simple machine is a device or instrument which is used to do work more conveniently and more quickly. The simple machines used by the man for making his work easier are: the lever, the pulley, the inclined plane, the screw and the gear. The use of a simple machine for doing work has three advantages:

(i) It reduces the effort needed to do a particular job.
(ii) It transfers the point at which effort is needed to a more convenient point, and
(iii) It can change the direction of effort applied to a more convenient direction.

A simple machine is called lever. A man's burden of work was reduced to some extent by the use of simple machines.

2. ENERGY OF WIND

Moving air is called wind. Wind possesses kinetic energy and it is this kinetic energy of wind that is utilised for doing work. The energy of wind was utilised by man in two ways:

(i) In sail boats for transport purpose.
(ii) In wind-mills to pump out water from earth, and grind grain to get flour.

Limitations of wind energy

An important limitation of wind energy (or wind power) is that it is not available all the time, and at the place where we need it to do various types of work. Despite these limitations, an important advantage of using wind energy is that its use does not cause any pollution and it is available free of cost.

3. ENERGY OF FLOWING WATER

The flowing water (or moving water) possesses kinetic energy. The kinetic energy of moving water has been used for doing various types of work. The device commonly used for obtaining energy from flowing water is called water-wheel. The moving water rotates the water - wheel, and this rotating water-wheel can be made to turn a machine that works for us.

The energy of naturally flowing water in high rivers is stored behind dams as potential energy and then used to produce electricity. The electricity generated by using the energy of flowing water is called hydro-electric power.

Limitations of water energy

An important limitation of water-energy is that flowing water or falling water is not available in plenty everywhere to turn the water-wheels and run the machines. An important advantage of water-energy is that its use does not cause any pollution. And like wind energy, it is also available free of cost.

HEAT AS A SOURCE OF MECHANICAL ENERGY

Whenever work is done against friction, mechanical energy (or work) is converted into heat. Thus, when we rub our hand together, then the mechanical energy is converted into heat energy and our hands become warm. No special device is needed for converting mechanical energy or work into heat energy. Heat energy can also be converted into mechanical energy or work. But the conversion of heat energy into mechanical energy or work is a complicated process and requires special device like a heat engine.

HEAT ENGINES

A device by which the heat energy is converted into mechanical energy is called a heat engine. Steam engine, petrol engine and diesel engine, are all examples of heat engines. Heat engines are of two types:

1. External combustion engine, and
2. Internal combustion engine.

Steam engine is an external combustion engine whereas petrol engine and diesel engine are internal combustion engines. Steam engine is called an external combustion engine because the combustion of fuel (coal) takes place outside the cylinder of the steam engine. On the other hand, a petrol engine is called an internal combustion engine because the combustion of fuel (petrol) takes place inside the cylinder of the petrol engine.

The utility of steam engine in industry and transport was so great that the invention of steam engine led to a historic revolution called industrial revolution.

Limitations of a steam engine

(i) A steam engine is huge and heavy.
(ii) A steam engine does not start at once.
(iii) A steam engine is unsafe to use.
(iv) A steam engine has low efficiency.
(v) The burning of coal in the steam engine causes pollution of air.

TRANSFORMATION OF ENERGY

The changing of one form of energy into another form (or forms) of energy is called transformation of energy. During the free fall of a body, the potential energy is converted into kinetic energy, and then into heat energy. This heat energy escapes into the ground but it is not destroyed. At a hydroelectric power house, the potential energy of water is transformed into electrical energy. At a thermal power station, the chemical energy of coal is changed into electrical energy. A steam engine converts the heat energy of steam into mechanical energy.

A motor converts electrical energy into mechanical energy and a cell or battery converts chemical energy into electrical energy. A lamp converts electrical energy into light energy and a heater converts electrical energy into heat energy. A car engine converts the chemical energy of petrol into heat energy and then into mechanical energy. A photoelectric cell converts light energy into electrical energy. A transmitter converts sound energy into electrical energy and a radio set convert electrical energy into sound energy.

PRINCIPLE OF CONSERVATION OF ENERGY

Whenever one form of energy is converted into another form, the total amount of energy remains constant. Energy can neither be created nor destroyed, it can only be changed in form or transferred from one body to another.

THE CASE OF A WATER-FALL

The water at the bottom of a water-fall is slightly warmer than at the top. This can be explained as follows on the basis of interconversion of energy. At the top of the water-fall, the water possesses potential energy. When this water falls down, this potential energy gets converted into kinetic energy. And when this falling water hits the ground, a part of this kinetic energy is converted to heat energy.

EFFICIENCY OF HEAT ENGINES

$$\text{Thermal efficiency of an engine} = \frac{\text{heat converted into work}}{\text{total heat taken in}}$$

The efficiency of a heat engine can be 100% only if all the heat energy gets converted into work (or mechanical energy). The impossibility of converting heat energy completely into mechanical energy, limits the efficiency of heat engines.

Note :

1. Mechanical energy can be completely converted into heat energy.
2. Heat energy can not be completely converted into Mechanical energy because a part of heat remains unsused and does not get converted to mechanical energy.

SOLAR ENERGY

The sun is source of all energy. The sun provides us heat and light energy free of cost! The energy obtained from the sun is called solar energy. About one-third portion of the sunlight consists of infra-red rays.

DEVICES BASED ON SOLAR ENERGY

1. SOLAR COOKER :

A solar cooker is a device which is used to cook food by utilizing the energy radiated by the sun. A solar cooker consists of an insulated metal box which is painted all black from inside. There is a thick glass sheet as a cover over the box and a plane mirror reflector is also attached to the box. The food to be cooker is placed in a metal container and the container is kept in the box and covered with glass sheet. The food container is painted black from outside to make it a good absorber of heat. In order to cook the food, the solar cooker is kept in the sunlight and its reflector is adjusted in such a way that a strong beam of sunlight falls over the cooker top.

2. SOLAR HEATER :

A solar heater is a device used to heat water by utilizing the energy radiated by the sun. In a solar water heater, sunlight is reflected on to black pipes containing water, by means of plane reflectors. These water pipes are arranged in a box similar to that of a solar cooker having a glass cover. The heat energy of the sun is absorbed by black water pipes due to which water gets heated. This hot water is then supplied into big buildings like hotels through pipes.

3. SOLAR POWER PLANTS:

Solar energy can be used to produce electricity on large scale as follow: the sunlight is reflected by concave reflectors to black pipes containing water. The sun's heat converts the water into steam. The steam thus produced runs a turbine. The turbine drives a generator and produces electricity.

4. SOLAR FURNACE:

In a solar furnace, thousands of small plane mirrors are arranged in a curve form to make a very big concave reflector. Now, if a furnace is placed at the focus of such a big concave reflector, then the heat energy of the sun is great enough to melt steel. A temperature of upto 3000°C can be produced in a solar furnace.

5. SOLAR CELLS:

Solar cells are device which convert the sunlight energy directly into electrical energy or electricity. Solar cells are made from semi-conductor like silicon and germanium. Solar cells are used to generate electricity needed in man-made space-satellites, and to provide electricity in far-off places.

USES OF SOLAR ENERGY

1. Solar energy is used for cooking food. This is done by using solar cookers.
2. Solar energy is used for heating water supply in big buildings like hotels. This is done by using solar water heaters.
3. Solar energy is used for producing electricity needed in space satellites, and to run watches and calculators. This is done by using solar cells.
4. Solar energy is used for the production of large scale electricity in solar power plants.
5. Solar energy is used to melt and forge metals in solar furnaces.

ADVANTAGES OF SOLAR ENERGY

An important advantage of solar energy is that it does not cause any pollution. Moreover, it is available in abundance in a hot country like ours and free of cost.

HARNESSING SOLAR ENERGY

The known reserves of the fossil fuels like coal, petroleum and natural gas are very limited which will get exhausted in a few decades time. This will create a energy crisis on the earth. So, in order to overcome the impending energy crisis, the man has accelerated the search for renewable sources of energy. The sun is one of the major sources of renewable energy. The sun is the most abundant and everlasting source of energy on the earth. The energy given by the sun (in the form of sunshine) is called solar energy.

LIMITATIONS OF SOLAR ENERGY

The important limitations of solar energy (or sun's energy) are as follows:

(i) The first limitation of solar energy is that it reaches the earth in a very diffused form. Every square metre area of the upper atmosphere of earth receives 1.36 kilojoule of solar energy per second. But only 47 per cent of this solar energy (that is only about 0.64 kilojoule of solar energy) reaches every square metre area of the earth's surface in one second. This intensity of solar energy is too small for doing useful work.

(ii) Another limitation of solar energy is that it is not available uniformly all the time and at all the places. The available of solar energy keeps on changing everyday and even at one place the solar energy keeps on changing the whole day. Moreover, the availability of solar energy is more at some places on the earth and much less at other places.

(iii) The solar energy is not available during the night.

(iv) If during the day time, the sky is covered with clouds, even then the solar energy is not available to us.

TRADITIONAL USES OF SOLAR ENERGY

Since the solar energy is available on the earth in a very diffused form and non-uniformly. Therefore, traditionally the solar energy has been put to very limited uses.

SOME OF THE TRADITIONAL USES OF SOLAR ENERGY ARE GIVEN BELOW

(i) Solar energy has been used for drying clothes.

(ii) Solar energy has been used for obtaining salt from sea-water.

(iii) Solar energy has been used for reducing the moisture content in food grains after harvesting the crops.

(iv) Solar energy has been used for the preservation of fruits, vegetables and fish, etc. by the process of sun-drying.

SOLAR ENERGY IN INDIA

In India, efforts are being made to harness solar energy on a large scale to meet its very increasing needs for energy. Some of the important steps taken in this direction are as follows:

(i) The use of solar cookers for cooking food is being encouraged in India. The development of Non-conventional energy sources (DNES) of the government of India and similar departments at the states level are making all out efforts to popularize the use of solar cookers for cooking food. In fact, in 1962, India became the first country in the world to start the production of solar cookers on a commercial scale. These solar cookers are then made available to the public at highly subsidised rates.

(ii) The use of solar water heaters for heating water is being encouraged in India. The solar water heaters can now be seen on the roof-tops of hotels, hospitals and industrial establishments in our country.

(iii) In order to harness solar energy on a commercial scale, many solar energy parks are being established in India.

HYDROELECTRICITY

The energy of water flowing in a river or stored in a dam is another potential source of energy.

PRINCIPLE OF GENERATION OF HYDROELECTRICITY

The basic principle of generation of hydroelectricity is given below: the water flowing in a river is collected by constructing a high rise dam. The water stored in the dam is then allowed to fall from the top of the dam. Now, water turbine is located near the bottom of the dam and the shaft of water turbine is connected to the electric generator. When the fast moving water coming from the dam falls on the blades of the water-turbine, then the kinetic energy of the flowing water rotates the water turbine rapidly. When the water-turbine rotates, then the armature of the generator also rotates rapidly and produces electricity.

ADVANTAGES OF GENERATING HYDROELECTRICITY

(i) The generation of electricity from water energy does not produce any environmental pollution.

(ii) Water energy is a renewable source of electric energy which will never get exhausted.

DISADVANTAGES OF GENERATING HYDROELECTRICITY

The production of electricity power from hydroenergy by constructing high-rise dams on rivers may give rise to a number of environmental problems. A vast variety of flora and fauna as well as human settlements get submerged in the water of reservoir formed by the dam. Due to this many plants and trees are destroyed, animals get killed and many people are rendered homeless. The construction of dam on a river disturbs the ecological balance in the downstream area of the river.

THE REAL SOURCE OF HYDROENERGY

The energy of water is called hydroenergy. The energy of water is in fact an indirect source of solar energy. This is because it is the solar energy which recirculates water in nature in the form of water-cycle.

ENERGY FROM THE OCEANS

The property of high "specific heat capacity" of water enables the oceans to act as a storehouse of solar heat energy. The oceans cover almost 71per cent of the surface of earth with water and they act as a vast collector of solar heat energy but it has also a great storage capacity for the solar heat energy (because of its high specific heat). Thus, the solar heat energy stored in the water of oceans can provide us a renewable source of energy.

