MOTION SAMPLE BOOKLET CLASS VIII

- FORCE & PRESSURE
- METALS & NON-METALS
- CELL & TISSUE
- RATIONAL NUMBERS & RADICALS
- FROM TRADE TO TERROTORY

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MOTION
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CLASS - VIII

THEORY AND EXERCISE BOOKLET

CONTENTS

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FORCE & PRESSURE

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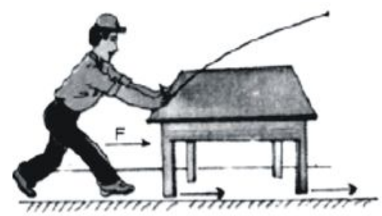
FORCE & PRESSURE

INTRODUCTION

We use force all the time. We use force to open a door, to pick up the school bag, to brush our teeth, to squeeze out toothpaste from a tube, to turn on a tap and so on. Even the earth is exerting a force on us all time. It is pulling all of us and all things on earth towards it.In fact we use force for every single action of ours! You have studied about force in previous classes.

Do you remember what a force is ?



A person pushing a table

FORCE

The external agent which tends to set a body in motion or which changes the speed and direction of motion of a body or which can change the shape of a body is called force.

(i) To push or to pull is also called as force.

(ii) It is a vector quantity

UNIT OF FORCE

(i) The SI unit (in standard international system) of force is called Newton and its symbol is **N** (kg × m/sec^2)

(ii) C.G.S unit of force is dynes (gm cm/s^2)

1 Newton = 10^5 dynes,

1 N = kg – m/s^2

= 1(1000 gm) (100 cm/s^2)

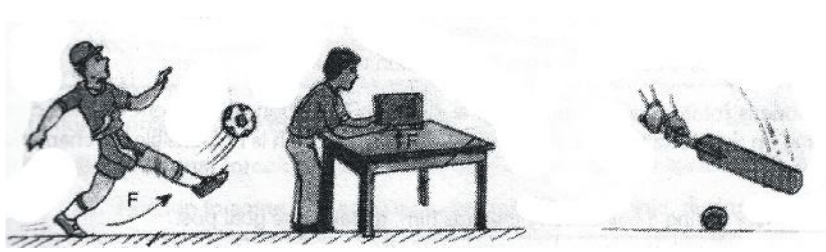
= 10^5 gm–cm/s^2

So that 1 N = 10^5 dyne

EFFECT OF FORCE

1. FORCE CAN MOVE A BODY LYING AT REST

Example :



Force exerting on bodies to move them from rest

(a) Kicking a stationary football. **(b)** Lifting a book kept on a table top.

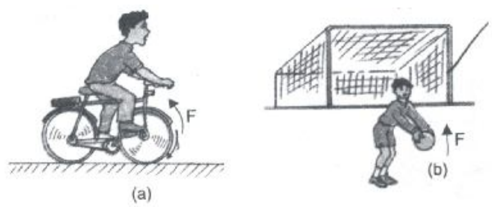
(c) Hitting a stationary ball with a bat.

2. FORCE CAN STOP A MOVING BODY

Example :

(a) A goalkeeper stopping a football moving towards the goal post.

(b) A moving bicycle coming to rest on applying brakes. Here the frictional force between the brake lining of the brake shoe and the bicycle wheel rim, acts to stop the bicycle.



Force exerted to stop a moving body

3. FORCE CAN CHANGE THE SPEED OF A MOVING BODY

Ex. To decrease speed, force is applied in a direction which is opposite to the motion of the body. If we apply force in the direction of motion of the body, it tends to increase the speed of the body. For example, if your friend is riding a bicycle and you push the bicycle in the same direction. The speed of bicycle will increase. On the other hand if you pull the bicycle, i.e., you apply force against the direction of motion, the speed of bicycle decreases.

(a) Force exerted in the direction of velocity (b) Force exerted in opposite direction of velocity

4. FORCE CAN CHANGE THE DIRECTION OF A MOVING BODY

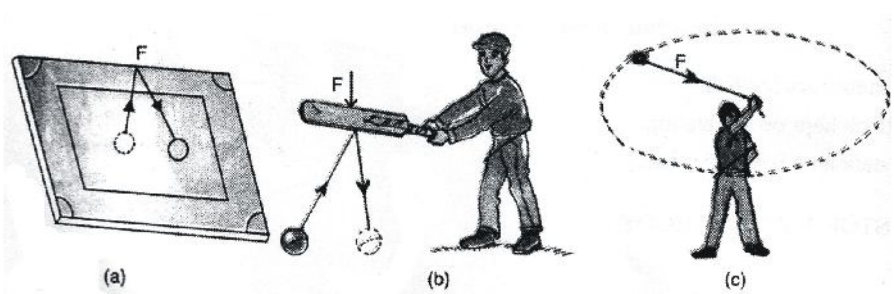
Example :

(a) A carrom counter changes its direction after a collision.

(b) When a batsman hits a ball, he changes the direction of the ball.

(c) When a stone is rotated in a circular path, the direction of motion of the stone change continuously. The force acting on the stone towards the centre of the circular path is responsible for changing the direction of the stone.

(d) A football player hitting a ball coming towards him, towards the goal post.



Force exerted to change the direction of a moving body

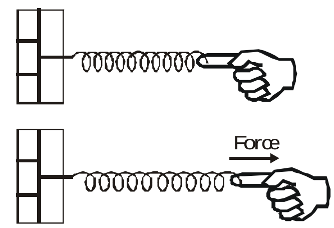
5. FORCE CAN CHANGE THE SHAPE AND SIZE OF AN OBJECT

Example :

(a) When we squeeze a toothpaste tube, it gets flattened.

(b) When we stretch a rubber band, its shape and size changes.

(c) On stretching a spring, its length changes.



Force exerted to stretch a spring

6. FORCE CAN MAKE A BODY ROTATE.

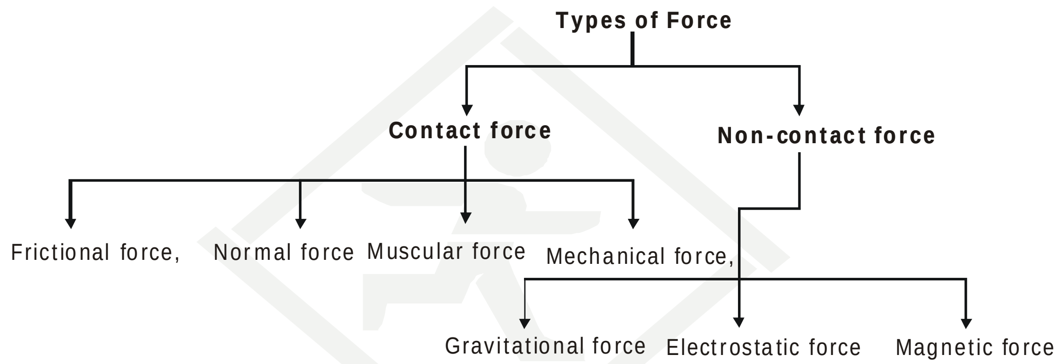
Example :

(a) When electric current is passed through a motor of a ceiling fan, forces are produced in the dynamo (or motor) which makes the fan to rotate.

(b) For closing a door you apply a push.

To conclude → a force can accelerate a body, change its shape and size or can produce a rotational effect.

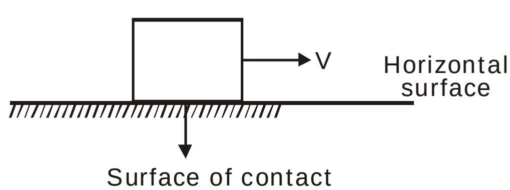
TYPES OF FORCE



(A) CONTACT FORCE : When a force involves direct contact of two bodies we call the force a contact force.

(i) FRICTIONAL FORCE :– The force which acts to reduce relative motion between the surfaces of contact is called the frictional force.

Suppose a block is moving on a horizontal surface with a velocity v. The darkened line at the bottom of the block is the surface of contact of the block with floor. We notice that this surface of contact is moving towards right with respect to the horizontal surface. To reducing this relative motion, frictional force acts. Frictional force is exerted by the floor on the block in a direction opposite to velocity.



NOTE : Friction force : (i) Frictional force acts in a direction opposite to that of the motion

(ii) The smoother the surface the lesser is the frictional force.

- **Static friction :** Which acts when a body is stationary.
- **Kinetic friction :** Which acts when a body is moving.

(ii) NORMAL FORCE : The force acting on a body perpendicular to the surface of contact is called a normal force.

NOTE : Tension and spring force are also contact forces.

(iii) MUSCULAR FORCE : The force resulting due to the action of muscles is known as the muscular force. Animals also make use of muscular force to carry out their physical activities and other tasks. Animals like bullocks, horses, donkey and camels are used to perform various tasks for us. In performing these tasks they use muscular force. Since muscular force can be applied only when it is in contact with an object. This force is also known as Biological force.

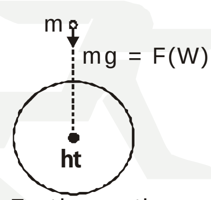
(iv) MECHANICAL FORCE : The force exerted by a machine is called mechanical force. Machines do not produce force by themselves. In order to produce force they need energy from other sources. Mechanical force produced by a car engine, and mechanical force produced by the turbines in a hydroelectric power station are examples of Mechanical force.

(B) NON-CONTACT FORCE

The force which a body applies on another body when the two bodies are not in contact with each other is called non-contact force.

(i) GRAVITATIONAL FORCE : The force of attraction which one body exerts on the other because of their masses is called gravitational force.

Gravitational force is the weakest force in nature and still this force is responsible for the revolution of earth around the sun.



Earth exerting gravitational force on mass m

Force of gravity on a body is equal to the true weight of the body.

The force with which earth attracts a body is called the force of gravity. A body of mass m is attracted by earth towards its centre. This force is also called the weight (W) of the body.

$$\boxed{W = mg}$$

(ii) ELECTROSTATIC FORCE : The force which results due to the repulsion of similar charges or attraction of opposite charges is called electrostatic force. If we rub a plastic object like a pen or a comb with hair and bring it close to tiny bits of paper, the bits of paper get attracted to the plastic object. This is due to electric force. Tiny particles of dust and smoke can also be attracted by electrostatic force. This method is used in air purifiers and in factories to purify air in chimneys, before letting it escape into the atmosphere.

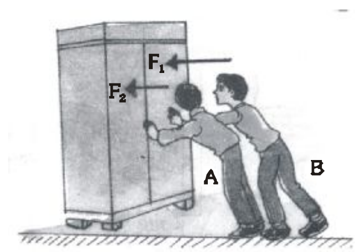
(iii) MAGNETIC FORCE : This is the force exerted by magnets on each other and on some metals like iron and nickel. Since magnets attract iron, magnets are used to separate waste iron object form garbage dumps so that they can be recycled. Magnetic force and electrostatic force are inter-related and are together called electro-magnetic force.

RESULTANT FORCE

If a single force acting on a body produces the same acceleration as produced by a number of forces, then single force is called the resultant of these individual forces.

The resultant force is also called the net force.

Ex. Suppose an almirah is being pushed by two persons A and B. Let the force applied by A be F_1 = 2N and that by B be F_2 = 3N. These two forces together will result in some displacement of the almirah in a given time. In another situation, a person C is pushing the same almirah kept initially in the position as that of the previous situation. The person C is applying a force F = 5N in the same direction as that of A and B.

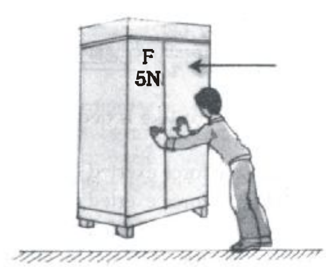


Two persons pushing an almirah

BALANCED FORCES

When the force acting on a body cancel out the effects of each other in such a way that the resulting force is zero, then these forces are said to be balanced.

Ex. Let us consider a rigid almirah kept at rest on a horizontal surface. Let two forces F_1 and F_2 act simultaneously on the almirah from opposite directions. If the two forces are equal, the effects produced by one force get cancelled by the effect produced by the other. The net force or the resultant force is then zero. The almirah continues to remain at rest. When a numbers of forces acting on a body do not cause any change in its state of rest, or of uniform motion is a straight line then the force are said to be balanced forces.



One person pushing an almirah

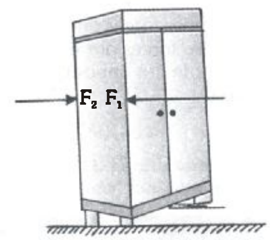
UNBALANCED FORCES

If number of forces acting on a body produce an acceleration in the body, then the forces acting are called unbalanced.

Ex. Suppose F_1 = 5 Newton and F_2 = 3 Newton. In this case a resultant force is acting on the almirah towards the direction of F_1. We say that an unbalanced force of 2 Newton will act on the almirah towards the direction of F_1.

If forces acting on an object are balanced → An object at rest, remains at rest ($a = 0$)
→ An object in motion remains in motion with the same velocity ($a = 0$)

If forces acting on an object are unbalanced → Object is accelerating (Acceleration depends on) unbalanced force and mass of the object



Two opposing forces acting on the almirah

NEWTON'S LAWS OF MOTION

(A) **Newton´s I law :** A body cannot change its state of motion by itself. If the object is at rest it will remain at rest and if it is in uniform motion, it continues to be in motion unless some external force is applied on it.

Inertia :

(i) There is an inherent property of an object by virtue of which it cannot change its state of motion or rest by if self. This property is called 'inertia'.

(ii) Inertia is of two types– inertia of rest and inertia of motion.

(a) **Inertia of rest:** If the body is at rest, it will continue to be at rest unless some external force is applied on it. Examples are following.

(i) When a train at rest starts moving suddenly, a passenger standing inside the compartment tends to fall backward.

(ii) When a carpet is beaten up with a stick, the dust particles are detached.

(iii) When a bullet is fired into a glass pane, it pierces a hole only at the pt where the bullet hits the glass without breaking the entire glass pane into pieces.

(b) **Inertia of motion :** When a body is in uniform motion, it will continue to remain in its uniform motion, i.e. it resists any change in its state of motion due to inertia of motion.

(i) When a person jumps out of a moving bus, he should run in the direction in which bus is moving otherwise he will fall down.

(ii) A train moving with a uniform speed and if a ball is thrown upwards inside the train by a passenger, then the ball comes back to his hand.

Mass and Inertia :

(i) Larger the mass of the body, larger is the inertia.
eg. it is more difficult to stop a cricket ball than a tennis ball.

(B) **Newton's second law of motion**

Force F is equal to the product of mass, m of a body and acceleration, a produced in the body due to that force. i.e. $F = ma$

Acceleration: Acceleration is the rate of change of velocity.

$$a = \frac{v - u}{t} = \frac{\text{final velocity} - \text{initial velocity}}{\text{time}}$$

Newton's second law can be written as $F = ma = \left[\frac{\varepsilon}{\ }\right]$

Note: Newton's first law of motion gives a qualitative idea of force, while the second law provides us an idea to measure the force.

(C) Newton's third law of motion

(i) Newton's third law of motion states that " if a body A exerts a force on the body B, the body B will also exert an equal and opposite force on A."

(ii) The force exerted by A on B is called action while the force exerted by B on A is called the reaction.

(iii) Newton's third law is also stated as "to every action there is an equal and opposite reaction."

(iv) Action and reaction always act on different bodies.

Applications of Newton's III law :

(i) Recoil of a gun : where the bullet is fired from a gun, an equal and opposite force is applied on the gun, due to which the gun recoils in backward direction.

(ii) Application in walking : while moving in forward direction we push the ground backwards that is the action. An equal and opposite force is applied by the ground on the man, thus the reaction due to which man moves forward.

(iii) Rowing a boat in river : when we push the water backward with the help of oars (applying a force backward), an equal and opposite force acts on the boat. This is the reaction which moves the boat forward.

(iv) Launching Rocket : In rocket, gases are produced in large amount. Due to internal combustion they come out and move backwards with an equal and opposite force which in turn acts on the rocket and moves it forward.

MASS & WEIGHT

◈ **MASS** The amount of matter contained in a body is called its mass

OR

The measure of the quantity of matter in a body is called its mass.

The mass of a body is a scalar quantity. It is independent of surroundings and the position of the body. It is a constant quantity for a given body.

Mass is measured in kilogram (kg) in S.I. System.

◈ **WEIGHT**

Everybody on the surface of earth is attracted towards the centre of the earth. The force of attraction depends upon the mass of the body and the acceleration due to gravity. The weight of the body is the force with which it is attracted towards the centre of the earth. We know

$$F = ma$$

The acceleration produced by the force of attraction of the earth is known as acceleration due to gravity i.e., g

$$\therefore \quad F = ma = mg$$

But by definition this force is equal to the weight of the body i.e., F = W.

$$\therefore \quad W = mg$$

SI unit of weight is Newton (N) and in CGS, it is measured in dyne.

DIFFERENCES BETWEEN MASS AND WEIGHT

	MASS	WEIGHT
1	The mass of an object is the quantity of matter contained in it.	The weight of an object is the force with which it is attracted towards the centre of the earth
2	The SI unit of mass is kilogram (kg)	The SI unit of weight is newton (N).
3	The mass of an object is constant.	The weight of an object is not constant. It changes with the change in acceleration due to gravity (g).
4	The mass of an object can never be zero.	The weight of an object can be zero. For example, in the interplanetary space, where g = 0, the weight of an object becomes zero.

IMPORTANT POINTS

- **Mathematical Representation of force :** Mathematically, force F is equal to the product of mass M of a body and acceleration, a produced in the body due to that force. i.e. F = ma

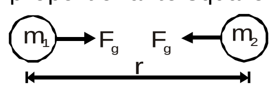
Acceleration : Mostly the velocity of a moving object changes either in magnitude or in direction or in both when the object moves. The body is then said to have acceleration. So it is the rate of change of velocity i.e. change in velocity in unit time is said to be acceleration. (it is vector quantity)

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{time}} \Rightarrow \frac{v-u}{t} = \frac{\text{Final velocity} - \text{initial velocity}}{\text{time}}$$

Its SI. unit is m/s^2 & C.G.S. unit is cm/s^2

- **Gravitational force : *According to Newton***

"Every body in the universe attract another body with a force which is directly proportional to product of their masses and inversely proportional to square of the distance between them."



$f_g \propto m_1 m_2$ ......(i) ; $f_g \propto \frac{1}{r^2}$ ......(ii)

From equation (i) and (ii)

$f_g \propto \frac{m_1 m_2}{r^2}$ $\quad f_g = \frac{Gm_1 m_2}{r^2}$

Where G = universal gravitational constant G = 6.67×10^{-11} Nm^2/kg^2 or $Nm^2\ kg^{-2}$

- **ELECTROSTATIC FORCE : *According to "Coulomb"***

"The force acting between the charges is known as electric force." If q_1 and q_2 are the charges then the force acting between them would be,

$$F = \frac{Kq_1 q_2}{r^2}$$

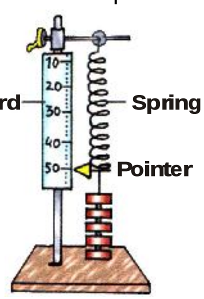
Where 'r' is the distance between q_1 and q_2, K is the **Coulomb's** constant

Force can be attractive or repulsive.

- **SPRING BALANCE**

A spring balance is a device used to measure the weight of an object. It can also be used for the measurement of forces.

Weighing machines which are used in schools or hospitals are also spring balances.



Spring Balance

NOTE :– Spring applies force on both ends. These forces are equal in magnitude but opposite in direction.

A spring balance consists of a spring inserted in a metal tube. The metal tube has a vertical slop through which the pointer comes out. The object to be weight is suspended on the hook at the bottom. When the object comes to equilibrium it stretches the spring. As a result, the pointer comes down and shows the reading against a scale.

PRESSURE

It is defined as the force per unit area. The SI unit of pressure is Pascal (Pa), which is Newton per square metre.

$$\textbf{Pressure (in Pa)} = \frac{\textbf{Force(in newton)}}{\textbf{Area (in m}^2\textbf{)}} \; [P = F/a]$$

Ex. If a force of 2 N is applied over an area of 2 cm^2, calculate the pressure produced.

Sol. To get the pressure in Pa, we have to make sure that the force is in Newton and the area in m^2.

Here, the area is in cm^2. To convert this to m^2, we have to divide the given are a by 10, 000

Thus, area = $\frac{2}{10,000}$ = 0.0002 m^2

Now, Pressure = $\frac{\text{Force}}{\text{Area}} = \frac{2N}{0.0002m^2}$ = 10, 000 Pa

Ex. Calculate the pressure if a force of 2N is applied on an area of 2 mm^2. Here, again the area is not in m^2. To change it into m^2, we divide the area by 1, 000,000.

Sol. Thus, area = $\frac{2}{1,000,000}$ = 0.000002 m^2

Now, Pressure = $\frac{\text{Force}}{\text{Area}} = \frac{2N}{0.000002\,m^2}$ = 1,000,000 Pa

◈ **VARIATION OF PRESSURE WITH AREA**

The same force, increasing the area over which it acts decreases the pressure applied. The inverse is also true: decreasing the area of application increases the pressure produced for the same force.

Ex. The area under the edge of a knife's blade is extremely small.
Beneath it the pressure is high enough for the blade to push easily through the material that needs to be cut.

⏩ Wall foundations have a large horizontal area. This reduces the pressure underneath so that the walls do not sink further into the ground under the weight of the building.

UNITS OF PRESSURE

The SI unit of pressure is called **Pascal (Pa)** in honour of **Blaise Pascal.**

I Pa = 1 N/m^2

One Pascal is defined as the pressure exerted on a surface area of 1 m^2 by a thrust of 1 N (acting normally on it).

Other units:

(i) In C.G.S unit of pressure is dyne/cm^2

(ii) 1 bar = 10^5 N/m^2

(iii) 1 milibar = 10^2 N/m^2

(iv) 1 atmospheric pressure (1 atm) = 101·3 k Pa = 1·013 bar = 1013 m bar = 760 mm of Hg

(v) 1 Torr = 1mm of Hg

PRESSURE IN FLUIDS

Liquids and gases are together called fluids.

Fluids exert pressure on all bodies immersed in them and on the walls of the container that holds them. The air inside the balloon exerts a pressure on the inner walls of the balloon.

LAWS OF PRESSURE

(i) Pressure exerted by the liquid is the same in all directions about a points

(ii) Pressure exerted is the same at all points in a horizontal plane as well as in a stationary liquid.

(iii) Pressure at a points inside a liquid increases with depth from the free surface.

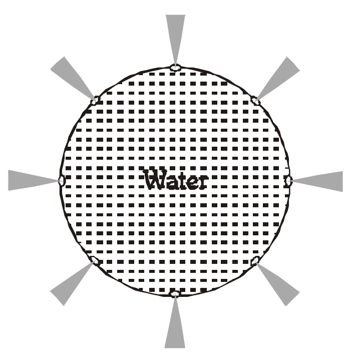
(iv) Pressure at a particular depth is different for different liquids, i.e. P = hdg

where, h = height of the column of liquid. d = density of the liquid

g = acceleration due to gravity

(v) The pressure exerted anywhere in a confined liquid is transmitted equally and undiminished in all directions throughout the liquid which is called 'Pascal's law'.

PASCAL'S LAW



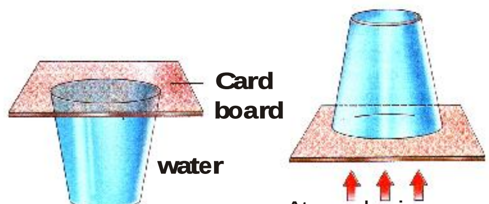
In an enclosed fluid, if pressure is changed in any part of the fluid, then this change of pressure is transmitted undiminished to all the other parts of the fluid.

ATMOSPHERIC PRESSURE

A layer of air called the **atmosphere** surrounds the earth. As you know, air is also matter and has weight. The weight of the atmosphere exerts a pressure on the surface of earth. This pressure is called **atmospheric pressure**. Its magnitude is around 100 kilo pascals (100 kPa) at sea level. However, as we go upward, the magnitude of atmospheric pressure decreases gradually. The following activity will show the magnitude of atmospheric pressure on the earth's surface.

◈ THE MAGNITUDE OF ATMOSPHERIC PRESSURE

Take a glass tumbler and fill it with water to the brim. Cover it with a thick sheet of paper (or cardboard). Press your palm over the sheet and quickly invert the tumbler. Slowly remove your palm supporting the piece of paper. What do you observe? Surprised?

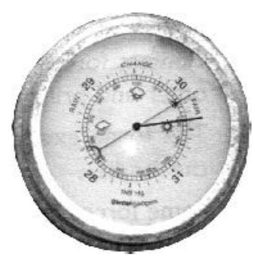


A glass with water covered with a sheet

Glass containing water in inverted position

You have seen that the paper did not fall (as one expected it to.) This is because the atmospheric pressure provides enough force to push the piece of paper upward.

BAROMETER



A barometer is a device used for measuring the atmospheric pressure.

Atmospheric pressure measurements are important to meteorologists for weather forecasts. The unit of pressure used for meteorological purpose is called the bar. A bar is a CGS unit of pressure and equals 10^5 Pascals or 1 bar = 10^5 Nm^{-2}.

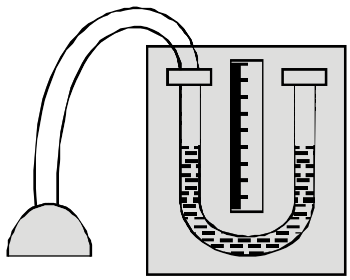
LIQUID PRESSURE

The normal force (or thrust) exerted by a liquid at rest per unit area of the surface in contact with it is called "pressure of liquid or hydrostatic pressure."

Take some discarded plastic bottle and fix a glass tube near its bottom. It can be done by slightly heating one end of the glass tube and then inserting it near the bottom of the bottle. In case there is some leakage, your must seal it with molten wax. Now cover the free end of the glass tube with a thin rubber sheet. On filling the plastic bottle upto half with water, the rubber sheet fixed to the glass tube bulges. When more water is added in the plastic bottle, there is change in the bulge of the rubber sheet. Since the rubber sheet is fixed on the side of the container, it shows that water exerts pressure on the side of the container. In other words, liquids exert pressure on the walls of the container.