TIDAL ENERGY IN INDIA

The rise of ocean water due to the attraction of moon is called 'high tide' whereas the fall of ocean water is called 'low tide'. The tidal waves in the ocean build up and recede twice a day. The enormous movement of water between the high tides and low tides provides a very large source of energy in the coastal areas of the world.

Three potential sites have been chosen in India to harness the energy of tidal waves.

These are:

(i) Gulf of Kutch in Gujarat

(ii) Cambay in Gujarat and

(iii) Sunderbans along the East Coast in West Bengal.

NUCLEAR ENERGY (OR ATOMIC ENERGY)

Whenever the nucleus of a big atom is split to form small atoms, energy is released. And if the nuclei of two small atoms are combined together to form a bigger atom, even then energy is released. The energy released by the fission of a big nucleus of an atom into smaller nuclei; or by the fusion of smaller nuclei into a bigger nucleus, is called nuclear energy, because it originate from the nucleus of atom. Sun's energy comes from the nuclear fusion reactions. Thus, nuclear energy is by no means new, it is one of the oldest things of the universe. The nuclear energy is also known as atomic energy because it comes from the atoms.

NUCLEAR FUSION IS THE SOURCE OF SUN'S ENERGY

The correct explanation of the source of sun's energy was provided by Hans Bethe in the year 1939. Hans Bethe said that the nuclear reactions in which the nuclei of hydrogen atoms fuse to form the nucleus of helium atoms, is the source of energy given out by the sun. The sun is made up of hydrogen atoms, each hydrogen atom has a tiny nucleus at its centre. At the core of the Sun, where the temperature is very high, the Hydrogen nuclei are moving at very high speeds. When two such hydrogen nuclei fuse, they form the nucleus of a bigger atom called helium . The nuclear fuel in the sun is hydrogen, and the source of sun's energy is the nucleus of hydrogen atom.

THE EXTENDED SOLAR SPECTRUM

If we pass sunlight through a triangular glass prism, we get a band of seven colours: Red, Orange, Yellow, Green, Blue, Indigo and Violet. This is called visible spectrum because we can see it with our eyes. All the colours of the visible spectrum have different wavelengths, with red colour having the longest wavelength and violet colour having the shortest wavelength. The formation of spectrum consisting of seven colours shows that the visible part of sunlight consists of seven different colours.

COMPOSITTION OF SUNLIGHT

The sun-light consists of three types of waves: ultra-violet rays, visible light and infra-red rays, all having different range of wavelengths. Out of these, ultra-violet rays have the shortest wavelengths and the infra-red rays have the longest wavelengths. We can see only the visible part of the sun-light called 'visible light' having the wavelength range from about 4×10^{-7} metre to 7×10^{-7} metre. The ultra-violet rays and infra-rays and infra-red rays contained in sunlight are invisible, and cannot be seen with our eyes. Infra-red rays produce a sensation of heat whereas ultra-violet rays produce fluorescence in certain substances.

1. INFRA-RED RAYS

The invisible rays whose wavelength is longer than that of the visible red light, are called infra-red rays. Since the wavelength of infra-red radiation is longer than that of red light, its frequency will be lower than that of red light. We cannot see the infra-red rays with our eyes, but we can detect its presence because of its heating effect. Thus, an important property of the infra-red rays is that they can heat the objects on which they fall. Sun is a very good source of infra-red rays. About one-third of the energy that we receive from the sun consists of infra-red rays. This is why we feel hotter in sun-shine than in shade. Infra-red rays are emitted by all hot objects.

2. VISIBLE LIGHT

The wavelengths of light which we can see range from 4×10^{-7} m in violet to 7×10^{-7} m in red. Our eyes are sensitive only to the waves whose wavelengths are between that of violet and red. The wave having wavelengths in the range 4×10^{-7} metre to 7×10^{-7} metre which can be seen by our eyes, is known as visible light. The sun is waves having wavelengths either less than 4×10^{-7} metre or more than 7×10^{-7} metre. The sun is one the best sources of visible light. The visible part of the sunlight consists of seven different wavelength corresponding to a different colour. Thus, the visible part of the sunlight consists of seven different colours. The violet colour has the shortest wavelength of 0.4 microns (0.4×10^{-6}m or 0.4μ) and the red colour has the longest wavelength of 0.7 microns (0.7×10^{-6}m or 0.7μ).

3. ULTRA-VIOLET RAYS

The invisible rays whose wavelength is shorter than that of the visible violet light, are called ultra-violet rays. Since the wavelength of ultra-violet rays is shorter than that of visible violet light an important property of the invisible ultra-violet rays is that they darken the photographic film just like ordinary light rays. The sun is a source of ultra-violet rays, but most of these ultra-violet rays are absorbed by the upper layers of the atmosphere and only a small part of it reaches the ground. The exposure of our body to the ultra-violet rays can produce a change in the colour of our skin. Too much ultra-violet radiation is dangerous to health because of its ionizing effects and can cause skin cancer.

FUEL

Any substance which is easily available and burns in air at a moderate rate, producing large amount of heat energy without leaving behind any undesirable residue is called a fuel.

CALORIFIC VALUE OF FUEL

The amount of heat energy produced on completely burning one kilogram of fuel in pure oxygen is called the calorific value of fuel.

Thus, a fuel which produces more heat energy per kilogram is said to have a higher calorific value.

The calorific value of the fuels is expressed in kilojoules per kilogram.

CLASSIFICATION OF FUELS

On the basis of physical state of fuel, fuels are classified into-

Solid fuels:- The fuels which occur in a solid state at room temperature are called solid fuels.

Examples: -Wood, agricultural residues, charcoal, coal, coke, paraffin wax.

Liquid fuels:- The fuels which occur in a liquid state at room temperature are called liquid fuels.

Examples:- Liquified hydrogen, petrol, kerosene oil, diesel, furnace oil, alcohol.

Gaseous fuels : The fuels which occur in a Gaseous state at room temperature are called Gaseous fuels.

Examples:- Water gas, producer gas, coal gas, compressed natural gas (CNG), gobar gas, hydrogen gas.

SOURCES OF ENERGY

The term 'fuel' means any material which can produce heat energy on burning. All the fuels available to us have solar energy stored in them in form of chemical energy over a period of millions of years. Once these fossil fuels get exhausted, it is not possible to regenerate them. Thus, fossil fuels are non-renewable sources of energy and are called conventional sources of energy.

There are alternative sources of energy which are freely available in nature such as solar energy, energy of flowing water and wind, Such sources of energy are called renewable sources of energy.

WOOD AND BIOMASS

Wood has been the most important source of energy right from prehistoric times. Wood, on burning produces heat energy. The heat energy so generated is put to a number of uses.

However, with the increase in population, the availability of wood is decreasing rapidly.

Biomass consists of dried leaves, cow dung or any other non-usable product of animal or vegetable life. The biomass is converted into combustible gases, such as methane, in the gobar gas plants.

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BURNING AND COMBUSTION

A large number of materials burn in oxygen or air with the release of heat and light energy. The materials which burn, are commonly called supporter of combustion and the chemical reaction which takes place with the release of energy is called combustion.

(a) COMBUSTION

The chemical process, in which a substance burns in air or oxygen, with the release of heat and light energy is called combustion.

(b) COMBUSTIBLE SUBSTANCE

A substance that burns in air or oxygen or catches fire easily, is called a Conbustible substance. Combustion is an oxidation process.

Examples :-

Wood, paper, coal, coke, hydrogen, liquified petroleum gas (LPG), compressed natural gas (CNG), petrol, kerosene, diesel, alcohol, ether, etc. are the examples of combustible substances.

(c) SUPPORTER OF COMBUSTION

A substance which helps in the combustion of a combustible substance is called a supporter of combustion.

Examples :-

Oxygen and air are the supporters of combustion. It must be remembered that air contain 21% of oxygen by volume which is a supporter of combustion. 78% of nitrogen by volume is neither combustible, nor a supporter of combustion.

It is for the same reason that combustible substances burn at a moderate rate in air, but burn at a very fast rate in pure oxygen.

(d) IGNITION TEMPERATURE

The minimum temperature (lowest temperature) to which a substance must be heated before it catches fire, is called ignition temperature.

(e) INFLAMMABLE SUBSTANCES

The substances which have a low ignition temperature (generally less than 100°C) are called inflammable substances. The vapours of these substances in air can easily catch fire with a minor spark and, hence, can cause serious accidents.

CONDITIONS NECESSARY FOR COMBUSTION

1. There must be a combustible substance.
2. There must be a continuous supply of supporter of combustion.
3. The temperature of combustible substance should be above its ignition temperature.

FOSSIL ENERGY FROM THE FOSSIL FUELS

The fuels which are preserved in Earth's crust as the remains of plants and animals are called fossil fuels.

These fuels were formed in prehistoric times. Following are the main types of fossil fuels:

1. Coal
2. Petroleum
3. Natural gas

ORIGIN OF THE FOSSIL FUELS

Millions of years ago, due to certain natural calamities such as earthquakes, cyclones, storms, floods, etc, a large number of animals and plants got buried beneath the earth. Under humid conditions and very high pressure and temperature of the earth and bacterial decomposition in the absence of air, they gradually decomposed to form coal, petroleum or natural gas, depending upon the external factors to which they were subjected.

COAL

Coal was formed in prehistoric times when huge forest areas got buried under the surface of the earth. Under humid and hot conditions, they were attacked by anaerobic bacteria which progressively removed hydrogen and oxygen, leaving behind carbon. Due to very high temperature and pressure of the earth, the carbon got compact to form stony residue, called coal. Some amount of methane was trapped in the coal. The slow conversion of wood into coal by a biochemical process extending over millions of years is called carbonisation.

Coal is a complex mixture of free carbon and compounds of carbon. If burnt directly, it produces harmful gases due to the burning of organic compounds. This leads to atmospheric pollution.

PETROLEUM

Petroleum is a fossil fuel. It is a dark coloured, viscous and foul smelling liquid commonly called crude oil. It is always found trapped between two impervious rocks. Its name is derived from the latin word, 'petra' meaning rock and 'oleum' meaning oil. Thus, petroleum literally means rock oil.

ORIGIN OF PETROLEUM

Crude oil or petroleum is a complex mixture of solid, liquid and gaseous hydrocarbons, mixed with salt water and earthly particles.

Petroleum is formed by the anaerobic decomposition of extremely small sea animals and plants, which got buried millions of years ago. The bodies of dead plants and animals decayed in the absence of air under very high temperature and pressure of the earth. The product of decay was petroleum and natural gas. This product got trapped between the two layers of impervious rocks forming an oil trap. The natural gas always collects above the petroleum layer.

OCCURRENCE OF PETROLEUM

Petroleum occurs at moderate depths (500 m to 2000 m) between two layers of impervious rocks. Petroleum deposits are usually found mixed with salt water. Petroleum is lighter than salt water and, hence, floats over it. Natural gas is found above petroleum trapped in between the rock cap and the petroleum layer.

PETROLEUM GAS

Petroleum gas is the gaseous fraction obtained during the fractional distillation of petroleum.

Composition

Petroleum gas is a mixture of

(i) Butane (C_4H_{10})

(ii) Propane (C_3H_8)

(iii) Ethane (C_2H_6)

The main constituent of petroleum gas in Butane.

LIQUIFIED PETROLEUM GAS

The petroleum gas when subjected to high pressure at room temperature gets liquified. The liquified petroleum gas is commonly called LPG. It is highly volatile in nature and changes to gas as soon as the pressure is removed.

STORAGE AND TRANSPORT OF LPG

LPG is mixed with a small amount of a strong smelling volatile liquid called Mercaptan or ethyl mercaptan (C_2H_5SH) which has smell like that of hydrogen sulphide. If the LPG gas leaks in air due to some reason, it can be easily detected by the smell of mercaptan.

ADVANTAGES OF LPG AS A DOMESTIC FUEL

1. It burns with a blue flame without any smoke. Thus it does not blacken utensils or pollute air.
2. It does not produce any poisonous gases during combustion.
3. It is very easy to handle, ignite or to put off.
4. It has a very high calorific value of 50kj g.