MANOMETER

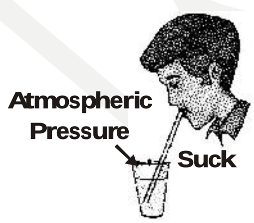
It is an a instrument used to measure liquid pressure. An open tube manometer is a simplest type of pressure gauge which measures pressure. It consists of a U-shaped tube containing a liquid. One arm of the tube is open to air and the other arm is connected to the vessel in which we want to measure the pressure. The difference in liquid level represents the applied pressure.



An open tube manometer

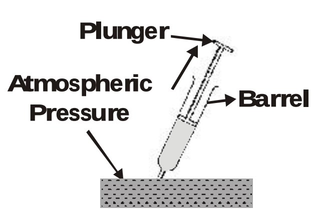
❖ OTHER APPLICATIONS OF PRESSURE

(a) Drinking straw Straw is used to suck up aerated water, when air is sucked in, it causes a decrease in air pressure inside the straw. The outside atmospheric pressure forces the liquid inside the straw. The dropper also works on the same principle. This is known as suction mechanism.



DRINKING WATER WITH A STRAW

(b) Syringe In syringe the pressure of the liquid (blood) force the liquid to move into the syringe when its plunger is withdrawn.



INJECTION SYRINGE

(c) **Vacuum cleaner** A vacuum cleaner is an electrical appliance that cleans by suction. A fan inside the vacuum cleaner lower the air pressure and creates a low pressure the device. As a result, the air and dirt particles on and near the surface are sucked into the device.

VACUUM CLEANER

(d) **Sphygmomanometer** An instrument called **sphygmomanometer** is used to measure the blood pressure of humans. The blood pressure of a person is the ratio of systolic (maximum) and diastolic (minimum) pressures. Normally it is 120/80 mm of Hg in a healthy adult. Pressures above 140/90 needs medical attention.

DENSITY

Density of a substance is defined as its mass per unit volume.

$$\text{density(d)} = \frac{\text{mass(m)}}{\text{volume(V)}}$$

Unit of density :- Since mass (M) is measured in kilogram (kg) and the volume (V) is measured in metre^3 (m^3), the unit of density is kg/m^3. In cgs system, the unit of density is g cm^{-3}.

These units are related as : 1 g cm^{-3} = 1000 kgm^{-3}.

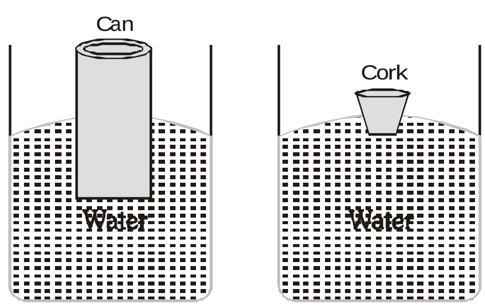
BUOYANCY

When a body is partially or wholly immersed in a liquid, an upward force acts on it which is called upthrust or buoyant force. The property of the liquids responsible for this force is called **buoyancy**.

Buoyancy is a familiar phenomenon : a body immersed in water seems to weigh less than when it is in air. When the body is less dense than the fluid, then it floats. The human body usually floats in water, and a helium filled balloon floats in air.

When a body is immersed in a fluid (liquid or gas) it exerts an upward force on the body. This upward force is called upthrust or buoyant force (U or F_B) and the phenomenon is termed as buoyancy. Thus buoyancy or upthrust is the upward force exerted by a fluid (liquid or gas) when a body is immersed in it.

It is a common experience that when a piece of cork is placed in water it floats with two-fifth of its volume inside water. If the cork piece is pushed into water and released it comes to the surface as if it has been pushed by someone from inside due to the buoyant force exerted by fluid.



ARCHIMEDES PRINCIPLE

Archimedes principle states that :- "Anybody completely or partially submerged in a fluid is buoyant up by a force equal to the weight of the fluid displaced by the liquid".

In other words :- "When a body is partially or completely immersed in a fluid, the fluid exerts an upward force on the body equal to the weight of the fluid displaced by the body.

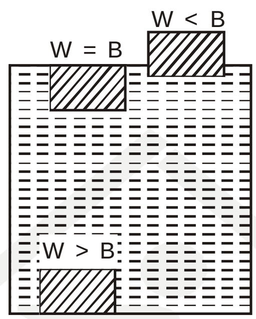
LAW OF FLOATATION

Law of floatation is an extension of Archimedes principle.

When a body is partially or fully immersed in a fluid, then following vertical forces are experienced by it.

(a) Its weight (W) acting vertically downwards through the centre of the body.

(b) Force of buoyancy (B or F_B) or upthrust, acting vertically upwards through the centre of gravity of the body.



Floatation

The following three cases arise :-

(1) When W < B, the body floats : In this case the body will rise above the surface on the liquid to the extent that the weight of the liquid displaced by its immersed part equals the weight of the body. Then the body will float with only a part of it immersed in the liquid. In this case $V\rho g < V\sigma g$ or $\rho < \sigma$. Thus if a cork, which has a density less than that of water will rise in water till a portion of it is above water. Similarly a ship floats in water since its density is less than the density of water.

(2) When W > B, the body sinks :- If ρ and σ present the densities of the body and the fluid respectively and V the volume of the body (which is also the volume of the fluid displaced) then $V\rho g > V\sigma g$ or $\rho > \sigma$ i.e., the body sinks in the fluid in case its density is greater than the density of the fluid. An iron nail has greater density than water, therefore it sinks in water.

(3) When W = B :- The resultant force acting on the body when fully immersed in the fluid is zero. The body is at rest anywhere within the fluid. **The apparent weight of the body is zero for all such positions.**

Thus, we find that a body will float when its weight is equal to the weight B of the fluid displaced i.e. the upthrust.

SOLVED EXAMPLES

Ex.1 In a tug of war, the three members of team A pull with a force of 100 N, 120 N, and 135N. The three members of team B pull with a force of 130 N, 105 N, and 120 N which team will win?

Sol. Force exerted by team A = 100 N + 120 N + 135 N = 355 N.

Force exerted by team B = 130 N + 105 N + 120 N = 355 N.

Teams are pulling with same force

The resultant force is zero. Neither team will win. (Ans.)

Ex.2 A force of 20 N acts over on area of 4 m^2. What is the pressure?

Sol. Given : F = 20 N, A = 4 m^2, pressure?

We know that pressure = $\frac{\text{Force}}{\text{Area}} = \frac{20}{4}$ = 5 N/m^2 or 5 Pa.

Ex.3 A pressure of 50 N/m^2 acts on an area of 5 m^2. Calculate the total force.

Sol. Given : P = 50 N/m^2, A = 5 m^2, force?

We know that pressure = $\frac{\text{Force}}{\text{Area}}$

Force = Area × pressure = $5m^2 \times 50\ N/m^2$ =

F = 250 N (Ans.)

Ex.4 A force of 800 N exerts a pressure of 40 N/m^2. What are is it action?

Sol. Given : F = 800 N, P =40 N/m^2, Area?

We know that pressure = $\frac{\text{Force}}{\text{Area}}$

$\therefore$ = Area = force/pressure = $\frac{800}{40}$ = 20 m^2

Ex.5 A person weigh 600 N. He is wearing shoes with a total area of 0.02 m^2. What pressure do they exert on the floor?

Sol. Given : F = 600 N, A = 0.02 m^2, pressure?

We know that pressure = $\frac{\text{Force}}{\text{Area}} = \frac{600}{0.02}$ = 30000 N/m^2 or 30 KPa. (Ans.)

Ex.6 In a game of tug of war, three girls of team A pull the rope with forces of 100 N, 120 N and 170 N. In team B, the three members pull the rope with force of 130 N, 150 N and 155 N. Who will win the rug of war? What is the resultant force?

Sol. [Team A will win, 45 N]

Ex.7 A horse pulls a cart with a force of 1500 N. The force of friction between the cart and the ground is 1500 N. The cart does not move. Why?

Sol. [Same force applied in opposite direction so resultant force zero]

Ex.8 Define pressure. What are the units of pressure in this list: N/cm^2, N, N/m^2, cm^2, m^2

Sol. [N/m^2 or N/cm^2]

Ex.9 A force of 500 N acts on a square piece of plywood, each of whose sides is 5 m long. Calculate the pressure acting on the piece of plywood.

Sol. [20 N]

Ex.10 A body stands on the ground. The area below his feet is 70 cm^2. The pressure he exerts on the ground is 7 N/cm^2. Calculate the total force acting on the ground.

Sol. [490 N/cm^2]

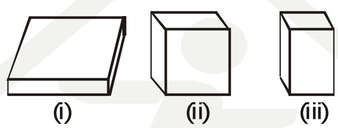
Ex.11 A force exerts a pressure of 45 N/m^2 when it acts on an area of 10 m^2. Calculate the total force.

Sol. [450 N/m^2]

Ex.12 A force of 400 N exerts pressure of 20 N/cm^2. What is the area on which the force acts?

Sol. [20 N]

Ex.13 The picture shows a heavy box placed on the floor in three different ways. In which case would the pressure on the floor be the least? When would it be the most? Why?

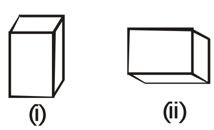


Sol. [Fig (iii) least pressure because is area is minimum]

Ex.14 You want to lift a heavy box. The force of gravity pulls it down wards with a force of 500 N. Your father applies an upward force of 220 N form below. how much force will you have to apply to lift it upwards?

Sol. [Less than 220 N]

Ex.15 The surface area of the end of a brick 50 cm^2. The surface area of the base brick is 200 cm^2. Each brick weighs 50 N. What pressure is exerted on the ground by the brick in the two cases shown here?



Sol. [(i) for standing brick 1N/cm^2

[(ii) For the brick lying on its box = 0.25 N/cm^2]

NCERT QUESTIONS WITH SOLUTIONS

Q.1 Give two examples of each of situation in which you push or pull to change the state of motion of an objects

Ans. (i) We push a bicycle to move it

(ii) We pull the table to change its position.

Q.2 Give two examples of situations in which applied force causes a change in the shape of an object.

Ans. (i) When we press the foam, its shape is changed.

(ii) When we stretch the rubber bend, then its shape is changed.

Q.3 Fill in the blanks

(a) To draw water from a well we have to ______ at rope.

(b) A charged body _____ an uncharged body towards it.

(c) To move a loaded trolley we have to ______ it.

(d) The north pole of a magnet ______ the north pole of another magnet.

Ans. (a) Pull (b) Attracts (c) Push (d) Repels

Q.4 An archer stretches her bow while taking aim at the target. She then releases the arrow, which begins to move towards the target. Based on this information fill up the gaps in the following statements using the following terms :

muscular, contact, non-contact, gravity, friction, shape, attraction

(a) To stretch the bow, the archer applies a force that causes a change in its _____ .

(b) The force applied by the archer to stretch the bow is an example of ______ force.

(c) The type of force responsible for a change in the state of motion of the arrow is an example of a _______ force.

(d) While the arrow moves towards its target, the forces acting on it are due to _______ and that due to _______ of air.

Ans. (a) shape (b) muscular (c) contact (d) gravity, friction

Q.5 In the following situations identify the agent exerting a force and the object on which it acts. State the effects of the force in each case.

(a) Squeezing a piece of lemon between the fingers to extract its juice.

(b) Taking out paste from a toothpaste tube.

(c) A load suspended from a spring while its other end is on a hook fixed to a wall.

(d) An athlete making a high jump to dear the bar at a certain height.

Ans. (a) The fingers are the agents, lemon is the object.

The effect of force is the lemon juice being expelled by squeezing.

(b) The hand is the agent, toothpaste tube is object and the coming out of paste from toothpaste tube is the effect of force.

(c) Suspended load is agent, spring is the object, the effect of force can be seen in the form of elongation of spring on suspension of load.

(d) Athlete is the agent, bar is the object. The force can be seen In the form of jump.

Q.6 A blacksmith hammers a hot piece of iron while making a tool. How does the force due to hammering affect the piece of iron ?

Ans. The force due to hammering causes the change in shape of iron and iron can be moulded in the shape of the required tool.

Q.7 An inflated balloon was pressed against a wall after it has been rubbed with a piece of synthetic cloth. It was found that the balloon sticks to the wall. What force might be responsible for the attraction between the balloon and the wall ?

Ans. Electrostatic force.

Q.8 Name the force acting on a plastic bucket containing water held above ground level in your hand. Discuss why the forces acting on the bucket do not bring a change in its state of motion.

Ans. Muscular and gravitational forces act on plastic bucket. The force acting on the bucket do not bring a change in state of motion because they are acting in opposite direction with equal magnitudes.

Therefore the net force on bucket remains zero.

Q.9 A rocket has been fired upward to launch a satellite in its orbit. Name the two forces acting on the rocket immediately after leaving the launching pad.

Ans. (i) Gravitational force (ii) Force of friction.

Q.10 When we press the bulb of a dropper with its nozzle kept in water, air in the dropper is seen to escape in the form of bubbles. Once we release the pressure on the bulb, water gets filled in dropper. The rise of water in the dropper is due to

(a) pressure of water (b) gravity of the earth

(c) shape of rubber bulb (d) atmospheric pressure

Ans. (d) atmospheric pressure.

EXERCISE – I BOARD PROBLEMS

Q.1 Is weight a force? Write the SI unit of force.

Q.2 What are different types of forces?

Q.3 Define 1 kgf.

Q.4 Name two units of force.

Q.5 Is force a scalar or a vector?

Q.6 What are electrostatic forces?

Q.7 What is the main use of a spring balance?

Q.8 Write the SI unit of pressure.

Q.9 What do you mean by thrust?

Q.10 What is a manometer?

Q.11 What is atmospheric pressure at sea level?

Q.12 Distinguish between mass and weight.

Q.13 Define weight of a body. Name the unit used to measure it.

Q.14 State and explain Pascal's law. Does it apply to gases also?

Q.15 What are the factors on which the pressure of a liquid depends?

Q.16 Why are railway tracks laid on wooden or iron sleepers?

Q.17 Why do we feel pain when we walk on a ground having small pebbles?

Q.18 Explain how it is possible to drink a liquid by using a straw?

Q.19 Why are dams made broader at the bottom than at the top?

Q.20 Explain in suitable detail, the effect of force on a body.

Q.21 Explain the basic principle of gravitational force. How will you measure it? Write its SI unit.

Q.22 Define force. Briefly explain different units of force.

Q.23 (i) What do you mean by atmospheric pressure?

(ii) Why does a fountain pen start leaking at higher altitudes?

Q.24 Briefly explain the principle, construction and working of a manometer.

Q.25 (i) State Pascal's law

(ii) Give two examples of pressure in everyday life.

Q.26 Why is one end of a drawing pin kept wide, but the other end very sharp?

Q.27 What is force? Explain the four effects a force can produce, giving relevant examples.

Q.28 Explain contact and non-contact forces by giving suitable examples.

Q.29 Distinguish between thrust and pressure. Write their units. What is the relation between them?

EXERCISE – II OLYMPIAD QUESTIONS

Q.1 If a rock is brought from the surface of the moon :
(A) Its mass will change
(B) Its weight will change, but not mass.
(C) Both mass and weight will change
(D) Its mass and weight will remain the same.

Q.2 When an object undergoes acceleration :
(A) Its speed always increases
(B) Its velocity always increases
(C) It always falls towards the earth
(D) A force always acts on it

Q.3 External forces are :
(A) Always balanced
(B) Never balanced
(C) May or may not be balanced
(D) None of these

Q.4 The net force acting on a body of mass 1 kg moving with a uniform velocity of 5 ms^{-1} is :
(A) 5 N (B) 0.2 N
(C) 0 N (D) None of these

Q.5 How many dynes are equal to 1 N?
(A) 10^6 (B) 10^4
(C) 10^5 (D) 10^3

Q.6 A force can :
(A) Change the direction of a moving body
(B) Change the state of rest or uniform motion of a body.
(C) Change the shape of a body
(D) All of the above

Q.7 The S.I. unit of pressure is –
(A) Newton (B) Dyne/cm^2
(C) Pascal (D) Joule

Q.8 Which among the following will exert maximum pressure when pushed with the same amount of force?
(A) An eraser of area 2 cm^2
(B) A sharpened pencil tip
(C) The blunt end of a pencil
(D) The rear portion of a closed safety pin

Q.9 Pressure is also measured in :
(A) Joule (B) mm of Hg
(C) mm of Ag (D) Metre

Q.10 Force per unit area is called :
(A) Energy (B) Work
(C) Pressure (D) Thrust

Q.11 Atmospheric pressure is measured by :
(A) Barometer (B) Manometer
(C) Screw gauge (D) None of these

Q.12 A manometer is used to measure :
(A) Height
(B) Pressure
(C) Liquid density
(D) Atmospheric pressure

Q.13 How does pressure vary as we come from mountain top to sea level?
(A) Increases (B) Decreases
(C) Remains same (D) Depends on weather

Q.14 As we go deeper beneath the surface of liquid, the pressure :
(A) Remains same (B) Increase
(C) Decreases (D) Depends on weather

Q.15 A vacuum cleaner works on the principle of :
(A) Electromagnetic Induction
(B) Suction
(C) Mutual Induction
(D) Energy conservation

Q.16 The S.I. unit of force is :
(A) metre (B) Newton
(C) Pascal (D) Second

Q.17 A contact force cannot act through
(A) Empty space
(B) Touching
(C) Touching with a metal rod
(D) Touching with a wooden rod

Q.18 Which of the following is a unit of pressure?

(A) Metre (B) Newton

(C) Square metre (D) Pascal

Q.19 Deep-sea diving vessels have to withstand pressure from the crushing effect of sea water acting :

(A) Upwards (B) Downwards

(C) Side ways (D) In all directions.

Q.20 Which of the following is a type of a pressure gauge?

(A) Speedometer (B) Manometer

(C) Syringe (D) Thermometer

Q.21 Which of these is not a contact force?

(A) Friction (B) Muscular force

(C) Magnetic force (D) None of these

Q.22 A force has :

(A) Magnitude only

(B) Direction only

(C) both magnitude and direction

(D) None of these

Q.23 When a force is applied on a body it may change its

(A) Speed only

(B) Direction only

(C) both speed and direction

(D) None of these

Q.24 When we press the bulb of a dropper with its nozzle kept in water, air in the dropper is seen to escape in the form of bubbles. Once we release the pressure on the bulb, water gets filled in the dropper. The rise of water in the dropper is due to :

(A) Pressure of water

(B) Gravity of the earth

(C) Shape of rubber bulb

(D) Atmospheric pressure

Q.25 Gravitational force acts :

(A) Only between the sum and the planets moving around it.

(B) Only between the earth and the bodies on it

(C) Between all bodies in the universe

(D) Only between the sun and the earth

Q.26 The relation between the S.I. unit of force and the weight of a 1 kg mass is :

(A) 1 kgf = 1 N (B) 1 kgf = 0.98 N

(C) 1 kgf = 9.8 N (D) 1 N = 9.8 kg

Q.27 If a force of 100 N acts on an area of 10 m^2, the pressure equal :

(A) 100 N/m^2 (B) 10 N/m^2

(C) 1000 N/m^2 (D) 1000 Nm^2

Q.28 1 dyne is equal to :

(A) 980 g wt (B) 1/980 g wt

(C) 980 kg wt (D) None of these

Q.29 Which of the following class of force is different from others?

(A) magnetic force

(B) Electrical force

(C) Gravitational force

(D) Stretching of a spring

ANSWER KEY

1.	B	**2.**	D	**3.**	C	**4.**	C
5.	C	**6.**	D	**7.**	C	**8.**	B
9.	B	**10.**	C	**11.**	A	**12.**	B
13.	A	**14.**	B	**15.**	B	**16.**	B
17.	A	**18.**	D	**19.**	D	**20.**	B
21.	C	**22.**	C	**23.**	C	**24.**	D
25.	C	**26.**	C	**27.**	A	**28.**	B
29.	D						

METALS AND NON-METALS

Lavoiser classified all elements into metals, nonmetals and metalloids on the basis of their properties. Some commonly used metals, nonmetals and metalloids are given below.

(i) **Metals :** Iron, Copper, Gold, Silver, Aluminium, Zinc, Lead are some commonly used metals.

(ii) **Nonmetals :** Hydrogen, Oxygen, Nitrogen, Carbon, Sulphur, Phosphorus, Chlorine, Bromine, Iodine are commonly used nonmetals.

(iii) **Metalloids :** Boron, Silicon, Arsenic and Germanium are some metalloids.

CHARACTERISTICS OF METALS

Some important characteristics of metals are :

(i) Metals are good conductors of heat and electricity.

(ii) All metals except mercury are solid at room temperature. Mercury is the only metal which is liquid at room temperature.

(iii) Metals are malleable and ductile – that is metals can be beaten into thin sheets and drawn into thin wires.

(iv) Metals have lustre and can be polished.

(v) Metals have tensile strength.

(vi) Metals are electropositive elements. That is, metals have a tendency to lose electrons and form positively charged ions, (called cations).

I. Occurrence of Metals

Metals occur in nature in the free as well as in the combined states.

Metals in nature

In free (or native) form
(Silve, Gold, Platinum, Mercury)

In the combined state
(Sodium, Potassium, Calcium, Magnesium, Iron, Aluminium, Copper etc.)

(i) All metals which are not affected by water and by the gases present in the air occur in free state in nature.

(ii) The naturally-occurring compounds of metals mixed with earthly materials are called minerals.

(iii) A mineral from which a metal can be extracted on the commercial scale, economically and easily, is called an ore.

II. Physical Properties of Metals

All metals show similar physical properties. There are however a few exceptions.

(i) **Physical State :** Under normal pressure, all metals except mercury are solids at room temperature. Mercury is liquid at room temperature.

(ii) **Colour :** Most metals except gold and copper are silver-grey in colour. Copper is reddish-brown and gold is golden yellow.

(iii) **Appearance :** All metals are shiny. The characteristic shine of metals is called metallic lustre. Thus all metals have metallic lustre. Metals can be easily polished.

(iv) **Hardness :** Most metals are hard except sodium and potassium. Sodium and potassium metals can be easily cut with a knife. Osmium is hard enough to scratch glass.

(v) **Tensile strength :** Metals have high tensile strength. Metals are very strong. For example, iron can bear a lot of stress. That is why it is widely used in construction of buildings, bridges, railway lines etc.

(vi) **Malleability :** Metals are malleable. This means that metals can be hammered into very thin sheets. Silver can be beaten to very thin leaves. You must have seen silver varak on burfee. Aluminium foil is used in the packaging of food materials.

(vii) **Ductility :** Metals are ductile. This means that metals can be drawn into thin wires. Silver and gold can be drawn into very thin wires.

(viii) **Conductivity :** Metals are good conductor of heat and electricity. Silver is the best conductor of electricity. Copper is the next best conductor of electricity.

(ix) **Density :** Metals, except sodium and potassium have high densities. Sodium and potassium have much lower densities.

(x) **Sound :** Metals are sonorous. Metals when hit by a hammer produce a ringing sound. That is why metal are used for making bells and wires for musical instruments.

CHEMICAL PROPERTIES OF METALS

All metals give similar chemical reactions. However, the reactivity of a metal depends upon its nature and reaction conditions.

Some typical reactions of metals are described below :

(i) **Reaction with oxygen :** All metals combine with oxygen to form metal oxides. Different metals react with oxygen under different conditions.

For example,

$$4\,Na + O_2 \longrightarrow 2\,Na_2O$$

Sodium (Na) : Sodium + Oxygen/air $\xrightarrow{\text{room temp.}}$ Sodium oxide

$$2\,Mg + O_2 \longrightarrow 2\,MgO$$

Magnesium (Mg) :Magnesium + Oxygen $\xrightarrow[\text{(burns with a dazzling white light)}]{\text{Heat}}$ Magnesium oxide

$$2\,Zn + O_2 \longrightarrow 2\,ZnO$$

Zinc (Zn) : Zinc + Oxygen $\xrightarrow[\text{(burns with a blue flame)}]{\text{strong heating}}$ Zinc oxide

$$3\,Fe + 2\,O_2 \longrightarrow Fe_3O_4$$

Iron (Fe) : Iron + Oxygen $\xrightarrow[\text{(no burning)}]{\text{strong heating}}$ Ferroso-ferric oxide

$$2\,Cu + O_2 \longrightarrow 2\,CuO$$

Copper (Cu) : Copper + Oxygen $\xrightarrow[\text{(no burning)}]{\text{prolonged strong heating}}$ Copper oxide

From the reaction conditions of the reactions given above, the order of reactivity of metals with oxygen is,

Sodium (Na) > Magnesium (Mg) > Zinc (Zn) > Iron (Fe) > Copper (Cu)

(ii) Reaction with Water : Different metals react with water under different conditions.

Reactions of some common metals with water are given below :

		Na	**+**	$\mathbf{H_2O}$	$\longrightarrow$ **NaOH**	**+**	$\mathbf{H_2}$
Sodium (Na)	:	Sodium	+	Water (cold)	$\longrightarrow$ Sodium hydroxide	+	Hydrogen
		Mg	**+**	$\mathbf{H_2O}$	$\longrightarrow$ **MgO**	**+**	$\mathbf{H_2}$
Magnesium(Mg)	:	Magnesium	+	Water (boiling)	$\longrightarrow$ Magnesium oxide	+	Hydrogen
		2 Fe	**+**	$\mathbf{3H_2O}$	$\longrightarrow$ $\mathbf{Fe_2O_3}$	+	$\mathbf{3\ H_2}$
Iron (Fe)	:	Iron (red hot)	+	Steam	$\longrightarrow$ Ferroso-ferric oxide	+	Hydrogen
		Cu	**+**	$\mathbf{H_2O}$	$\longrightarrow$ No Reaction		
Copper (Cu)	:	Copper	+	Water	$\longrightarrow$ No reaction even at high temperature		

From the reaction conditions of the above reactions, the order of reactivity of metals with water is

Sodium (Na) > Magnesium (Mg) > Iron (Fe) > Copper (Cu)

(iii) Reactions with Acids : Most metals react with dilute acids produce salt and hydrogen gas.