NATURAL GAS

Natural gas was formed millions of years ago along with petroleum when microscopic sea plants and animals died and got buried under the sand and mud.

COMPOSITION

Natural gas consists of 95% methane (CH_4) and 5% of a mixture of ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}).

OCCURANCE

Natural gas is found trapped between impervious rocks. Sometimes along with petroleum and sometimes without petroleum.

USES OF NATURAL GAS

1. **AS A FUEL:** Natural gas has a very high calorific value of 55kj/gm. It burns readily and is used as a fuel in homes, automobiles and industries.

2. **AS A SOURCE OF HYDROGEN AND CARBON:** When natural gas is heated strongly in the absence of air, it decomposes to form carbon and hydrogen.

(i) The hydrogen so obtained is used in the manufacture of ammonia gas, which is further used in the manufacture of fertilisers such as ammonium sulphate, urea etc.

(ii) The carbon so obtained is used as filler in the rubber tyre industry.

ADVANTAGES OF NATURAL GAS AS A FUEL

(i) Natural gas can be directly pipes from production wells to homes and factories in much the same way as water through underground pipes. The initial cost of laying underground pipes is very high, but in the long run, it is cheaper as it saves on storage and transportation costs. In Gujarat, quite a number of cities are provided natural gas for domestic consumption through underground pipes.

(ii) It is an efficient fuel having calorific value of 55 kj/g. It causes no pollution on burning.

BIOGAS-AN INDIRECT WAY OF OBTAINING FUEL FROM ANIMAL DUNG

Biogas is a mixture of gases formed when the slurry of animal dung and water is allowed to ferment in the absence of oxygen. The fermentation of animal dung which takes place in the absence of air due to the presence of anaerobic bacteria present in the animal dung is called anaerobic fermentation.

Biogas is a mixture of methane, carbon dioxide, hydrogen and traces of hydrogen sulphide along with water vapour. The chief constituent of biogas is methane gas and is about 65 per cent by volume.

CONDITIONS FOR THE FORMATION OF BIOGAS

1. A fairly large amount of water should be added to animal dung so as to make slurry. Presence of inadequate amount of water reduces the anaerobic fermentation with the result, the production of biogas drops.
2. The animal dung slurry should ferment only in the absence of air.
3. The temperature of slurry should be maintained around 35°C. Any drop in temperature reduces the anaerobic fermentation and, hence, the yield of biogas.

ADVANTAGES OF BIOGAS

Biogas is a good domestic fuel on account of the following reasons:

1. Biogas has fairly large calorific value.
2. Biogas is a convenient and clean fuel which does not produce smoke or other harmful gases.
3. Biogas is cheaper than any other fuel.
4. Biogas has no storage problems as it can be directly supplied to a number of houses through pipelines.
5. The slurry left behind is a good agricultural manure.

BIOMASS

Waste material produced by living beings and the dead materials of living beings are collectively called biomass.

LIGHT

INTRODUCTION

Light travels in a straight line. This property of light is called rectilinear propagation of light. But, it has been found that the rays of light deviate from their path while travelling from one medium to another medium.

DEFINITION OF REFRACTION

The phenomenon due to which a ray of light deviates from its path, at the surface of separation of two media, when the ray of light is travelling from one optical medium to another optical medium, is called refraction of light.

RULES FOR THE DEVIATION OF RAYS IN ANOTHER OPTICAL MEDIUM

1. When a ray of light travels from an optically less dense medium (air) to an optically more dense medium (glass),

it bends towards the normal at the surface of separation of two media.

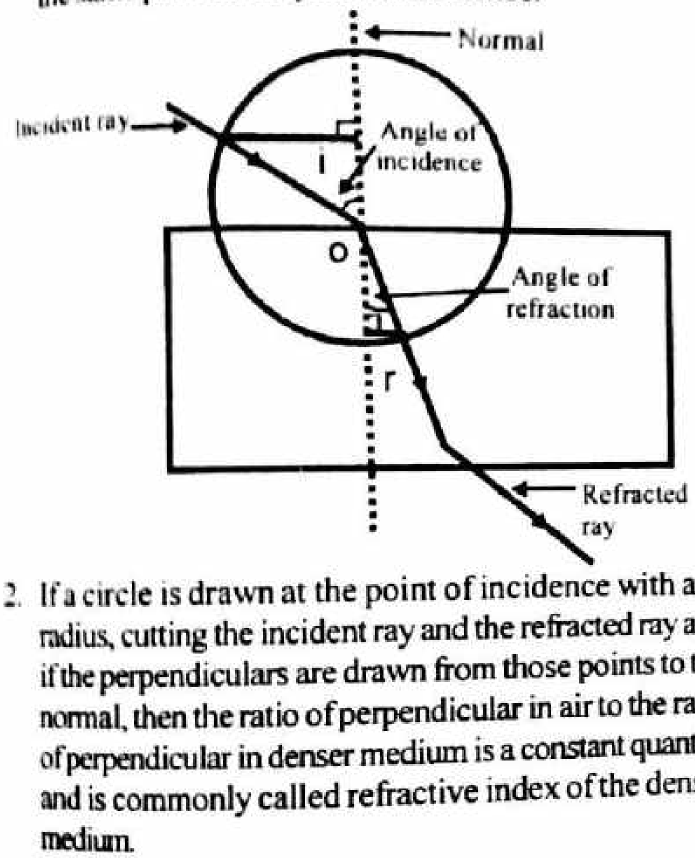
2. When a ray of light travels from an optically more dense medium to the optically less dense medium, it bends away from the normal at the surface of separation of two media.

3. When a ray of light strikes the surface of separation of two media at an angle 90° C. It does not deviate from its path.

LAWS OF REFRACTION

There are two laws of refraction.

1. The incident ray, the reflected ray and the normal lie in the same plane at the point of incidence.



2. If a circle is drawn at the point of incidence with any radius, cutting the incident ray and the refracted ray and if the perpendiculars are drawn from those points to the normal, then the ratio of perpendicular in air to the ratio of perpendicular in denser medium is a constant quantity and is commonly called refractive index of the denser medium.

LATERAL DISPLACEMENT

The perpendicular shift in the path of incident ray with respect to the emergent ray, while emerging from a block of some optical medium (such as glass) is called Lateral displacement.

The magnitude of the lateral displacement depends upon the following factors:

(i) Lateral displacement increases with the increase in the thickness of the glass block.

(ii) Lateral displacement increases with the increase in the angle of incidence.

RELATION BETWEEN VELOCITY OF LIGHT IN VARIOUS MEDIA & REFRACTIVE INDEX

Light travels with a velocity of 3×10^8 ms^{-1} in vacuum or air. However, when light enters some optically denser medium, it slows down.

SIMPLE EFFECTS OF REFRACTION OF LIGHT

(a) A stick immersed obliquely in water appear bent and short.

(b) A coin placed at the bottom of a beaker containing water appear raised.

(c) Faces of people sitting opposite to you around a camp fire appear to shimmer.

REFLECTION OF LIGHT

Light is a form of energy which enables us to see objects from which it comes (or from which it is reflected). The objects like the sun lamp, candle, etc. which emit their own light are called luminous objects. Those objects which do not emit light energy themselves but only reflect (or scatter) the light which falls on them, are called non-luminous objects. Light is a form of energy which causes in us the sensation of sight.

NATURE OF LIGHT

Light consists of electromagnetic waves which do not require a material medium (like solid, liquid or gas) for their propagation. The speed of light waves in vacuum is very high, being 3×10^8 metres per second. The speed of light in glass and water is, however, much less than that in air.

REFLECTION OF LIGHT

When light falls on the surface of an object, it may be

(i) absorbed

(ii) transmitted or

(iii) reflected

If an object absorbs all the light which falls on it, then it will appear perfectly black. The process of sending back the light rays which fall on the surface of an object, is called reflection of light. Silver metal is one of the best reflectors of light. So, ordinary mirrors are made by depositing a thin layer of silver metal on one side of a plane glass sheet. The silver layer is then protected by a coat of red paint. The reflection of light in a plane mirror (or any other mirror) takes place at the silver surface in it.

A ray of light is the straight line along which light travels.

A 'bundle of light rays' is called a ' beam of light'.

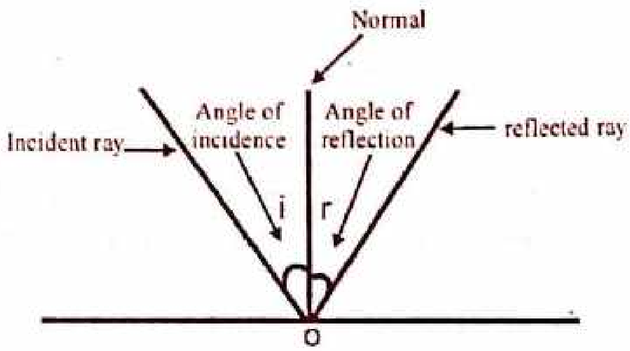
The 'normal' is a line at right angle to the mirror surface at the point of incidence.

The angle of incidence is the angle made by the incident ray with normal at the point of incidence.

The angle of reflection is the angle made by the reflected ray with the normal at the point of incidence.

LAWS OF REFLECTION OF LIGHT

1. **FIRST LAW OF REFLECTION:-** The incident ray, the reflected ray, and the normal (at the point of incidence), all lie in the same plane.



2. **SECOND LAW OF REFLECTION:-** The angle of reflection is always equal to the angle of incidence. (A ray of light which is incident normally (or perpendicularly) on a mirror is reflected back along the same path because the angle of incidence as well as the angle of reflection for such a ray of light are zero).

REAL IMAGES

The image which can be obtained on a screen is called a real image.

VIRTUAL IMAGES

The image which cannot be obtained on a screen is called a virtual image. A virtual image can be seen only by looking into a mirror (or a lens). The image of our face in a plane mirror is an example of virtual image.

THE POSITION OF IMAGE FORMED IN A PLANE MIRROR

Distance of image from mirror = distance of object from mirror

LATERAL INVERSION

If an object is placed in front of a plane mirror, then the right side of the object appears to be the left side of the image and the left side of the object appears to be the right side of its image. This change of sides of an object and its mirror image is called lateral inversion.

THE IMAGE FORMED IN A PLANE MIRROR IS LATERALLY INVERTED WITH RESPECT TO THE OBJECT

The characteristics of an image formed by a plane mirror:

1. The image is formed in a plane mirror is virtual. It cannot be received on a screen.
2. The image formed in a plane mirror is erect. It is the same side up as the object.
3. The image in a plane mirror is of the same size as the object.
4. The image formed by a plane mirror is at the same distance behind the mirror as the object is in front of the mirror.
5. The image formed in a plane mirror is laterally inverted (sideways reversed).

REFLECTION OF LIGHT FROM CURVED SURFACES: SPHERICAL MIRRORS

When a parallel beam of light rays falls on a plane mirror, it is reflected as a parallel beam. So, a plane mirror changes only the direction of incident light rays, it does not 'converge' or 'diverge' the parallel rays of light (to bring the parallel rays of light 'closer together' is called 'to converge' the right rays whereas 'to spread out' the parallel rays of light is called 'to diverge' the light rays).

A spherical mirror is that whose reflecting surface is the part of a hollow sphere of glass. The spherical mirrors are of two types: concave mirrors, and convex mirrors.

(i) A concave mirror is that spherical mirror in which the reflection of light takes place at the concave surface (bent-in surface).

(ii) A convex mirror is that spherical mirror in which the reflection of light takes place at the convex surface.

CENTRE OF CURVATURE, RADIUS OF CURVATURE, POLE AND PRINCIPAL AXIS OF A SPHERICAL MIRROR

The centre of curvature of a spherical mirror is the centre of the hollow sphere of glass of which the mirror is a part.

The radius of curvature of a spherical mirror is the radius of the hollow sphere of glass of which the mirror is a part.

The centre of a spherical mirror is called its pole.

The straight line passing through the centre of curvature and pole of a spherical mirror is called its principal axis.

That portion of a mirror from which the reflection of light actually takes place is called the aperture of the mirror.

RELATION BETWEEN RADIUS OF CURVATURE AND FOCAL LENGTH OF A SPERCIAL MIRROR

The focal length of a spherical mirror (a concave mirror or a convex mirror) is equal to half of its radius of curvature.

$F = R/2$

FORMATION OF DIFFERENT TYPES OF IMAGES BY A CONCAVE MIRROR

We can place the object at different positions (or different distances) from a concave mirror to get different types of images. For example, we can place the object:

(i) Between the pole (P) and focus (F)

(ii) At the focus (F)

(iii) Between focus (F) and centre of curvature (C)

(iv) At the centre of curvature (C)

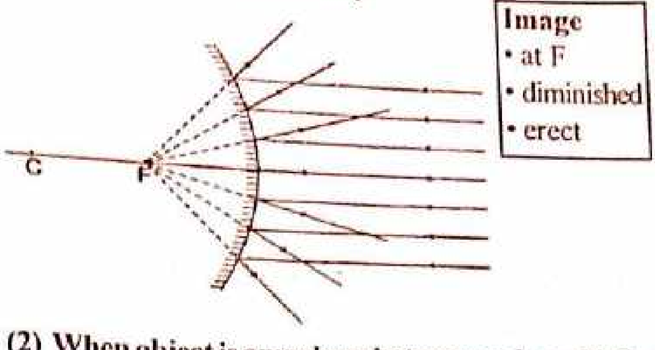
(v) Beyond the centre of curvature (C) and

(vi) At far-off distance called infinity

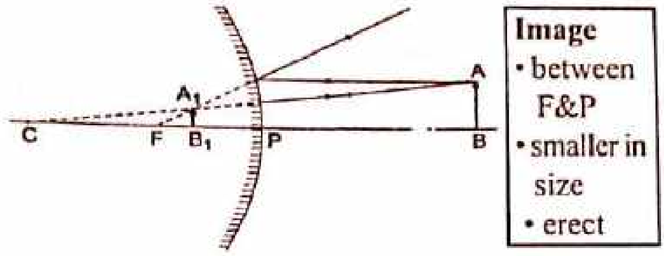
SUMMARY OF THE IMAGES FORMED BY A CONCAVE MIRROR

	Position of object	Position of image	Size of image	Nature of image
1.	Anywhere between pole P and infinity	Behind the mirror between P and F	Diminished	Virtual and erect
2.	At infinity	Behind the mirror at focus F	Highly diminished	Virtual and erect

(1) When object is at infinity.



(2) When object is anywhere between pole and infinity.



USES OF CONCAVE MIRRORS

(i) Concave mirrors are used as shaving mirrors.

(ii) Concave mirrors are used as reflectors in car head-lights, search lights, hand torches, and table lamps.

(iii) Concave mirrors are used by doctors to concentrate light on body parts like ears and eyes which are to be examined.

(iv) Large concave mirrors are used in the field of solar energy to focus sun-rays on the objects to be heated.

SOME IMPORTANT CONCLUSIONS

The images formed by a concave mirror can be either behind the mirror (virtual) or in front of the mirror (real). So, the image distance for a concave mirror can be either positive or negative depending on the position of the image. If an image is formed behind a concave mirror (to the right side), the image distance is positive but if the image is formed in front of the mirror (on the left side), then the image distance will be negative.

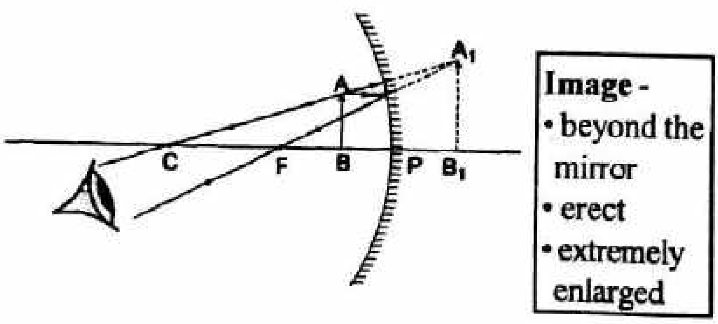
In a convex mirror, the image is always formed on the right hand side (behind the mirror), so the image distance for a convex mirror will be always positive.

The focus of concave mirror is in front of the mirror on the left side, so the focal length of a concave mirror is positive (and written with a minus sign, say – 10cm). On the other hand, the focus of a convex mirror is behind the mirror on the right side, so the focal length of a convex mirror is positive (and written with a plus sign, say + 20cm or just 20cm).

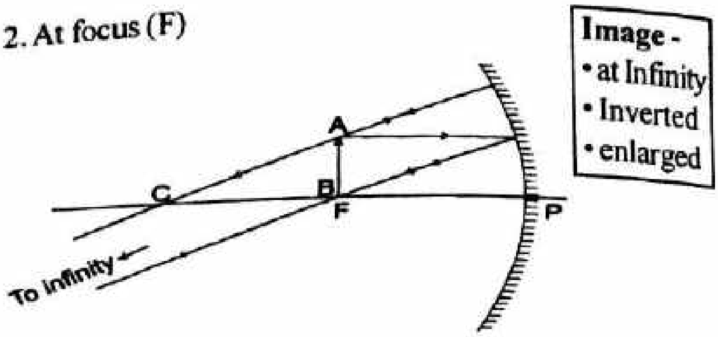
SUMMARY OF THE IMAGES FORMED BY A CONVEX MIRROR

	Position of object	Position of image	Size of Image	Nature of Image
1.	Within focus (between pole P and focus F)	Behind the mirror	Enlarged	Virtual and erect
2.	At focus (F)	At infinity	Highly enlarged	Real and inverted
3.	Between F and C	Beyond C	Enlarged	Real and inverted
4.	At C	At C	Equal to object	Real and inverted
5.	Beyond C	Between F and C	Diminished	Real and inverted
6.	At infinity	At focus F	Highly diminished	Real and inverted

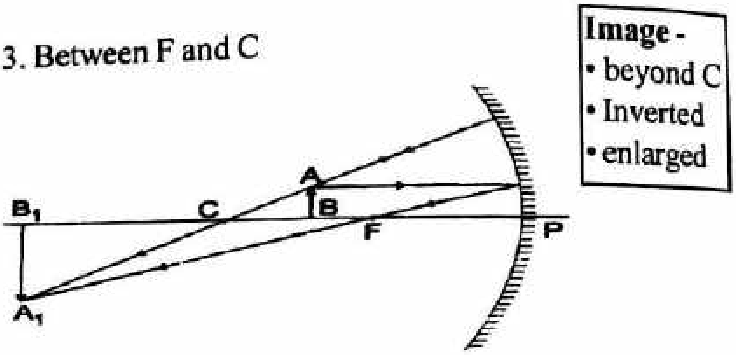
1. Within focus (between pole P and focus F)



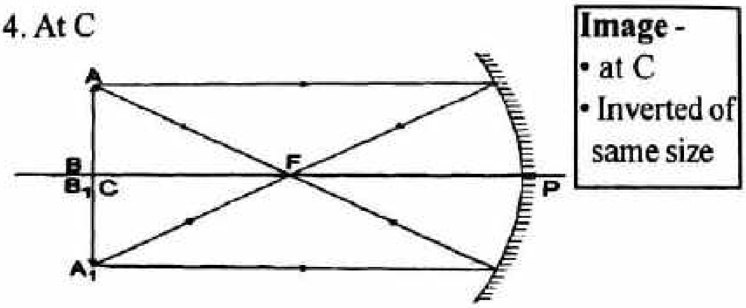
2. At focus (F)



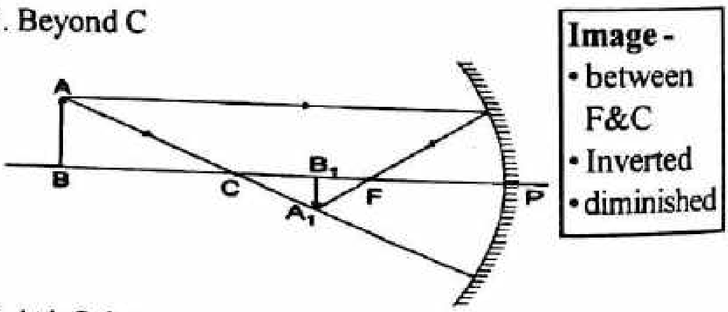
3. Between F and C



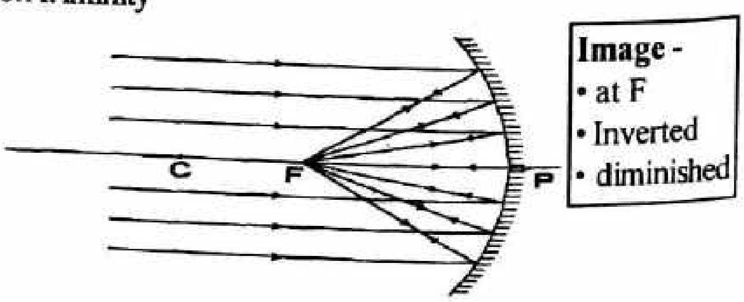
4. At C



5. Beyond C



6. At infinity



USES OF CONVEX MIRRORS

(i) Convex mirrors are used as rear-view mirrors in automobiles (like cars, trucks and buses) to see the traffic at the back side. A driver prefers to use a convex mirror as back view mirror because of two reasons:

(ii) A convex mirror always produces an erect image of the objects.

(iii) The image formed in a convex mirror is highly diminished or much smaller than the object, due to which a convex mirror gives a wide field of view (of the traffic behind).

MIRROR FORMULA

The ratio of the height of image to the height of object is known as linear magnification.

Magnification = height of image / height of object

Or $m = h_2 / h_1$

Where h_2 = height of image

And h_1 = height of object

If the magnification has a plus sign, then the image is virtual and erect. For a real image, h2 is negative and h1 is positive, so the magnification (h2/h1) for a real (and inverted) image is always negative. In other words, if the magnification has a minus sign, then the image is real and inverted.

The object can be:

(i) Anywhere between pole (P) and infinity and

(ii) At infinity

PRISM

A prism is a piece of glass or any other transparent material, which is bounded by two triangular surfaces and three rectangular surfaces. The rectangular surfaces are called refracting faces. The angle between two refracting faces is called angle of prism.

The angle between the incident ray and emergent ray is called angle of deviation.

If we measure

(i) angle of incidence (ii) angle of emergence

(iii) angle of prism and (iv) angle of deviation

DISPERSION OF WHITE LIGHT THROUGH A PRISM

The order of colours from the base of prism is, violet, indigo, blue, green, yellow, orange and red. This order of colours can be easily remembered by remembering the word VIBGYOR

(i) Dispersion: The phenomenon due to which white light splits into seven colours *(VIBGYOR)*, when passed through and equilateral prism is called dispersion.

(ii) **Spectrum:** The band of seven colours obtained on the screen, when white light splits into seven colours is called spectrum.

RAINBOW

A rainbow is formed by the dispersion of sunlight by the tiny droplets of water, suspended in air, just after the rain. The suspended droplets of water act as innumerable small prisms. When sunlight passes through them, it gets dispersed to form a band of seven colours. The red colour appears on the upper arc and the violet colour on the lower arc of the rainbow.

INVISIBLE SPECTRUM

The spectrum obtained from white light (sunlight) comprising of seven colours is often referred to as visible spectrum.

The components of the solar spectrum, which are not visible to the eye are collectively called invisible spectrum.

INFRA-RED REGION

An invisible region of the solar spectrum, which is not visible spectrum is called infra-red region.

The infra-red rays basically produce a heating effect. All hot bodies emit infra-red rays including our own body. However, the wavelength of these rays depends on the temperature of the hot body. Higher the temperature of a body is, shorter is its wavelength and vice versa.

While the temperature of a body rises, it absorbs infra-red radiations. Conversely, when a body cools, it gives out infra-red radiations. The heat energy in the sunlight is due to the infra-red radiations.