Reaction of some common metals with dilute hydrochloric acid are given below :

		2Na	**+**	**2HCl**	$\longrightarrow$	**2NaCl**	**+**	$\mathbf{H_2}$	
Sodium (Na)	:	Sodium	+	Hydrochloric acid (dil)	$\longrightarrow$	Sodium chloride	+	Hydrogen	**Vigorous**
		Mg	**+**	**2HCl**	$\longrightarrow$	$\mathbf{MgCl_2}$	**+**	$\mathbf{H_2}$	
Magnesium (Mg)	:	Magnesium	+	Hydrochloric acid (dil)	$\longrightarrow$	Magnesium chloride	+	Hydrogen	**Rapid**
		Zn	**+**	**HCl**	$\longrightarrow$	$\mathbf{ZnCl_2}$	**+**	$\mathbf{H_2}$	
Zinc (Zn)	:	Zinc	+	Hydrochloric acid (dil)	$\xrightarrow{\text{room temp.}}$	Zinc chloride	+	Hydrogen	**Moderate**
		Fe	**+**	**2HCl**	$\longrightarrow$	$\mathbf{FeCl_2}$	**+**	$\mathbf{H_2}$	
Iron (Fe)	:	Iron	+	Hydrochloric acid (dil)	$\xrightarrow{\text{heating}}$	Iron chloride	+	Hydrogen	**Moderate**
		Cu	**+**	**HCl**	$\longrightarrow$	No Reaction			
Copper (Cu)	:	Copper	+	Hydrochloric acid (dil)	$\longrightarrow$	No reaction even on heating			

From the reaction conditions of the reaction given above, the order of reactivity of these metals with dilute acid is

Sodium (Na) > Magnesium (Mg) > Zinc (Zn) > Iron (Fe) > Copper (Cu)

Uses of some Common Metals

Main uses of some common metals are listed below :

Metal	Main Uses
Iron	For making bridges, engine parts, iron sheets and bars used in construction, steels etc.
Copper	For making electrical wires and cables, utensils, kettles, coins etc; for making alloys
Silver	For making jewellery, in electroplating, in photography, silvering of mirrors
Gold	For making jewellery, for decorative purposes, in photography for toning
Mercury	Used in thermometers and barometers
Aluminium	For making electrical wires and cables, domestic utensils, alloys, metallic paints, aluminium foil for packaging
Lead	For making automobile batteries, lead pipes, alloys such as solder, protective screen for X-ray machines, for manufacturing many chemical compounds and paints.

CHARACTERISTICS OF NON METALS

Some important characteristics of metals are :

(i) Nonmetals are soft solids, liquids or gases.

(ii) Nonmetals (except graphite) are nonconductors of heat and electricity.

(iii) Solid nonmetals are brittle.

(iv) Nonmetals (except graphite and diamond) are low melting and low boiling.

(v) Nonmetals are electronegative elements. That is, nonmetals have a tendency to gain electrons and form negatively charged ions (called anions).

III. Occurrence of Nonmetals

Many nonmetals occur free in nature, whereas many more occur only in the form on their compounds as minerals.

The modes of occurrence of some typical nonmetal are described below :

Nonmetal	Free native form	Combined form
Nitrogen	Air contains about 78% (by volume) of nitrogen	In all living organisms as proteins, in the soil as nitrogen compounds
Oxygen	Air contains about 21% (by volume) of oxygen	As water, oxides in the soil/rocks
Nobal gases	Air contains these gases in smaller amounts	—
Hydrogen	Free hydrogen is present in stars	As water
Sulphur	Native sulphur occurs inside the earth.	As sulphide, sulphate ores, as H_2S in certain spring water
Phosphorus	—	As phosphate rocks, in bones of our body as calcium phosphate
Silicon	—	As oxide (SiO_2, Silica, Sand), As silicate rocks
Carbon	As diamonds, graphite	As carbonate rocks, minerals As hydrocarbons – petroleum, natural gas etc. As carbon dioxide in the air.

Most nonmetals are either mined directly from their mines or obtained as by-products in some industrial processes.

(i) Nitrogen and Oxygen are obtained from the air by fractional distillation of liquid air.

(ii) Chlorine is obtained from common salt by electrolytic method.

(iii) Sulphur is mined in its elemental form

(iv) Nonmetals such as phosphorus and silica are obtained from their ores by chemical methods.

IV. Physical Properties of Nonmetals

Some common general physical properties of nonmetals are given below :

(i) Physical state : Nonmetals may occur as solids, liquids or gases at room temperature. For example, under normal conditions, sulphur, phosphorus are solids, bromine is a liquid, whereas hydrogen, oxygen and nitrogen are gases.

(ii) Colour : Nonmetals come in many colours.
For example, sulphur is yellow, phosphorus is white, or red, chlorine is greenish-yellow, bromine is redish-brown. Hydrogen, oxygen and nitrogen are colourless.

(iii) Appearance : Nonmetals have dull appearance i.e., they do not shine. However, graphite and iodine are the only nonmetals which have metallic lustre.

(iv) Malleability and ductility : Nonmetals are neither ductile nor malleable. Nonmetals cannot be drawn into wires, and beaten into leaves/sheets.

(v) Conductivity : Nonmetals do not conduct heat and electricity, i.e., nonmetals are insulators. Graphite however, is a good conductor of heat and electricity.

(vi) Density : Nonmetals usually have low densities and are soft. Diamond however is an exception. Diamond is the hardest natural substance known.

(vii) Tensile strength : Nonmetals have low tensile strength, i.e., Nonmetals can be easily broken.

(ix) Melting and boiling points : Nonmetals except graphite have low melting and boiling points.

(x) Sound : Nonmetals do not produce sound when hit with an object, i.e., nonmetals are non-sonorous.

CHEMICAL PROPERTIES OF NONMETALS

Some general chemical properties of nonmetals are described below :

V. Electronegative Character

Nonmetals are electronegative elements. Nonmetals have a tendency to accept electrons and form negatively charged ions (anions).

For examples.

Chlorine + e^- $\longrightarrow$ Chloride ion (an anion)

Oxygen + $2e^-$ $\longrightarrow$ Oxide ion (an anion)

Thus, nonmetals are able to remove electrons from electropositive elements and act as oxidising agents.

Hydrogen is the only nonmetal which can lose as well as gain an electron.

H	+	e^-	$\longrightarrow$	H^-
Hydrogen	+	from a highly electropositive element	$\longrightarrow$	Hydride ion (an anion)
H	–	e^-	$\longrightarrow$	H^+
Hydrogen	–	from a highly electronegative element	$\longrightarrow$	Hydrogen ion (acation)

Thus, hydrogen can act both as an oxidising as well as reducing agent.

VI. Reaction with Oxygen

Nonmetals react with oxygen to give covalent oxides. Such oxides are either neutral or acidic in nature. Acids oxides of nonmetals dissolve in water to form corresponding acids. Reaction of some common nonmetals with oxygen are described below:

(i) Nitrogen : Nitrogen reacts with oxygen under different conditions to form five different oxides. Some of these are neutral, while others are acidic in nature.

For example,

Nitrogen	+	Oxygen	$\longrightarrow$	Nitrous oxide	(neutral)
Nitrogen	+	Oxygen	$\longrightarrow$	Nitric oxide	(neutral)
Nitrogen	+	Oxygen	$\longrightarrow$	Dinitrogen trioxide	(acidic)
Nitrogen	+	Oxygen	$\longrightarrow$	Nitrogen dioxide	(acidic)
Nitrogen	+	Oxygen	$\longrightarrow$	Dinitrogen pentoxide	(acidic)

Dinitrogen pentoxide reacts with water to give nitric acid.

Dinitrogen pentoxide + Water $\longrightarrow$ Nitric acid.

(ii) Carbon : Carbon reacts with oxygen to form two oxides – carbon monoxide (CO) and carbon dioxide (CO_2). Carbon monoxide is neutral, whereas carbon dioxide (CO_2) is acidic in nature. Carbon dioxide dissolves in water to give carbonic acid.

Carbon	+	Oxygen (limited supply)	$\longrightarrow$	Carbon monoxide (neutral)	(CO)
Carbon	+	Oxygen (excess)	$\longrightarrow$	Carbon dioxide (acidic)	(CO_2)
Carbon dioxide	+	Water	$\longrightarrow$	Carbonic acid	(H_2CO_3

(iii) Phosphorus : Phosphorus reacts with oxygen to give two oxides – phosphorus trioxide (P_2O_3) and phosphorus pentoxide (P_2O_5). Both are acidic oxides.

Phosphorus	+	Oxygen (limited)	$\longrightarrow$	Phosphorus trioxide (acidic)	(P_2O_3)
Phosphorus	+	Oxygen (excess)	$\longrightarrow$	Phosphorus pentoxide (acidic)	(P_2O_5)

(iv) Sulphur : Sulphur on burning in air forms two oxides – sulphur dioxide (SO_2) and sulphur trioxide (SO_3). Both these oxides are acidic.

S	+	**O_2**	$\longrightarrow$	**SO_2**
Sulphur	+	Oxygen	$\longrightarrow$	Sulphur dioxide (acidic)
S	+	**O_2**	$\longrightarrow$	**SO_3**
Sulphur	+	Oxygen	$\longrightarrow$	Sulphur trioxide (acidic)
SO_3	+	**H_2O**	$\longrightarrow$	**H_2SO_4**
Sulphur trioxide	+	Water	$\longrightarrow$	Sulphuric acid

(v) Hydrogen : Hydrogen reacts with oxygen to form an oxide H_2O. H_2O is called water. Water (H_2O) is a neutral oxide

H_2	**+**	**O_2**	$\longrightarrow$	**H_2O**
Hydrogen	+	Oxygen	$\longrightarrow$	Water (neutral)

VII. Reaction with Halogens

Nonmetals react with halogen to give covalent halides. In pure state, the halides of nonmetals do not conduct electricity.

For example with chlorine,

2P	+	**$3Cl_2$**	$\longrightarrow$	**$2PCl_3$**
Phosphorus	+	Chlorine	$\xrightarrow{\text{Heat}}$	Phosphorus trichloride
2P	+	**$5Cl_2$**	$\longrightarrow$	**$2PCl_5$**
Phosphorus	+	Chlorine	$\xrightarrow{\text{Heat}}$	Phosphorus pentachloride
H_2	+	**Cl_2**	$\longrightarrow$	**2HCl**
Hydrogen	+	Chlorine	$\xrightarrow{\text{sunlight}}$	Hydrogen chloride

Sulphur reacts with fluorine at higher temperature to give sulphur hexafluoride.

S	+	**3Fe**	$\longrightarrow$	**SF_6**
Sulphur	+	Fluorine	$\xrightarrow{\text{high temp.}}$	Sulphur hexafluoride

VIII. Reaction with Hydrogen

Nonmetals react with hydrogen to form covalent hydrides. Thus in the hydrides of nonmetals, hydrogen is bonded to the nonmetal atom by covalent bonds. The hydrides of nonmetals atom by covalent bonds. The hydrides of nonmetals do not conduct electricity. The hydrides of nonmetals may be acidic, basic or neutral depending upon the nature of the nonmetal.

For example,

(i) Sulphur with hydrogen gives hydrogen sulphide (H_2S). H_2S is weakly acidic in nature.

H_2	+	**S**	$\longrightarrow$	**H_2S**
Hydrogen	+	Sulphur	$\longrightarrow$	Hydrogen sulphide (weakly acidic)

(ii) Nitrogen reacts with hydrogen to give ammonia (NH_3). Ammonia is basic in nature.

H_2	+	**$3N_2$**	$\longrightarrow$	**$2NH_3$**
Hydrogen	+	Nitrogen	$\longrightarrow$	Ammonia (basic)

(iii) Oxygen reacts with hydrogen to given water (H_2O). Water is neutral in nature.

H_2	+	**O_2**	$\longrightarrow$	**$2H_2O$**
Hydrogen	+	Oxygen	$\xrightarrow{\text{electric spark}}$	Water

IX. Reaction with Acids

Nonmetals do not displace hydrogen from dilute acids. This is because nonmetals are able to give electron(s) for the reduction of H^+. Some nonmetals however react with concentrated oxidising acids to form the corresponding oxyacids.

For example, sulphur reacts with conc. nitric acid to give sulphuric acid.

Sulphur + Nitric acid (conc.) $\longrightarrow$ Sulphuric acid + Nitrogen dioxide + Water

X. Displacement Reactions

Certain more reactive nonmetals displace less reactive nonmetals from their salt solutions. For example, Chlorine displaces bromine from bromides and iodine from iodides.

2KBr	+	**Cl_2**	$\longrightarrow$	**2KCl**	+	**Br_2**
Potassium bromide	+	Chlorine	$\longrightarrow$	Potassium chloride	+	Bromine
2KI	+	**Cl_2**	$\longrightarrow$	**2KCl**	+	**I_2**
Potassium iodide	+	Chlorine	$\longrightarrow$	Potassium chloride	+	Iodine

Uses of Some Common Nonmetals

Main uses of some common nonmetals are listed below :

Nonmetal	Main Uses
Carbon	In the form of diamond, it is used for making jewellery, cutting and grinding equipments. In the form of graphite it is used for making black lead pencils, and high temperature crucibles
Sulphur	For the manufacture of gun powder, Sulphuric acid and in the vulcanization of rubber
Phosphorus	For the manufacture of matchsticks, rat poison, phosphoric acid and fertilizers.
Oxygen	Supporter of combustion, for respiration by living organisms.
Nitrogen	For manufacturing ammonia, nitric acid etc.
Chlorine	For bleaching, sterilizing water, manufacturing chlorine compounds
Hydrogen	As a fuel, in oxygen-hydrogen flame used in welding For manufacturing ammonia, hydrogen chloride, vegetable ghee by hydrogenation of oils, and as a reducing agent.
Iodine	For preparing iodised common salt , tincture iodine is used as an antiseptic.