ULTRAVIOLET REGION

An invisible region of the solar spectrum, found below the violet region of the visible spectrum is called ultraviolet region.

The wavelength of ultraviolet radiations is smaller than that of visible region. A prolonged exposure to ultraviolet rays can lead to skin cancer or blindness.

Ultraviolet rays are employed in the detection of fake currency note and for various purposes in many Scientific investigations.

LENS

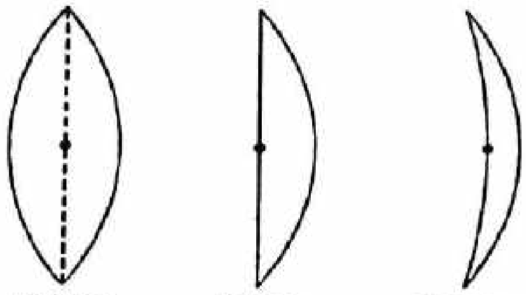
A lens is a piece of a transparent optical material, having one or two spherical surfaces. A lens can have either one spherical and one plane surface or two spherical surfaces. Lenses can be divided into two broad classes.

CONVEX LENS

A piece of transparent optical material, having one or two spherical surfaces, such that it is thicker in the middle and tapering (thin) at the edges, is called a conves lens.

Depending upon the shape of the surfaces, the convex lenses are further divided into three classes,

(i) Double convex lens
(ii) Plano-convex lens
(iii) cancavo-convex lens



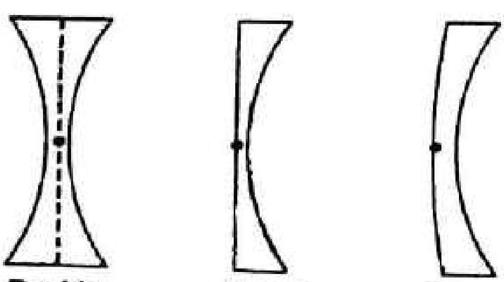
Double convex lens | Plano-convex lens | Concavo-convex lens

CONCAVE LENS

A piece of transparent, optical material, having one or two spherical surfaces, such that it is tapering (thin) in the middle and thicker at the edges is called a concave lens.

Depending upon the shape of the surfaces, the concave lenses are further divided into three classes.

(i) Double concave lens
(ii) Plano-concave lens and
(iii) Convexo-concave lens



Double concave lens | Plano concave lens | Convexo concave lens

CENTRE OF CURVATURE (C)

The centre of the imaginary glass sphere of which the lens is a part is called centre of curvatures of the two spheres, of which the lens is a part is called principle axis.

OPTICAL CENTRE (O)

A point within a lens, where a line drawn through the diameter of lens meets principal axis, is called optical centre.

PRINCIPAL FOCUS FOR CONVEX LENS (F)

It is a point on the principal axis of a convex lens, where parallel beam of light, travelling parallel to principal axis, after passing through the lens actually meets.

PRINCIPAL FOCUS FOR CONCAVE LENS (F)

It is a point on the principal axis of a concave lens, from where a parallel beam of light, travelling parallel to the principal axis, after passing through the lens, appears to come.

FOCAL LENGHT

The distance between principal focus and optical centre is called focal length. It is denote by the letter f and 2 f denotes double the distance than the focal length. It corresponds to the radius of curvature of the sphere of which lens is a part.

GEOMETRIC CONSTRUCTION OF IMAGES FOR CONVEX LENS

1. When object is at infinity

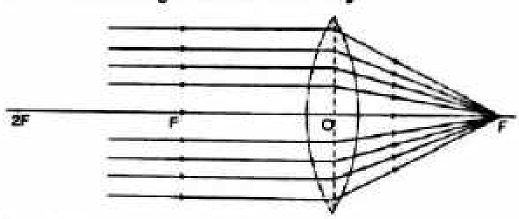


Image
1. Real
2. Diminished to point
3. Inverted
4. Formed at F on the other side of lens

2. When object is beyond 2 F, but not at infinity

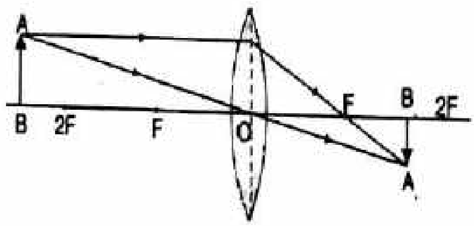


Image
1. Real
2. Diminished
3. Inverted
4. Formed between F and 2 F on the other side of lens.

3. When object is at 2F

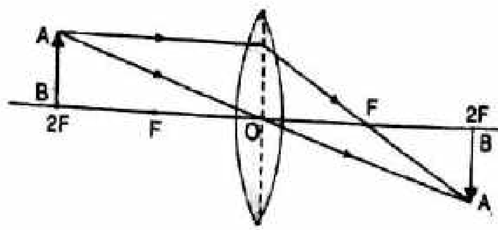


Image
1. Real
2. Same size as object
3. Inverted
4. Formed at 2 F on the other side

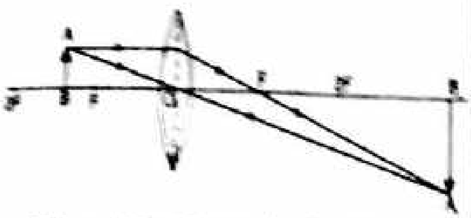


Image
1. Real
2. Magnified
3. Inverted
4. Formed beyond 2 F on the other side of lens

5. When object is at principal focus

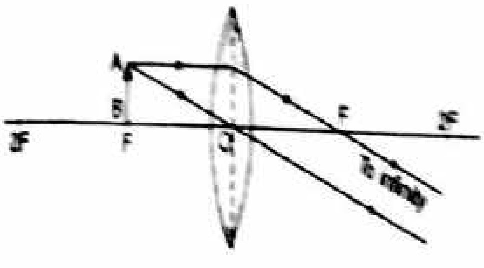


Image
1. Real
2. Magnified
3. Inverted
4. Formed at Infinity on the other side of lens

6. When the object is between opical centre and principal focus

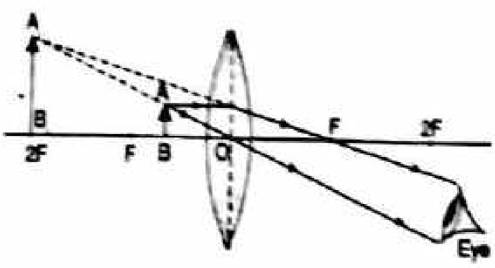


Image
1. Virtual
2. Magnified
3. Erect
4. Formed on the same side of the object

GEOMETRIC CONSTRUCTION OF IMAGES FOR CONCAVE LENS

1. When object is at infinity

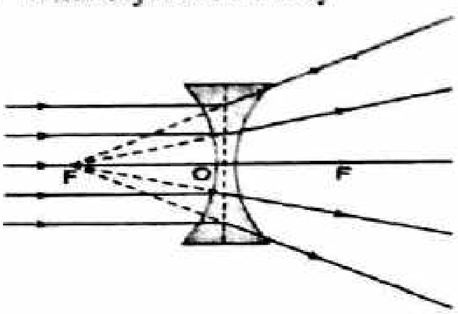


Image
1. Virtual
2. Diminished to a point
3. Erect
4. Formed at F on the same side of the lens.

2. When the object is anywhere between the optical centre and Infinity

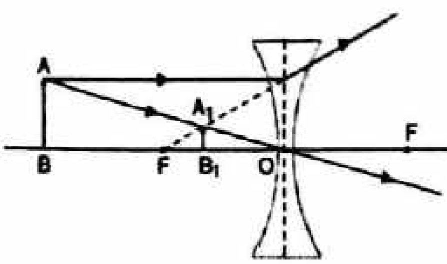


Image
1. Virtual
2. Diminished
3. Erect
4. Formed between O and F on the same side of the lens.

COMPOUND MICROSCOPE

A compound microscope consists of two metallic tubes blackened from inside, such that they can easily slide into one another. On the side of the smaller tube, a convex lens of lesser focal length is fitted, whereas, on the side of the bigger tube, a convex lens of larger focal length is fitted. The lens with lesser focal length is called objective lens whereas, the lens with larger focal length is called eye lens.

TELESCOPE

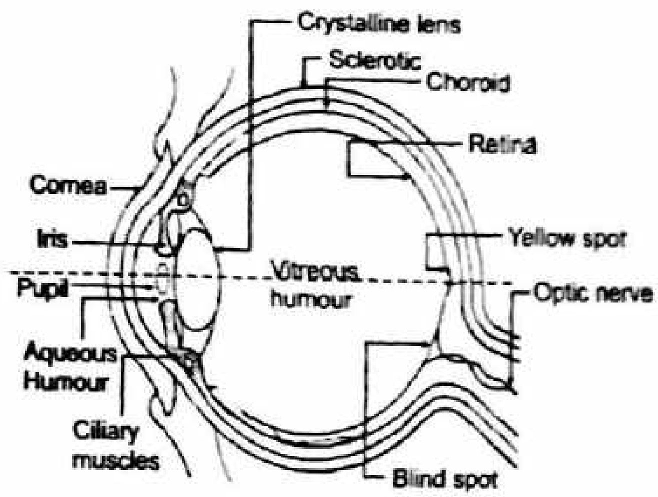
A telescope is a device used for seeing distant objects clearly, which otherwise are not very clearly visible to the human eye. The first telescope was invented by Johannes kepler in 1611.

A telescope consists of two convex lenses, objective lens of very large focal length and eye lens of very small focal length. These lenses are mounted on separate metallic tubes which can easily slide into one another. The tubes are blackened from inside so as to prevent reflection of light from its side.

The telescope is used to study the surface features of moon and the planets. It is used to study distant stars: comets etc.

HUMAN EYE

The construction and working of the human eye is similar to photographic camera in many respects. Human eye is almost a special ball, with a slight bulge in the front. The structure and function of each part of the eye is given below:



1. **Sclerotic:** It is the outermost covering of the eye. It is made of white tough fibrous tissues. Its function is to house and protect the vital internal parts of the eye.

2. **Cornea**: It is the front bulging part of the eye. If is made of transparent tissues. Its function is to act as a window to the world, i.e. to allow the light to enter in the eye ball.
3. **Choroid**: It is a grey membrane attached to the sclerotic from the inner side. Its function is to darken the eye from inside and, hence, prevent any internal reflection.
4. **Optic nerve**: It is a bundle of approximately 70,000 nerves originating from the brain and entering the eye ball from behind. Its functions is to carry optical messages to the brain.
5. **Retina**: The optic nerve on entering the ball, spreads like a canopy, such that each nerve end attaches itself to the choroid. The nerve endings form a hemi-spherical screen called retina. These nerve endings on the retina are sensitive to visible light. The function of retina is to receive the optical image of the object and then convert it to optical pulses. These pulses are then sent to the brain through optic nerve.
6. **Yellow spot**: It is a small area facing the eye lens. It has high concentration of nerve endings and is slightly raised as well as slightly yellow in colour. Its function is to form a very clear image by sending a large number of optical pulses to brain.
7. **Blind spot**: It is a region on the retina, where the optic nerve enters the eye ball. It has no nerve endings and hence, is insensitive to light. It does not seem to have any function. Any image formed on this spot is not visible.
8. **Crystalline lens**: It is a double convex lens made of transparent tissues. It is held in position by a ring of muscles, commonly called ciliary muscles. Its function is to focus the images of different objects clearly on the retina.
9. **Ciliary muscles**: It is a ring of muscles which holds the crystalline lens in position. When these muscles relax, they increase the focal length of the crystalline lens and vice versa. Its function is to alter the focal length of crystalline lens so that the images of the objects, situated at different distances, are clearly focussed on the retina.
10. **Iris**: It is a circular diaphragm suspended in front of the crystalline lens. It has a tiny hole in the middle and is commonly called pupil. It has tiny muscles arranged radially around the pupil. These muscles can increase the diameter of the pupil. The iris is heavily pigmented. The colour of eyes depends upon colour of pigment. The function of iris is to control the amount of light entering the eye. This is done by increasing or decreasing the diameter of pupil.
11. **Vitreous humour**:-It is a dense jelly-like fluid, slightly grey in colour, filling the part of eye between crystalline lens and retina. Its function is-

(i) To prevent the eye ball from collapsing due to change in atmospheric pressure

(ii) In focussing the rays clearly on the retina.

12. **Aqueous humour**:- it is watery, saline fluid, filling the part of the eye between the cornea and the crystalline lens and retina. Its function is

(i) To prevent front part of the eyeball from collapsing with the change in atmospheric pressure

(ii) To keep the cornea moist.

ACCOMMODATION OF EYE

The process, by which ciliary muscles alter the focal length of the crystalline lens, so as to focus the nearer or the far off objects clearly on the retina, is called accommodation of the eye.

NORMAL EYE

An eye whose ciliary muscles can alter the focal length of crystalline lens, such that it can focus clearly the images of objects as near as 25 cm and as far as infinity clearly on the retina, is called a normal eye.

The least distance from which the normal eye can see clearly without any strain is called least distance of distinct vision. Its value is 25 cm for normal eye.

The far off distance of distinct vision for normal eye is infinity.

DEFECTIVE EYE

An eye whose ciliary muscles cannot alter the focal length of a crystalline lens properly, such that it is unable to focus either nearer objects clearly on the retina or the far off objects clearly on the retina or both , is called a defective eye.

PHOTOGRAPHIC CAMERA

DEFINTION: It is a device used to record a permanent image of an object on the photographic plate.

PRINCIPLE: It is based on the principle that if an object is placed beyond 2F of a convex lens, it always forms a real, inverted and diminished image between F and 2F on the other side of the lens.

CONSTRUCTION: It consists of a light tight box. At one end of the box is fixed a convex lens of very small focal length. The convex lens is usually called camera lens.

At the other end of the box is a photographic film. The sides of the box are made of folded leather or rexine and are blackened from inside so as to stop any internal reflection. The distance between the lens and the film can be changed by turning the adjustment knob.

Just behind the lens is a circular metallic screen having a hole in it. The diameter of the hole is called aperture and the metallic screen is called diaphragm. The aperture (diameter of hole) can be changed by turning a ring mounted in front of the camera. Following are functions of diaphragm-

(1) It control the amount of light entering the camera. The size of aperture is increased in dim light and decreased in bright light.

(2) It controls the subject to be photographed. For example if a wide field is to be photographed then size of aperture is increased. Conversely for a smaller field such as portrait the size of aperture is decreased.

A shutter of variable speed is used to control exposure time of the film.

MAGNETISM AND ELECTRICITY

MAGNET

Magnetite (Fe_3O_4) is the world's first magnet. It is also called a natural magnet. It has two very important properties.

1. It attracts small pieces of iron towards itself. This is called attractive property.
2. When suspended freely, it always points in the north-south direction. This is called directive property.

The directive property of natural magnet was put to use by sailors as it always pointed in north-south direction. Initially, this freely suspended stone was called 'leading stone'. However, with time the name changed to 'lode stone'.

NATURAL AND ARTIFICIAL MAGNETS

NATURAL MAGNET: A magnet which occurs naturally and is not made by any artificial means is called a natural magnet.

Magnetite is the only natural magnet known to man. It is an ore of iron (Fe_3O_4).

ARTIFICIAL MAGNET: A substance to which properties of the natural magnet are imparted by artificial means is called artificial magnet.

The magnets made from iron, steel, cobalt or nickel are called artificial magnets.

MAGNETIC AND NON-MAGNETIC SUBSTANCES

Magnetic substances: The substances which are strongly attracted by a magnet or can be converted into a magnet artificially are called magnetic substances.

Iron, Cobalt, Nickel, Steel or their alloys are magnetic substances.

A mixture of Ferric Oxide and Barium Oxide is strongly magnetic in nature. It is commonly called 'Ferrite'. It is used for making very powerful magnets for radios and transistors.

Non-magnetic substances: substances which are neither attracted by a magnet nor can be converted into artificial magnets are called non-magnetic substances.

Stones, China ware, glass, wood, paper, brass, aluminium, mica, ebonite, gold, silver, etc. are non-magnetic substances.

POLES OF A MAGNET

The ends of a magnet where most of its magnetic strength is acting are called magnetic poles.

North pole: The end of the freely suspended magnet, which points towards the geographic north is called north pole of the magnet.

South pole: The end of a freely suspended magnet, which points towards the geographic south is called south pole of the magnet.

PROPERTIES OF MAGNET:

The following are the properties of magnet:

1. A magnet attracts magnetic substances towards itself.
2. When a magnet is suspended freely, it point in north-south direction.
3. Like poles repel each other.
4. Opposite poles attract each other.
5. Repulsion is the surest test of magnetism.
6. When a bar magnet is rubbed over an unmagnetised piece of iron or steel, it changes into a magnet.
7. When a magnet is broken, then each piece is a complete magnet. The magnetic poles can not be separated.
8. Magnetic force can easily pass through non-magnetic substances.
9. If a magnet is heated or handled roughly, it loses its magnetism.

TEMPORARY AND PERMANENT MAGNETS

Temporary magnets: The magnets which cannot retain their magnetism for long time are called temporary magnets. For example, if soft is magnetised by rubbing with a steel magnet, it loses its magnetism, as soon as the rubbing is stopped. Similarly, electromagnets lose their magnetism, as soon as the current stops flowing through them.

Permanent magnets: The magnets which retain their magnetism for a very long time are called permanent magnets.

The permanent magnets are generally made from steel. More powerful permanent magnets are made from ALNICO, and alloy of Aluminium, Nickel and Cobalt. These days permanent magnets of different shapes and sizes are made from Ferrite.

MAGNETIC COMPASS

A magnetic compass is a simple device used by the pilots and navigators to find the direction in which their ship or aeroplane is going.

It consists of a flat circular aluminium box at the base of which are marked directions like North, South, East, West, North-East, North-West, etc. From its centre rises a sharp needle, over which is placed a magnetic needle. The magnetic needle is completely free to move in any direction. On the top of the box, is fixed a circular glass plate.

EARTH AS A HUGE BAR MAGNET

The earth acts as a hinge magnet. The geographic north pole of the earth lies the magnetic south pole of earth. Similarly, towards the geographic south pole of the earth, lies magnetic north pole of earth. The opposite poles of magnets attract each other. Thus, when a bar magnet is suspended freely, the south magnetic pole of the earth, attracts the north pole of the magnet and vice-versa. It is on account of this attraction of the earth's magnet, that a freely suspended magnet points in the north-south direction.

ELECTRICITY OR ELECTRIC CURRENT

There are two kinds of electrification. A body is said to be positively charged, if it has deficiency of electrons. Similarly, a body having excess of electrons is negatively charged. The flowing charge through a conductor is called electric current. A positive charge resides within the nucleus of an atom and therefore, is incapable of moving.

A conventional current flows from the positively charged body to the negatively charged body and the positively charged body is at higher potential and the negatively charged body is at a lower potential.

Electronic current flows from the negatively charged body to the positively charged body and the positively charged body is at a lower potential and the negatively charged body is at a higher potential.

ELECTRIC CELL

A cell is a device in which potential difference is maintained between its two terminals by the conversion of chemical energy into electrical energy.

SIMPLE VOLTAIC CELL

This cell was invented by alessandro volta in the year 1800. It was the first device which could create a constant potential difference with the help of chemical energy.

Construction: It consists of two metallic plates , one of copper and the other of zinc. These plates from which the current enters or leaves are called electrodes.

Each plate is provided with a brass terminal. The plates are placed in a glass container . Dilute sulphuric acid is used as an electrolyte. (Electrolyte is a chemical substance in solution form, which allows the passage of electric current.)

As soon as the circuit is completed the bulb glows.

Conventional current flows from copper to zinc through the bulb. The electronic current flows from zinc to copper through the bulb. The potential difference between the terminals of cell is 1.08 volts.

Limitations

This simple voltaic cell described above is a wet cell and cannot be carried from place to place. The current stops after few minutes due to inherent defects in this cell.

DANIELL CELL

This cell was developed by J.F. Daniell in 1836. It is a modification of the simple voltaic cell. This cell can supply a steady and continuous as long as the chemicals in it are not exhausted.

Construction

It consists of a cylindrical copper container provided with a perforated rim near the top and a brass terminal Into this container, is placed saturated copper sulphate solution which is in contact with copper sulphate crystals, placed on the perforated rim. In the copper sulphate solution, is placed a porous pot containing either zinc sulphate solution or dilute sulphuric acid. The porous pot does not allow the copper sulphate solution to mix with zinc sulphate solution or dilute sulphuric acid solution.

DRY LECLANCHE CELL

This cell is commonly used in torches, transistors etc. It was invented in 1865 by Leclanche Georges.

Construction:- It consists of a zinc cylinder, made from thick zinc plate. The zinc cylinder from outside is wrapped with a cardboard cylinder, so as to make its sides non-conducting. Nowadays, leak proof cells are provided with tin casing, which is painted from the outer side, so as to make it non-conducting.

BUTTON CELLS

Button cells are as small as buttons. They are commonly employed in small electronic devices, such as quartz wrist watches, calculators, mini-microphones, etc.

SECONDARY CELLS OR LEAD ACID CELLS

The cells such as simple voltaic cells, Daniell cell, Leclanche cell and button cell are called primary cells

A cell which converts chemical energy into electrical energy and cannot function once the chemicals are exhausted is called primary cell.

A cell in which electrical energy is stored in the form of chemical energy such that when required the chemical energy is reconverted into electrical energy is called secondary cell.

Secondary cell was invented in 1854 by a French scientist Gastonplante.

ELECTRIC CIRCUITS

The path along which an electric current flows is called electric circuit.

CLOSED CIRCUIT OR COMPLETE CIRCUIT

When the path which starts from one terminal of the cell, ends at the other terminal of the cell, without any break, then such a circuit is called a complete circuit or closed circuit. When a circuit is closed, then any electric appliance in that circuit will start working.

OPEN CIRCUIT OR INCOMPLETE CIRCUIT

When the path of current, starting from one terminal of the cell, ends at the other terminal of the cell is broken at some point, then such a circuit is called open circuit or incomplete circuit.

CONDUCTORS: Materials which allow the electric current to flow through them are called electric conductors.

Examples :

1. All metals are conductors of electricity.

2. Non-metals like graphite and gas carbon are conductors of electricity.
3. All solutions of acids in water are conductors of electricity.
4. All solutions of alkalis in water are conductors of electricity.
5. All solutions of salts in water are conductors of electricity.

INSULATORS: Materials which do not allow the electric current to flow through them are called electric insulators.

Examples:

Rubber, plastics, wood, paper, mica, asbestos, petrol, kerosene oil, diesel oil, wax, alcohol, benzene, etc. are insulators.

The branch of physics which deals with the relationship between electricity and magnetism is called electromagnetism.

A coil with a core of iron nail or an iron bar which acts a magnet only, when electric current flows around iron nail or an iron bar is called electromagnet.

PRACTICAL USES OF ELECTROMAGNETS

1. They are used in electrical appliances, such as electric bell, electric fan, electric motor etc.
2. They are used in electric generators where very strong magnetic field is required.
3. They are used in television for deflecting electron beam of the picture tube.
4. They are used in magnetic separation of iron ores from earthy substances.
5. They are used for preparing strong permanent magnets.
6. They are used by doctors to cure certain diseases.

The electric bell: electric bell is a direct application of the electromagnets. It consists of the following parts which are fitted on a flat wooden or plastic board.

ELECTROMAGNETIC INDUCTION

An electric current flowing through a conductor produces magnetic field. Furthermore, the intensity of magnetic field increases with the increase in the magnitude of electric current in the conductor.

When a magnetic field is changed near a conductor, a current is produced in it. This fact was independently discovered in 1831, by Michael Faraday in England and Joseph Henry in United States of America.