OXIDES OF METALS AND NONMETALS

Both metals and nonmetals react with oxygen (present in the air) to form oxides. The oxides of metals and nonmetals differ in their properties.

XI. Oxides of Metals

The oxides of metals are basic in nature. When dissolved in water, metal oxides give alkaline (or basic) solution which turn red litmus blue.

For example, magnesium (Mg) burns in air to give magnesium oxide (MgO), which is basic in nature.

2Mg	+	**O_2**	$\longrightarrow$	**2(MgO)**
Magnesium	+	Oxygen (from air)	$\longrightarrow$	Magnesium oxide (basic oxide)
MgO	+	**H_2O**	$\longrightarrow$	**$Mg(OH)_2$**
Magnesium oxide	+	Water	$\longrightarrow$	Magnesium hydroxide (basic in nature) turns red litmus blue

XII. Oxides of Nonmetals

The oxides of nonmetals are acidic in nature. When dissolved in water nonmetal oxides give acidic give solutions which turn blue litmus red.

For example, sulphur on burning in air, gives sulphur dioxide (SO_2) which is acidic in nature.

S	+	$\mathbf{O_2}$	$\longrightarrow$	$\mathbf{SO_2}$
Sulphur	+	Oxygen (from air)	$\longrightarrow$	Sulphur dioxide (acidic oxide)
$\mathbf{SO_2}$	+	$\mathbf{H_2O}$	$\longrightarrow$	$\mathbf{H_2SO_3}$
Sulphur dioxide	+	Water	$\longrightarrow$	Sulphurous acid (acidic in nature) turns blue litmus red

Table : Composition and Uses of Alloys

Name of the alloy	Composition	Uses
Steel	Iron + Carbon	Construction material, machine parts.
Stainless steel	Iron + Chromium + Nickel	For making cooking utensils and cutlery, surgical implements.
Brass	Copper + Zinc	For making cooking utensils, decorative statues, nuts and bolts.
Bronze	Copper + Tin	For making cooking utensils, coins, medals statues.
German silver	Copper + Zinc + Nickel	For making table ware.
Duralumin	Aluminium + Copper + Magnesium + Manganese	For making aircraft bodies, automobile parts.
Alnico	Aluminium + Nickel + Cobalt	For making magnets.
Gun metal	Copper + Tin + Zinc	For making gun-barrels

REACTIVITY SERIES OF METALS

(a) The more reactive metals always displace less reactive metals in chemical reactions. If a metal loses electrons easily to form positive ions, it will readily react with other substances. On the other hand if a metal loses electrons less rapidly to form a positive ion, it will react slowly with the other substances. Such a metal will be less reactive.

"The arrangement of metals in the order of decreasing reactivities is called the reactivity series or activity series of metals".

(b) **Utility of Activity Series:** The activity series is very useful and it gives the following informations:

(i) the metal which is higher in the activity series is more reactive than the other. Lithium is the most reactive and platinum is the least reactive metal.

(ii) The metals which have been placed above hydrogen are more reactive than hydrogen and can displace hydrogen from its compounds like water and acids to liberate hydrogen gas.

(iii) The metals which are placed below hydrogen are less reactive than hydrogen and cannot displace hydrogen from its compounds like water and acids.

(iv) A more reactive metal (placed higher in the activity series) can displace the less reactive metal from the solution of its salt.

(v) Metals at the top of the series are very reactive and, therefore, they do not occur free in nature, while the metals at the bottom of the series are least reactive and, therefore, they normally occur free in nature.

	Potassium	K	**Most reactive metal**
	Sodium	Na	
	Barium	Ba	
	Calcium	Ca	
	Magnesium	Mg	
Metal more	Aluminium	Al	
reactive	Zinc	Zn	
hydrogen	Iron	Fe	
	Nickel	Ni	
	Tin	Sn	
	Lead	Pb	
Hydrogen	**H**		
	Copper	Cu	
Metal less	Mercury	Hg	
reactive than	Silver	Ag	
hydrogen	Gold	Au	
	Platinum	Pt	**Least reactivity metal**

Reactivity Increases

Reactivity Decreases

COMPARISON BETWEEN METALS AND NONMETALS

	Metals	**Non Metals**
1	Metals form basic oxides or amphoteric oxides, some of which form alkalies.	Nonmetals form acidic or neutral oxides.
2	Metals displace hydrogen from acids.	Nonmetals do not displace hydrogen from acids.
3	With chlorine, metals form chlorides which are ionic compounds.	Nonmetals with chlorine form chlorides which are covalent in nature.
4	With hydrogen, few metals form hydrides which are ionic (electrovalent) in nature.	Nonmetals with hydrogen form stable covalent hydrides.
5	Metals are reducing agents.	Nonmetals are oxidising agents except carbon and hydrogen. Carbon and hydrogen are good reducing agents.

SOLVED EXAMPLES

Ex.1 What is galvanisation ? Why is galvanised iron considered better than tin plated iron ? Name the ore of iron which is used to make ships and bridges and give its composition.

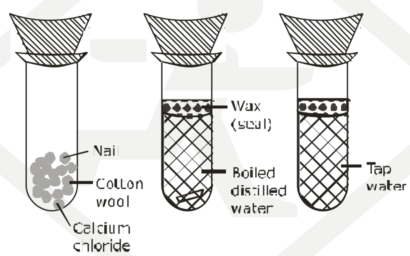
Sol. Galvanisation is the process of covering clean iron sheets with zinc by dipping them in molten zinc. Galvanised iron does not rust even if there is a scratch on the zinc layer but if the tin layer gets scratched, the iron starts rusting. Steel is used to make ships and bridges. Composition of steel –(Iron + 0.5 – 1.5 per cent carbon).

Ex.2 List different uses of metal in everyday life.

Sol. Metals are used for making
(i) machinery
(ii) automobiles, aeroplanes, trains, etc.
(iii) pins, cooking utensils, electrical gadgets.
(iv) electrical wires.
(v) thin sheets used for wrapping of food items, medicines, etc.

Ex.3 How will you show that rusting iron needs both the moisture and oxygen

Sol. Take three tubes with fresh iron nail in each. Place a small amount of anhydrous calcium chloride in the first test tube to dry the air. Fill the second test tube completely with boiled water from which dissolved oxygen has been completely removed. Add a small amount of water in the third test tube. Close the mouths of all the three test tubes using rubber stoppers. Keep them undisturbed for 3-4 days.



Rusting of iron

Observe the nails in the test-tubes. You will observe that the nails in the first and second test - tubes are free from rust while the nail in the third test tube has rusted. The above experiment shows that the presence of both air (oxygen) and water is essential for rusting.

Ex.4 Choose appropriate words from the bracket and complete the statements.
(a) Noble gases are found in (free state /compound forms)
(b) Non-metals are generally (malleable /brittle).
(c) Potassium after combustion will form (acidic oxide/ basic oxide).
(d) (Iodine / bromine) has antiseptic properties.
(e) German silver has (copper /silver) as major constituent

Sol. (a) Free state (b) Brittle (c) Basic oxide (d) Iodine (e) Copper

Ex.5 State whether the following statements are true or false :
(a) Sodium is more reactive than magnesium
(b) Magnesium reacts with cold water
(c) All metals exist in solid form at room temperature
(d) Gallium has a low melting point
(e) Gold is alloyed with copper to make it hard

Sol. (a) False (b) True (c) True (d) False (e) True

Ex.6 A set metals in order of their increasing chemical reactivity is given below : silver, copper, lead, iron ,zinc, magnesium and sodium.

(a) Which of the above metals is stored in kerosene ?

(b) Which metals will react with cold water ?

(c) Which gas will be liberated when metals react with cold water ?

(d) Which of the metals will react with oxgyen when heated ?

(e) Which of the metals become black in the presence of hydrogen sulphide ?

Sol. (a) Sodium (b) Sodium (c) Hydrogen (d) Zinc, magneiusm (e) silver

Ex.5 Some properties are listed in the following table. Distinguish between metals and non-metals on the basis of these properties.

S.No.	Properties	Metals	Non-metals
1	Appearance		
2	Hardness		
3	Malleability		
4	Ductility		
5	Heat conduction		
6	Conduction of Electricity		

Sol.

S.No.	Properties	Metals	Non-metals
1	Appearance	have metallic lustre	non- metals are dull
2	Hardness	hard	soft
3	Malleability	malleable	non- malleable
4	Ductility	ductile	not-ductile
5	Heat conduction	good conductors	bad conductor
6	Conduction of Electricity	good conductors	bad conductor/insulator

Ex.6 Give reasons for the following :

(i) Aluminium foils are used to wrap food items

(ii) Immersion rods for heating liquids are made up of metallic substances.

(iii) Copper cannot displace zinc from its salt solution

(iv) Sodium and potassium are stored in kerosene.

Sol. (i) Aluminium is highly malleable metal and it is very easy to make aluminium foil in compare to other metals.

(ii) Immersion rods are made up of metallic substances because metals are good conductors of heat and electricity.

(iii) Copper cannot displace zinc from its solution because zinc is more reactive than copper (i.e., copper is less reactive than zinc.)

(iv) Sodium and potassium metals are very reactive because they react with oxygen and water easily. A lot of heat is produced in the reaction so sodium and potassium are always stored in kerosene.

Ex.7 Can you store lemon pickle in an aluminium utensil? Explain.

Sol. No. this is because acids react with aluminium.

Ex.8 Match the substances given in Column-A with their uses given in Column-B.

S.No.	A	B
1	Gold	Thermometers
2	Iron	Electric wire
3	Aluminium	Wrapping food
4	Carbon	Jewellery
5	Copper	Machinery
6	Mercury	Fuel

Sol.

S.No.	A	B
1	Gold	Jewellery
2	Iron	Machinery
3	Aluminium	Wrapping food
4	Carbon	Fuel
5	Copper	Electric wire
6	Mercury	Thermometers

Ex.9 What happens when

(i) Dilute sulphuric acid is poured on a copper plate?

(ii) Iron nails are placed in copper sulphate solution?

Write word equations of the reactions involved.

Sol. (i) Copper sulphate is formed and hydrogen gas is liberated.

Copper + Sulphuric acid $\longrightarrow$ Copper sulphate + Hydrogen (gas)

(ii) Brown coating is deposited on the iron nails. This is because of the displacement of copper from copper sulphate solution by iron.

Iron + Copper Sulphate (solution) $\longrightarrow$ Iron sulphate (solution) + Copper

Ex.10 Saloni took a piece of burning charcoal and collected the gas evolved in a test tube.

(i) How will she find the nature of the gas?

(ii) Write down word equations of all the reactions taking place in this process.

Sol. (i) She will bring a wet litmus paper in contact with the gas. If the gas turns wet blue litmus paper into red, the gas will be acidic.

(ii) (a) Carbon + Oxygen $\longrightarrow$ Carbon dioxide.

(b) Carbon dioxide + Water $\longrightarrow$ Carbonic acid. (from wet litmus)

Ex.11 One day Reeta went to a jeweller's shop with her mother. Her mother gave an old gold jewellery to the goldsmith to polish. Next day when theybrought the jewellery back, they found that there was slight loss in its weight. Can you suggest a reason for the loss in weight?

Sol. The jeweller dip the jewellery in the solution of acid, which reacts with the outer covering of metals. Thus there is a net loss of weight in the metal of the ornament.

EXERCISE - I UNSOLVED PROBLEMS

Q.1 Give one example of each: metals and non-metals.

Q.2 Name the metal, which is the best conductor of heat and electricity.

Q.3 Name the property by which metals can be drawn into thin wires.

Q.4 Name the gas produced, when metals react with acids.

Q.5 What is the colour of the copper sulphate solution ?

Q.6 State the nature of oxides of non-metals.

Q.7 Which metal is stored in kerosene ?

Q.8 Name the property of the metal by which it can be drawn into thin sheets.

Q.9 What happens when sulphur reacts with oxygen ?

Q.10 Which non-metal catches fire, if exposed to air ?

Q.11 Name the gas that burns with a POP sound.

Q.12 What are Displacement reactions ?

Q.13 Give one use of non-metal in our daily life.

Q.14 What are metalloids ?

Q.15 Which metal is use to wrap food items

Q.16 What happens when sulphur di-oxide reacts with water ? Give the chemical reaction involved.

Q.17 Why lemon pickle cannot be stored in an aluminium foil ?

Q.18 Write two important properties of metals.

Q.19 Why copper cannot displace zinc from zinc sulphate solution ?

Q.20 Why immersion rods for heating are made up of metallic substances ?

Q.21 What happens when iron nails are dipped in water in a test tube for a week ?

Q.22 What happens when iron reacts with oxygen and water ? Give the chemical reaction involved.

Q.23 What happens when copper vessel is exposed to moist air for a long time ? Give the chemical reaction that takes place.

Q.24 Why gold is preferred in making jewellery

Q.25 What happens when dilute sulphuric acid is poured on a zinc plate ? Write the chemical reaction takes place.