FARADAY'S EXPERIMENT

1. Whenever the magnet is moved with respect to coil, i.e. the strength of magnetic field changes within the coil, an induced current is produced in the coil.
2. The induced current is not produced in a coil, if the motion of the magnet with respect to coil stops, i.e. the strength of magnetic field stops changing within the coil.
3. The direction of induced current produced in the coil changes with the increase or decrease of magnetic field. It means that when magnetic lines of forces are increasing within the coil, then the current flows in one particular direction. However, if the magnetic lines of forces decrease, then the current flows in the opposite direction.
4. The induced current produced within the coil is alternating in the magnetic lines of force passing through coil. Such current is commonly called A.C. which means alternating current.
5. The induced current produced is instantaneous in nature. It means it lasts for very short duration.

ELECTROMAGNETIC INDUCTION: Phenomenon due to which a changing magnetic field within a closed coil induces an electric current in the coil is called electromagnetic induction.

Induced current: Current produced in a closed coil, when the magnetic lines of force rapidly change within it, is called induced current. The principle of electromagnetic induction is used in generating electric current by a device called electric generator.

Magnitude of induced current depends upon:

(i) Strength of inducing magnet.
(ii) Number of turns in the coil.
(iii) Relative motion of magnet with respect to coil.

SCIENTIFIC INSTRUMENTS

Name of Instrument	Use
Altimeter	Measures altitudes (used in aircraft)
Ammeter	Measures strength of electric current
Anemometer	Measures force and velocity of wind and determines its directions
Audiometer	Measures intensity of sound
Barograph	Continuous recording of atmospheric pressure
Barometer	Measures atmospheric pressure
Binoculars	To view distant obejcts
Callipers	Measure inner and outer diameters of bodies
Calorimeter	Measures quantities of heat
Dilatometer	Measures changes in volume of substances
Dyanamo	To convert mechanical energy into electrical energy
Dynamometer	Measures electrical power
Electrometer	Measures very small but potential difference in electric currents
Electroscope	Detects presence of an electric change
Electromicroscope	To obtaing a magnifying view of very small objects capable of magnifying up to 20,000 times
Endoscope	To examine internal parts of the body
Galvanometer	Measures electric current
Hydrometer	Measures the relative density of liquids
Hygrometer	Measures level of humidity
Hypsometer	To determine boiling point of liquids
Lactometer	Measures the relative density of milk to determine purity
Magnetometer	Compares magnetic movements and fields
Micrometer	Measures distances/angles
Microphone	Converts sound waves into electrical vibrations
Microscope	To obtain a magnified view of small objects
Periscope	To view objects above sea level (used in submarines)
Radar	To detect the direction and range of an approaching aeroplane by means of radiowaves,(Radio, Angle, Detection and Range)
Spectroscope	To observe or record spectra
Stereoscope	To view two-dimensional pictures
Teleprinter	Receives and sends typed messages from one place to another
Telescope	To view distant obejcts in space
Thermometer	Temperature is measured by determining the electrical resistance of a coil of thin wire
Thermostat	Regulates the temperature to a particular point
Voltmeter	To measure electric potential difference between two points

INVENTIONS

Invention	Inventor	Country	Year
Aeroplane	Wright brothers	USA	1642
Ball-point pen	C. Biro	Hungary	1938
Barometer	E. Torricelli	Italy	1644
Bicycle	K. Macmillan	Scotland	1839
Calculating machine	Pascal	France	1642
Centrigrade scale	A Celsius	France	1742
Cinematograph	Thomas Alva Edison	USA	1891
Computer	Charles Babbage	Britain	1834
Cine camera	Friese-Greene	Britain	1889
Cinema	A.L. and J.L. Lumiere	France	1895
Clock (machanical)	Hsing and Ling-Tsan	China	1725
Clock (pendulum)	C. Hugyens	Netherlands	1657
Diesel engine	Rudolf Diesel	Germany	1892
Dynamite	Alfred Nobel	Sweden	1867
Dynamo	Michael Faraday	England	1831
Electric iron	H.W.Seeley	USA	1882
Electric lamp	Thomas Alva Edison	USA	1879
Electromagnet	W. Sturgeon	England	1824
Evolution (theory)	Charles Darwin	England	1858
Fountain Pen	Waterman	USA	1884
Gas lighting	William Murdoch	Scotland	1794
Jet Engine	Sir Frank Whittle	England	1937
Locomotive	Richared Trevithick	England	1804
Match (safety)	J. E. Lurdstrom	Sweden	1855
Microphone	David Hughes	USA	1878
Microscope	Z. Jansen	Netherlands	1590
Motorcycle	Edward Butler	England	1884
Neon-lamp	G. Claude	France	1915
Nylon	Dr W.H. Carothers	USA	1937
Photography (paper)	W.H. Fox Tablot	England	1835
Printing press	J. Gutenberg	Gemany	1455
Radar	Dr A. H.Taylor and L.C Young	USA	1922
Radium	Marie and Pierre Curie	Fance	1898
Radio	G. Marconi	England	1901
Razor (safety)	K.G. Gillette	USA	1895
Refrigerator	J. Harrison and A. Catlin	Britain	1834
Revolver	Samuel Colt	USA	1835
Rubber (vulcanized)	Charles Goodyear	USA	1841
Sewing machine	B. Thimmonnier	France	1830
Scooter	G . Bradshaw	England	1919
Steam engine (piston)	Thomas Newcome	Britain	1712
Telephone	Alexander Graham Bell	USA	1837
Television	Johan Logie Bared	Scothland	1926
Thermometer	Galileo Galilei	Italy	1539
Tractor	J. Froelich	USA	1892
Transistor	Bardeen, Shockley	USA &Britain	1949
Typewriter	C.Sholes	USA	1868
Watch	A.L. Breguet	France	1791

IMPORTANT DISCOVERIES

Discovery	Scientist	Year
Proton	Rutherford	1919
Neutron	James Chadwick	1932
Atom	John Dalton	1808
Atomic Structure	Neil Bohr & Rutherford	1913
Radioactivity	Henry Becquerel	1896
Radium	Madam Curie	1898
Raman Effect	C.V. Raman	1928
X-Rays	Roentgen	1895
Photoelectric effect	Albert Einstein	1905
Periodic table	Mandeleev	1888
Nuclear Reactor	Anrico Fermi	1942
Wireless Telegram	Marconi	1901
Dynamite	Alfred Nobel	1867

PREVIOUS YEAR QUESTIONS

1. A good conductor while carrying current is
   (A) alternatively charged positive and negative.
   (B) negatively charged
   (C) positively charged
   (D) electrically neutral
2. The angle between the magnetic meridian and the geographical meridian at a place is
   (A) Azimuthal (B) Dip
   (C) Declination (D) Latitude
3. The device used for measuring the wavelength of X-rays is
   (A) G.M. Counter
   (B) Cyclotron
   (C) Bragg Spectrometer
   (D) Mass Spectrometer
4. The atmospheric layer farthest from the Earth's surface is known as
   (A) Ionosphere (B) Mesosphere
   (C) Stratosphere (D) Exosphere
5. Photon is the fundamental unit/ quantum of
   (A) magnetism (B) light
   (C) gravitation (D) electricity
6. A liquid disturbed by stirring comes to rest due to
   (A) viscosity
   (B) centripetal force
   (C) density
   (D) surface tension
7. The ambient air is stable when the ambient laps rate is
   (A) Sub-adiabatic
   (B) Super-adiabatic
   (C) Neutrally stable
   (D) Hyper-adiabatic
8. The filter over which sewage is sprinkled is called as
   (A) Contact bed
   (B) Intermittent sand filter
   (C) Trickling filter
   (D) Percolating filter
9. Which one of the following atmospheric layers absorbs ultraviolet rays of the sun?
   (A) Troposphere (B) Stratosphere
   (C) Ionosphere (D) Ozonosphere
10. In nuclear reactions, there is conservation of
    (A) mass only
    (B) momentum only
    (C) energy only
    (D) mass, energy and momentum
11. When a particle and an antiparticle come in contact with each other, they
    (A) repel each other
    (B) annihilate each other
    (C) go undisturbed
    (D) spin about a common axis
12. Photoelectric effect is
    (A) an instantaneous process
    (B) delayed process
    (C) emission of protons
    (D) emission of neutrons
13. For a particle moving with a constant speed along a straight line PQ, the hodograph is
    (A) a straight line parallel to PQ
    (B) a straight line perpendicular to PQ
    (C) a point
    (D) a circle

14. Scattering of light takes place in
(A) Colloidal solution
(B) Acidic solutions
(C) Electrolyte solutions
(D) Basic solutions

15. In Astrophysics, the name which is given to a hypothetical hole in outer space from which stars and energy emerge is–
(A) Black hole (B) Ozone hole
(C) Asteroid belt (D) White hole

16. Neutrons are slowed down in a nuclear reactor by
(A) Fissionable material
(B) Moderator
(C) Control rods
(D) Cooling system

17. Centigrade and Fahrenheit temperatures are the same at
(A) -40^0 (B) 32^0
(C) 40^0 (D) -273^0

18. The dimensional formula for universal gravitational constant is
(A) $M^{-1}L^3T^{-2}$ (B) $M^{-1}L^3T^2$
(C) ML^2T^{-2} (D) M^{-2}

19. Ohm's law is valid in case of
(A) insulator (B) semiconductor
(C) conductor (D) superconductor

20. The Laser is a beam of radiations which are
(A) Coherent and non-monochromatic
(B) Non-coherent and monochromatic
(C) Coherent and monochromatic
(D) Non-coherent and non-monochromatic

21. The mass of a body measured by a physical balance in a lift at rest is found to be 'm'. If the lift is going up with an acceleartion 'a', its mass will be–
(A) zero (B) $m\left(1-\frac{a}{g}\right)$
(C) $m\left(1+\frac{a}{g}\right)$ (D) m

22. A white and smooth surface is
(A) bad absorber and bad reflector of heat
(B) good absorber and good reflector of heat
(C) bad absorber and good reflector of heat
(D) good absorber and bad reflector of heat

23. When a body is immersed in a liquid, the force acting on it is
(A) Upthrust (B) Weight
(C) Mass (D) Both (A) and (B)

24. When two semiconductors of p- and n-type are brought in contact, they form p-n junction which acts like a/an
(A) Amplifier (B) Conductor
(C) Oscillator (D) Rectifier

25. Which one among the following doesn't have any effect on velocity of sound?
(A) Pressure (B) Temperature
(C) Humidity (D) Density

26. The motion of a body around a circular path is an example of
(A) Uniform velocity, variable acceleration
(B) Uniform speed, uniform velocity
(C) Uniform speed, varible velocity
(D) Uniform speed, variable acceleration

27. A current carrying conductor is associated with
(A) a magnetic field
(B) an electric field
(C) an electro-magnetic field
(D) an electrostatic field

28. One kilobit is equal to ____ bits
(A) 512 (B) 1000
(C) 1024 (D) 1042

29. Hydrogen bomb is based on the principle of
(A) Double decomposition
(B) Artificial radioactivity
(C) Nuclear fission
(D) Nuclear fusion

30. The commonly used safety fuse-wire is made of
(A) an alloy of Nickel and Lead
(B) an alloy of Tin and Lead
(C) an alloy of Tin and Nickel
(D) an alloy of Lead and Iron

31. At what temperature is the density of water the maximum?
(A) 2°C (B) 4°C
(C) 0°C (D) 1°C

32. The linear expansion of a solid rod is independent of–
(A) increase in temperature
(B) time of heat flow
(C) its initial length
(D) its material

33. Cathode rays when obstructed by metal cause emission of
(A) γ–rays (B) X–rays
(C) α–rays (D) β–rays

34. Temperature is measured by the instrument called
(A) Voltmeter (B) Calorimeter
(C) Thermometer (D) Ammeter

35. Good conductors have many loosely bound
(A) atoms (B) electrons
(C) protons (D) neutrons

36. A change of 10°C in Centigrade Scale corresponds to what change in Fahrenheit scale?
(A) 10°F (B) 15°F
(C) 18°F (D) 21°F

37. Anomalous expansion is associated with
(A) Alcohol (B) Mercury
(C) Water (D) Benzene

38. What type of lenses are used in movie projectors?
(A) Concave (B) Convex
(C) Zoom lens (D) Meniscus lens

39. Magnetic keepers are used to protect magnets from:
(A) Earth's magnetic field
(B) effect of other magnets
(C) self-demagnetization
(D) demagnetization due to heating

40. An object which absorbs all the colours and reflects none appears:
(A) white (B) grey
(C) blue (D) black

41. The splitting of white light into its components is due to :
(A) reflection (B) refraction
(C) transmission (D) dispersion

42. A small drop of oil spreads over water because :
(A) oil has a higher surface tension
(B) water has a higher surface tension
(C) oil has a higher viscosity
(D) water has a higher viscosity

43. Radiations which is not emitted during radioactivity is:
(A) α rays (B) β rays
(C) γ rays (D) Cathode rays

44. The working principle of a beam balance is the principle of:
(A) Momentum (B) Moments
(C) Couple (D) Mass

45. Which one among the following given processes cannot be demonstrated with sound wave?
(A) Polarisation (B) Interference
(C) Transmission (D) Refraction

46. A simple machine cannot:
(A) multiply speed
(B) multiply work
(C) change the direction of applied force
(D) multiply force

47. The photoelectric effect described as the ejection of electrons from the surface of a metal when
(A) It is heated.
(B) It is placed in strong electric field.
(C) Electrons of suitable velocity impinge on it.
(D) Light of suitable wavelength falls on it.

48. X-rays are _______ waves.
(A) longitudinal
(B) transverse
(C) electromagnetic
(D) elastic

49. The shape of a rain drop is spherical due to
(A) Viscosity
(B) Surface tension
(C) Elasticity
(D) Gravitation

50. The penetrating powers of α, β and γ radiations, in decreasing order, are
(A) α, β, γ (B) γ, β, α
(C) β, α, γ (D) γ, α, β

51. Dioptre is the unit of
(A) power of a lens
(B) focal length of a lens
(C) light intensity
(D) sound intensity

52. In a filament type light bulb, most of the electric power consumed appears as
(A) visible light
(B) infra-red rays
(C) ultra-violet rays
(D) fluorescent light

53. A man standing on a edge of a cliff throws a stone vertically upwards with a certain speed. He then throws another stone downwards with the same speed. Find the ratio of the speeds of the two stones, when they hit the ground.
(A) 1 : 1
(B) 1 : 2
(C) 1 : 4
(D) Cannot be found from the given information

54. Which of the following is *not* caused by atmospheric refraction of light ?
(A) Sun appearing red at sunset
(B) Twinkling of stars at night
(C) Sun appearing higher in the sky than it actually is
(D) Sun becoming visible two or three minutes before actual sunrise

55. Matter waves are
(A) de Broglie waves
(B) Electromagnetic waves
(C) Transverse waves
(D) Longitudinal waves

56. When the milk is churned vigorously the cream from it is separated out due to
(A) Centripetal force
(B) Gravitational force
(C) Frictional force
(D) Centrifugal force

57. Gas thermometers are more sensitive than the liquid thermometers because the gases
(A) have large coefficient of expansion
(B) are lighter
(C) have low specific heat
(D) have high specific heat

58. A body moving in a circular path with constant speed has
(A) constant retardation
(B) constant acceleration
(C) variable acceleration
(D) radially outward acceleration

59. Total internal reflection occurs when light travel from
(A) a rarer medium to a denser medium
(B) a denser medium to a rarer medium
(C) a rarer medium to a denser medium with angle of incidence greater than critical angle
(D) a denser medium to a rarer medium with angle of incidence greater than critical angle

60. MCB, which cuts off the electricity supply in case of short-circuiting works on the
(A) chemical effect of current
(B) heating effect of current
(C) magnetic effect of current
(D) electroplating effect of current

61. The power of a lens is measured in :
(A) diopters (B) aeon
(C) lumen (D) candela

62. Which one of the following types of Laser is used in Laser Printers?
(A) Semiconductor laser
(B) Excimer Laser
(C) Dye Laser
(D) Gas Laser

63. Albert Einstein was awarded Nobel Prize for his path-breaking research and formulation of the:
(A) Theory of Relavitity
(B) Laws of Photo-Electric Effect
(C) Principle of Wave-Particle Duality
(D) Theory of Critical Opalescence

64. The instrument that measures arterial blood pressure is known as
(A) Pyknometer
(B) Hypsometer
(C) Sphygmoscope
(D) Sphygmomanometer

65. Which variety of glass is heat resistant?
(A) Hard glass (B) Flint glass
(C) Pyrex glass (D) Bottle glass

66. The type of glass used in making prisms and lenses is -
(A) Soft glass (B) Pyrex glass
(C) Jena glass (D) Flint glass

67. The most important property of nanomaterials is_____.
(A) force (B) friction
(C) pressure (D) temperature

68. The refractive index of a rarer medium with respect to a denser medium is_____.
(A) 1 (B) greater than 1
(C) smaller than 1 (D) negative

69. _____ is not a primary colour of white light.
(A) Red (B) Blue
(C) Violet (D) Green

70. Work done on an electric charge is stored in it as_____.
(A) potential energy
(B) kinetic energy
(C) thermal energy
(D) nuclear energy

71. Which of the following is not correct for electrical work?
(A) $W = VQ$ (B) $W = VIt$
(C) $W = I^2Rt$ (D) $W = I^2RQ$

72. How many electrons should flow in one second to contribute electric current of 1 ampere?
(A) 6.25×10^{18} (B) 6.25×10^{19}
(C) 1.60×10^{18} (D) 1.60×10^{18}

73. The magnetic field of a solenoid is quite similar to that of_____
(A) a straight conductor
(B) a horse-shoe magnet
(C) a bar magnet
(D) magnetic needle

74. The insulation cover on the earth wire is_____.
(A) red (B) black
(C) green (D) white

75. _____ is the unit of frequency of alternating current.
(A) Weber (B) Hertz
(C) Tesla (D) Ampere

76. A rocket works on the principle of_____.
(A) Newton's first law of motion
(B) Newton's second law of motion
(C) Newton's third law of motion
(D) First law of thermodynamics

77. Who was the first scientist to observe the magnetic effect of electric current?
(A) Faraday (B) Ampere
(C) Oersted (D) Volta

78. The direction of magnetic field lines is taken...
(A) north pole to south pole
(B) south pole to north pole
(C) entering both poles
(D) leaving both poles

79. The insulation cover on live wire is...
(A) red (B) black
(C) green (D) white

80. When resistors are connected in series...
(A) voltage drop is uniform
(B) current is uniform
(C) both voltage and current are uniform
(D) neither of the two is uniform

81. 1 A = ______ mA.
(A) 100 (B) 1000
(C) 10(-3) (D) 106

82. Equivalent resistance of resistances in parallel is–
(A) smaller than the smallest resistance
(B) greater than the greatest resistance
(C) an average of all resistances
(D) algebraic sum of all resistances

83. Arranging in the ascending order of wavelength, which one is true ?
(A) Blue, Green, Red
(B) Orange, Green, Red
(C) Blue, Yellow, Green
(D) Orange, Yellow, Green

84. Green + Magenta = ______.
(A) Cyan (B) Yellow
(C) Red (D) White

85. In spectrum obtained with prism, which colour is deviated maximum ?
(A) Violet (B) Green
(C) Orange (D) Red

86. The speed of light is ______ in vacuum.
(A) 3×10^5 m/s (B) 3×10^8 m/s
(C) 3×10^8 km/s (D) 3×10^6 km/s

87. We can see objects because of ______.
(A) reflection (B) refraction
(C) transmission (D) dispersion

88. Which of the following is a true statement?
(A) The power of a lens is always positive.
(B) The power of a lens is always negative.
(C) The power of a convex lens is positive.
(D) The power of a concave lens is positive.

89. The cut-off limit of human eye to see is ______.
(A) 1 nm (B) 100 nm
(C) 1000 nm (D) 10000 nm

90. Magnification for convex mirror is ______.
(A) always positive & less than one
(B) always negative
(C) 0
(D) 1

91. Who had patented more than 1000 inventions during his life time ?
(A) Edison (B) Volta
(C) Ampere (D) Faraday

92. Which of the following is not correct ?
(A) P = W/t (B) $P = I^2R$
(C) P = WI (D) P = VI

93. 1 eV = ______ Joule.
(A) $1.6 \times 10^{(-17)}$ (B) $1.6 \times 10^{(-18)}$
(C) $1.6 \times 10^{(-19)}$ (D) $1.6 \times 10^{(-20)}$

94. The stars appearing ______ have very high/highest temperature.
(A) red (B) blue
(C) white (D) yellow

95. The mirror formula is ______.
(A) $\frac{1}{u} - \frac{1}{v} = \frac{1}{f}$ (B) $\frac{1}{f} - \frac{1}{u} = \frac{1}{v}$
(C) $f = \frac{uv}{u+v}$ (D) $f = \frac{u+v}{uv}$

96. In a transparent medium, the velocity of ______ light is the least.
(A) red (B) green
(C) yellow (D) violet

97. 1 unit of domestic electric energy is equal to...

(A) 1 joule (B) 1 watt-second

(C) 3.6×10^6J (D) 3.6 x 106 kwh

98. The current passing through two separate lines(circuits) of our houses is ______ A and ______ A.

(A) 5,10 (B) 5,15

(C) 10,15 (D) 2,5

99 ______ is used for manufacturing scientific balance.

(A) Steel

(B) Brass

(C) Stainless steel

(D) Magnalium

100. The mass of earth is ______ times the mass of mercury.

(A) 10 (B) 14

(C) 18 (D) 22

101. The equivalent resistance of three resistors, each of 6 Ω, connected in parallel is ______.

(A) 6 Ω (B) 18 Ω

(C) 2 Ω (D) 0.5 Ω

102. What is the frequency of current used domestically in India ?

(A) 50 Hz

(B) 60 Hz

(C) 110 Hz

(D) 220 Hz

103. The principle of magnetic induction was given by ______.

(A) Faraday (B) Galileo

(C) Oersted (D) Ampere

104. 1 nanometer = ______ cm.

(A) 10^{-9} (B) 10^{-8}

(C) 10^{-7} (D) 10^{-6}

105. For a plane mirror, magnification (m) = ______.

(A) 0 (B) 1

(C) +1 or -1 (D) < 1

106. Blue + Green (light) = ______.

(A) Magenta

(B) Cyan

(C) Yellow

(D) Violet

ANSWER KEY

1. (D)	2. (C)	3. (C)	4. (D)	5. (B)	6. (A)	7. (A)	8. (C)	9. (B)	10. (B)
11. (B)	12. (A)	13. (A)	14. (A)	15. (D)	16. (B)	17. (A)	18. (A)	19. (C)	20. (C)
21. (D)	22. (C)	23. (D)	24. (D)	25. (A)	26. (C,D)	27. (D)	28. (C)	29. (D)	30. (B)
31. (B)	32. (B)	33. (C)	34. (C)	35. (B)	36. (C)	37. (C)	38. (B)	39. (B)	40. (D)
41. (D)	42. (B)	43. (D)	44. (A)	45. (A)	46. (B)	47. (D)	48. (C)	49. (B)	50. (B)
51. (A)	52. (B)	53. (A)	54. (A)	55. (A)	56. (D)	57. (A)	58. (C)	59. (D)	60. (C)
61. (A)	62. (A)	63. (B)	64. (D)	65. (C)	66. (D)	67. (B)	68. (B)	69. (C)	70. (A)
71. (D)	72. (A)	73. (C)	74. (C)	75. (B)	76. (C)	77. (C)	78. (A)	79. (A)	80. (B)
81. (B)	82. (A)	83. (A)	84. (B)	85. (A)	86. (B)	87. (A)	88. (C)	89. (C)	90. (A)
91. (A)	92. (C)	93. (C)	94. (B)	95. (B,C)	96. (D)	97. (C)	98. (B)	99. (D)	100. (C)
101. (C)	102. (A)	103. (A)	104. (C)	105. (B)	106. (B)				