Q.26 What happens when magnesium ribbon is burnt in air ?

Q.27 Why metals are used in making aeroplanes, bridges, satellites etc.

Q.28 Complete the following chemical reactions.

(i) $Zn + H_2SO_4 \rightarrow$

(iv) $2Cu + H_2O + CO_2$

(ii) $2Fe + O_2 + H_2O \rightarrow$

(v) $SO_2 + H_2O \rightarrow$

(iii) $Cu + HCl \rightarrow$

Q.29 what will happen when ash of magnesium is dissolved in water ? Is the solution acidic or basic ? What effect does litmus show in case of oxides of metals ?

Q.30 Explain the following terms :

(i) Malleability (ii) Ductility (iii) Sonorous (iv) Lustrous (v) Metalloids.

Q.31 Gold dissolves in (aqua regia / aqueous solution of silver nitrate).

Q.32 Silver tarnishes due to (nitrogen oxides / hydrogen sulphide) in the air.

Q.33 Name the components of stainless steel.

Q.34 what are the constituents of bronze ?

Q.35 Define the term alloy.

Q.36 What are the components of solder ?

Q.37 What do you understand by the term corrosion ?

Q.38 Describe the process of galvanization.

Q.39 What is the action of water on :

(i) Magnesium (ii) Sodium (iii) Iron

Q.40 What type of oxides are formed by non - metals ?

Q.41 What is the advantage of using stainless steel for making utensils as compared to iron

Q.42 Give the composition of brass.

Q.43 Define rusting.

Q.44 How can bridges be protected from rusting

Q.45 How are machines protected from rusting ?

Q.46 Name the alloy of aluminium and magnesium.

Q.47 What name is given to the alloy fo almminium copper, manganese and magnesium ?

Q.48 Name the soft metal which can be cut with a knife.

Q.49 Name the non-metal used in vulcanization.

Q.50 Name one non-metal which has lustre.

Q.51 Name one non-metal which is good conductor of electricity.

Exercise - II OLYMPIAD PROBLEMS

Q.1 Who classified the elements in metals and non-metals?
(A) Lavoisier (B) Priestley
(C) Lemaitre (D) Lenoir

Q.2 Which of the following metals occur in their pure state?
(A) Copper (B) Iron
(C) Zinc (D) Gold

Q.3 Which of the following metals is liquid at room temperature?
(A) Sodium (B) Mercury
(C) Zinc (D) Aluminium

Q.4 Which of the following is a good conductor of heat?
(A) Bromine (B) Chlorine
(C) Mercury (D) Iodine

Q.5 Which of the following non-metals occurs as liquid?
(A) Bromine (B) Sulphur
(C) Iodine (D) Carbon

Q.6 Which of the following non-metals occurs as a solid?
(A) Sulphur (B) Carbon
(C) Iodine (D) All of the above

Q.7 Which of the following non-metal occurs as a gas?
(A) Nitrogen (B) Chlorine
(C) Both the above (D) None of the above

Q.8 Which of the following metals has very low melting point and melts even in hand?
(A) Sodium (B) Gallium
(C) Potassium (D) Graphite

Q.9 Which of the following is lighter than water?
(A) Potassium (B) Sulphur
(C) Iodine (D) Graphite

Q.10 Which of the following is denser than many metals?
(A) Bromine (B) Chlorine
(C) Sulphur (D) Iodine

Q.11 Which non-metal is a good conductor of electricity?
(A) Bromine (B) Iodine
(C) Graphite (D) Chlorine

Q.12 Magnesium oxide is –
(A) Basic oxide (B) Acidic oxide
(C) Neutral oxide (D) None of these

Q.13 Sulphur dioxide is –
(A) Basic oxide (B) Acidic oxide
(C) Neutral oxide (D) None of these

Q.14 Which of the following is a noble metal?
(A) Copper (B) Iron
(C) Gold (D) Aluminium

Q.15 When medium reacts with cold water, it forms–
(A) Sodium hydroxide and oxygen
(B) Sodium hydroxide and hydrogen
(C) Sodium hydroxide and carbon dioxide
(D) None of these

Q.16 Which of the following is very reactive and kept in kerosene?
(A) Iodine (B) Bromine
(C) Sodium (D) Potassium

Q.17 Which of the following reacts violently with steam?
(A) Iron (B) Zinc
(C) Magnesium (D) None of these

Q.18 Which metal reacts with dilute hydrochloric acid to produce hydrogen?
(A) Zinc (B) Copper
(C) Iron (D) Platinum

Q.19 When zinc is put in copper sulphate solution, the colour of copper sulphate becomes –
(A) Greenish (B) Yellowish
(C) Brownish (D) Colourless

Q.20 When iron nail is placed in copper sulphate solution, the bluish colour of copper sulphate turns –
(A) Brownish (B) Yellowish
(C) Greenish (D) Colourless

ANSWER KEY

1.	A	**2.**	D	**3.**	B	**4.**	C
5.	A	**6.**	D	**7.**	C	**8.**	B
9.	A	**10.**	D	**11.**	C	**12.**	A
13.	B	**14.**	C	**15.**	B	**16.**	C
17.	C	**18.**	A	**19.**	D	**20.**	C

CELL AND TISSUE

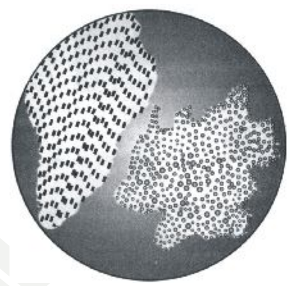
INTRODUCTION

A cell is the structural and functional unit of life. It is the building block of which all living organisms are made, and the smallest unit of life capable of all the living functions. It is defined as a mass of protoplasm bounded by a plasma membrane.

Cell vary in size. Most cells are very small (microscopic), some may be very large. Some cells may exist as independent units of life. Some such cells like Euglena and Amoeba can change their shape, but most cells have a fixed shape. The number of cells vary from organism to organism. An amoeba is single-celled, while a human body weighing about 60 kg may have as many as 60×10^{15} cells. In unicelluar organisms, e.g. Amoeba, Paramoecium or Chalamydomonas, all the basic functions of a living being are performed in one cell, while multicellular organisms have well-developed division of labour. So, their different functions are performed by different organs. For example, we have a stomach to digest food, a heart to pump blood and a brain to think.

An English scientist, Robert Hooke, discovered the cell in 1665 while examining thin sections of cork under his simple microscope. He observed a mass of hexagonal chambers like a honeycomb and called them(compartments) cells. Cell is the Latin word for 'a little room'.

DISCOVERY OF CELL

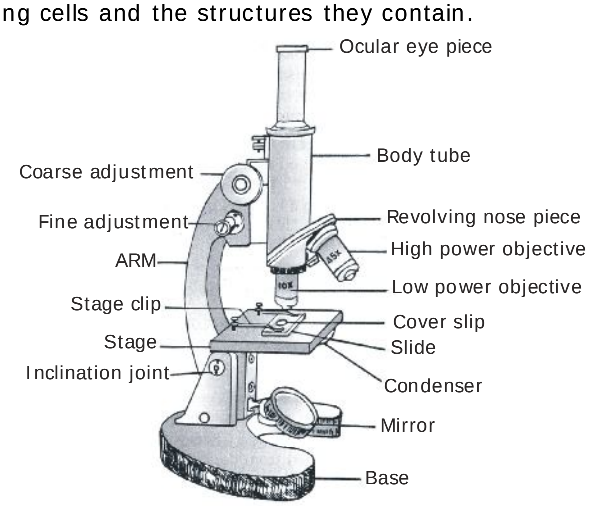


Cork section shown in Robert Hooke's Microscope

1. Robert Hooke (1665) :– An English man and first curator of Royal society of London.
   Observed a thin transverse section of bark of a tree under self designed microscope.
   He noticed honey - comb like compartments.
   He coined the term cell.
   He wrote a book - Micrographia.
   He actually observed dead cells.
2. Antony Van Leeuwenhoek (1674) was first to observe living cells like bacteria [from tartar of teeth] erythrocytes [fish], sperms and protozoans [eg. Vorticella]
3. N. Grew (1682) :– Proposed cell concept which states that cell is unit of structure of organisms.
4. Rudolf Virchow (1858) :– Proposed that new cells formed from the pre-existing cells.

MICROSCOPE

A microscope is an instrument to view small objects by magnifying them. It enables us to see the different types of living cells and the structures they contain.

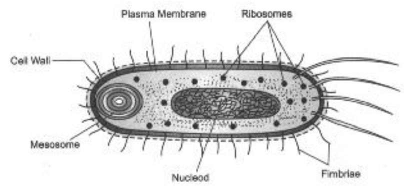


Parts of an ordinary compound microscope

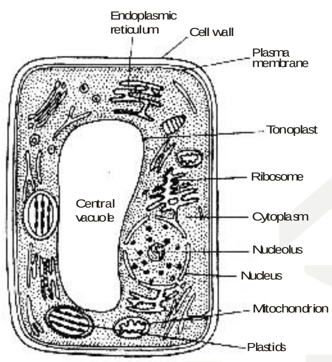
TYPES OF MICROSCOPES

There are mainly three types of microscopes. They are :

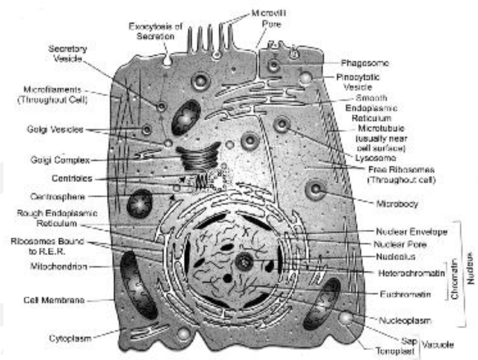
- Light microscope : The light microscope uses light to produce images.
- Transmission Electron Microscope (TEM) : The electron microscope was designed by Knoll & Ruska (1932). A TEM makes use of a beam of highly energetic electrons to examine objects. The image produced is of a very fine scale.
- Scanning Electron Microscope (SEM) : Like the TEM, the SEM also uses electrons to produce images. In the case of a SEM, electrons are reflected off the surface of the specimen, because of which SEM images usually manage to capture the physical features of a cell in great detail.



Bacterial cell



Plant cell



Animal cell

STRUCTURE OF A CELL

- **Cell membrane or plasma membrane:**

  A cell is essentially a tiny 'bag' of living matter. The covering of this 'bag' is called the cell membrane or plasma membrane. It maintains the shape and size of the cell and protects its contents. It acts like a sentry-allowing only some things to enter and leave the cell and stopping others. For example, it allows oxygen and nutrients to pass into the cell and lets wastes pass out of it. This is why it is called selectively permeable.

- **Cell wall:**

  Plant cells have an additional protective wll called the cell wall. It is thick, rigid and permeable, and is made up of a carbohydrate called cellulose.

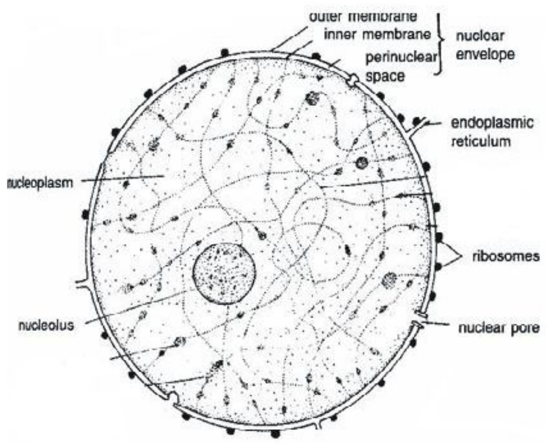
- **Cytoplasm :**

  The matter inside the cell mebrane is called cytoplasm. It consists of a jellylike fluid with various structures, such as the nucleus, floating in it. These structures are called organelles.

  Salts, proteins, sugar and other substances are dissolved in the fluid.

- **Nucleus:**

  Almost every cell has a nucleus. Red blood cells are among the exceptions. The nucleus is the largest and the most important organelle of the cell. It is usually spherical or oval in shape. Inside it there are thread like structures called chromosomes. Nucleus is the controlling central cell. Chromosomes have genes arranged in a linear fashion.



It is the most important part of the living cell.
It is usually spherical or oval in shape.
It controls all the vital functions of the cell.
It has four components:

(i) Nulcear Membrane (ii) Nulceoplasm
(iii) Nulceolus (iv) Chromosomes

(i) Nuclear membrane: Surrounds the nucleus and separates it from the cytoplasm. It is permeable and controls the passage of materials between cytoplasm and nucleoplasm

(ii) Nucleoplasm: The part of protoplasm which is enclosed by nuclear membrane is called nucleoplasm. It contains chromatin threads and nucleolus.

(iii) Nulceolus: It is a spherical body in the nucleus. It is composed of RNA and is responsible for protein synthesis.

(iv) Chromosomes: Nucleus contains thread like structures called chromosomes.

The hereditary units of chromosomes are the genes. They are responsible for the transmission of characters from parents to the offsping.

Nucleus along with tis role in inheritance regulates and controls differeny metabolic activities of the cell.

On the basis of well organised nucleus, cells can be of two types

(i) Prokaryotic cell (ii) Eukaryotic cell

(i) Prokaryotic cells: These are cells having primitive nucleus without nuclear membrane. Organism with primitive nucleus are known as prokaryotes.
Ex. Bacteria and blue green algae.

(ii) Eukaryotic cells: These are cells having a well organised nucleus with nuclear membrane. Organsims with true nucleus are known as eukaryotes.
Ex. Man, elephant, onion.

◆ **Vacuoles:**

The central part of most plant cells is occupied by a large vacuole. You may have noticed it in some of the plant cells you observed. It is a sac like structure filled with fluid. Food, wastes pigments and other substances are dissolved in the fluid. Some plant cells have a number of large vacuoles.

Vaculoes are not so common in animal cells. When they ocour, they are much smaller in size.

◆ **Plastids:**

These organelles are not present in animal cells. Chloroplasts (a type of plastid) contain the green pigment chlorophyll and are responsible for photosynthesis. Only green parts of plants have chloroplasts.

There are two other types of plastids called chromoplasts and leucoplasts. Chromoplasts contain pigments which give fruits and flowers their colours. Leucoplasts store food and are found in the storage organs of plants.

- **Endoplasmic reticulum (ER)**

The endoplasmic reticulum is a network of tube-like structures running through the cytoplasm. If ribosomes are attached to it, the reticulm is rough, otherwise it is smooth.

Function - It gives internal support to the colloidal matrix (cytoplasm).

Rough endoplamic reticulum (RER) is associated with the synthesis of proteins.

- **Ribosomes**

Ribosomes are extremely amall, round bodies found either in the state in the cytoplasm or attached to the surface of the ER. They are composed of ribonucleoprotein (ribonucleic acid and protein).

Functions - The main function of ribosomes is to act as a platform or work place for the synthesis of proteins.

- **Mitochondria**

Mitochondria are small, rod shaped organelles found in large numbers. Each mitochondrion is bounded by two membranes-outer and inner. The outer membrane is smooth and the inner membrane is pushed inwards at intervals forming crests called cristae. The cristae lie in a ground substane called matrix. Mitochondria process enzymes necessary for the oxidation of carbohydrates. This process releases energy in the form of ATP. This is why mitochondria are known as the powerhouses of the cell. Mitochondria have their own DNA and ribosomes. They can synthesize their own proteins and thus they are semiautonomous organelles. Function- Mitochondria provide energy for the vital activities of living cells.

- **Golgi body**

They store, modify, package and condense the proteins synthesized in the ribosomes.

- **Lysosomes**

These saclike, small spherical, single membrane-bound vesicles contain enzymes. These enzymes are synthesized in the RER, which are brought to the Golgi complex. Lysosomes are formed by the Golgi complex. They occur in animal cells and in the meristematic cells of a few plants. Function- They help in breaking down (digesting) large molecules of the cell. They work in defence againt bacteria and viruses. During stavation, lysosomes act on their own cellular organelles and digest them. This results in cell death. Hence lysosomes are called suicide bags or demonlition squads.

- **Centrioles**

The centrosome is a distinct region of the cytoplasm close to the nucleus of animal cells. It usually has two central granules called centrioles. The centrioles are hollow, cylindrical structure made of microtubules arranged in a specific manner. They are arranged at right angles to each other.

Function- At the time of cell division, centrioles move to the poles and form spindle fibre which help in the movement of chromatids (daughter chromosomes) in the daughter cells. They help in the formation of cilia and flagella.

- **Movement of subtances across the cell membrane**

- **Diffusion:**

Diffusion is the process of mixing up or different substances due to the random motion of their component atoms, molecules and ions. Diffusion takes place in solids, liquids and gases.

Ex. Burning of incense stick.

- **Osmosis:**

Diffusion of water across a semipermeable membrane is called Osmosis. The movement of water in living beings depends on osmosis. The movement of water molecules across the cell membrane is affected by the amount of solute dissolved in it. Here also the water molecules are free to pass across the membrane in both directions. But the net movement of water molecules takes place from the dilute solution to the concentration one, i.e., from the region of greater concentration of water towards the region of lower concentration of water.

Ex. Grains in water.

Plant Tissues

Plant tissue are basically of two types-meristematic and permanent. This differentiation is based on the ability of the mature cells of the tissue to divide and produce new cells. Meristematic tissue cells are capable of dividing, while permanent tissue cells are not.

Meristematic Tissue

This tissue consists of actively dividing cells and is present in the growing regions of plants, e.g., the tips of roots and stems. The cells can be round, oval, polygonal or rectangular, but there are a few things they have in common. They are packed closely without intercellular spaces, have thin cellulose walls, dense cytoplasm and prominent nuclei. Vacuoles are almost absent in such cells because they are completely filled with sap. Depending on the region of the plant where it is present, meristematic tissue can be of three types- apical, lateral and intercalary.

Apical (from apex) meristem, as the name suggests, is present at the growing tips of stems and roots. Apical meristem is primary meristem.

Lateral meristematic tissue occurs along the sides of the cental (longitudinal) axis of the plant. It gives rise to vascular tissues.

Intercalary meristem occurs at the base of leaves or internodes. These cells grow fast and soon change into permanent tissues.

Permanent Tissue

The division and differentiation of the cells of meristematic tissues given rise to permanent tissues. Cell division is the formation of two or more daughter cells from one mother cell. Simple permanant tissue consist of similar permanent cells that perform the same function or a similar set of functions. Parenchyma, collencyma and sclerenchyma are three types of simple permanent tissues. Complex permanent tissue are a group of different types of cells that perform a common function. Xylem and phloem are two types of complex permanent tissue.

Parenchyma

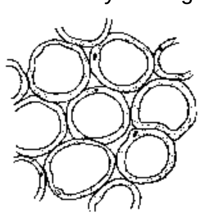
This tissue is composed of large, thin-walled cells which are generally oval or spherical. The cells are not packed closely, i.e., there are intercellular space. These living cells with a nucleus and a vacuole are found in the soft parts of the plant. They store food, fill up spaces between other tissue and provide temporary support to the plant. When they contain chloroplasts, as in leaves, they help manufacture food.

Collenchyma

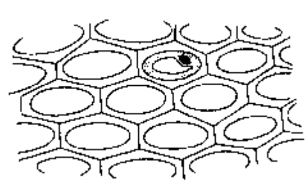
This tissue is composed of cells that are elogated and thickened with cellulose at the corners. There is no intercellular space. Collenchyma provides mechnical support to plant organs and is found in leaf stalks and below the epidermis of stems. It helps leaves and stems bend without breaking. It provides support, protection and flexibility ot plant organs. It is generally absent in roots.

Sclerenchyma

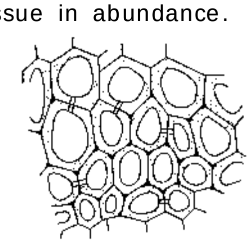
This tissue is composes of long, narrow cells whose walls are evenly thickened with lignin. Lignin is a chemical that acts like cement, sticking fibres and hardening them. Sclerenchyma cells are dead. They are packed together closely, and provide strength and flexibility to plant parts. They are present in stems, veins of leaves, the hard covering of seeds and nuts, and the husk of coconut. Fibre-yielding plants like jute and flax contain this tissue in abundance.



Parenchyma



Collenchyma



Sclerenchyma

- **Xylem**

Xylem, or wood, as it is often called, is a complex tissue. The cells are thick-walled, tubular and often dead. This tissue has four types of cells– tracheids, vessels, xylem parenchyma and xylem fibres. Of these only tracheids and vessels transport sap.

- **Phloem**

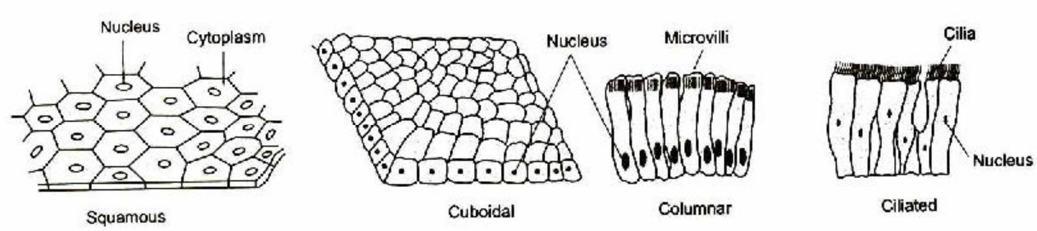
Phloem too is a complex tissue made up of four types of cells, or elements–sieve tubes, companion cells, phloem fibres and phloem parenchyma. It is not necessary for the phloem to contain all four types of cells. Phloem to contain all four types of cells. Phloem cells are living cells (except phloem fibres) which help transport food from leaves to the storage organs and growing regions of the plant.

- **Animal Tissues**

While doing the activities in this chapter, you have come across two types of animal tissue, the cheek cells are a type of epithelial tissue, while blood is a kind of connective tissue. There are two other types of animal tissue–muscular and nervous.

- **Epithelial Tissue:**

This tissue covers the surface of the body and lines the internal organs. Its main function is protection. The cells that form the different types of epithelial tissue differ in shape. Some are thin and flat, some cubelike, while others are columnar.



- **Connective Tissue:**

Blood, bones cartilages, tendons (which connect muscles with bones) and ligaments (which tie bones together) are diferent types of connective tissue. Adipose tissue, or what is generally known as fat, is also a kind of connective tissue. Though different in structure, connective tissues have one thing in common-the cells are suspended or embedded in a matrix. In blood, the matrix is liquid and is called the plasma.

- **Muscular Tissue:**

Muscular tissue is also of different types. However, the different types of muscular tissue (or muscles) have the same basic functoin. They contract and relax to make different parts of the body move. The muscles in our arms, legs thighs, back and so on help us move. The muscles in the heart help it pump blood. The muscles in the alimentary canal help the passage of food. The muscles in the blood vessels help them dilate and get constricted.

- **Nervous Tissue:**

Nerve cells make up nervous tissue. A nerve cell has a long tail and short branches coming out of it.The tail too has branches. These help to carry message from one cell to the other. The brain and spinal cord are make up of nervous tissue.

Differences between prokaryotic & Eukaryotic cells

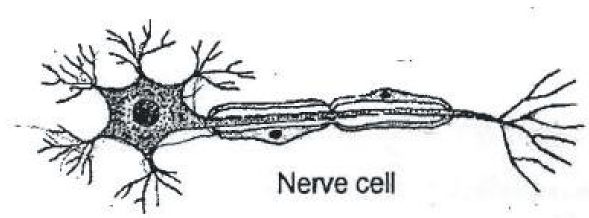
Feature	Prokaryotic cell	Eukaryotic cell
Cell size	Average diameter 0.5 - 50m	Diameter varies between. 10m - 40m.
Nucleus	Lacks true nucleus; Nucleolus and nuclear membrane are absent and contains circular DNA.	True nucleus bound by nuclear membrane contains linear DNA nucleolus and nudear membrane present.
Organelles	Membrane-bound organellers like Golgi bodies, platids, mitrochondria and endoplasmic reticulum (ER) are absent	Membrane bound organelles present.
Ribosomes	Smaller and randomly scattered in the cytoplasm	Bigger, can be free or attached to the ER.
Photosynthesis	No organized choloroplast; photosynthesis takes place on photosynthetic membranes which life freely in the cytoplasm.	Organized chloroplasts (containing stacked membranes called grana) take part in photosynthesis
Examples	Bacteria and cyanobacteria (blue green algae)	All other organisms.

Differences between Plant cell & animal cell

	PLANT CELL	ANIMAL CELL
1.	Plant cells are usually larger than animal cells	Animal cells are generally small in size.
2.	The plasma membrane of a plant cell is surrounded by a rigid cell wall made up of cellulose.	Cell wall is absent.
3.	Plastids (leucoplasts, chloroplasts, chromoplasts) are present in plant cells.	Plastids are absent.
4.	Vacuoles are present in abundance. They are larger in size.	Vacuoles are less in number and smaller in size.
5.	Plant cells have many simpler units of Golgi complex, called **dictyosomes**.	Animal cells have a single highly elaborate Golgi complex.
6.	Centrioles have not been found in plant cells (except in a few lower plants.	Animal cells possess centrioles.
7.	Cytokinesis takes place by cell-plate formation.	Cytokinesis takes place by constriction during cell division.
8.	Plant cells usually have a regular shape.	Animal cells are usually irregular in shape.

NCERT QUESTIONS WITH SOLUTIONS

Q.1 Make a sketch of the human nerve cell. What funtion do nerve cells perform?



Ans. Functions of human nerve cell:
(i) Nerve cells receive message from different parts of body.
(ii) They further transfer these messages to brain and accordingly brain send commands for functioning of different organs of body.

Q.2 Write short notes on the following:
(i) Cytoplasm (ii) Nucleus of a cell

Ans. (i) Cytoplasm : Cytoplasm is a jelly like substance which is present between the cell membrane and the nucleus. Various other organelles of cells are present in the cytoplasm. Cytoplasm is made up of chemical substances like carbohydrates, proteins and water. These chemical substances are present in cells of all types and sizes. Cytoplasm contains many important tiny substances called Organelles.
(ii) Nucleus of a cell: Nulceus is the master of the cell. It commands all the functioning of the cell. It is generally located in the center of the cell and is spherical in shape. A membrane called nuclear membrane separates it from cytoplasm. It contains the genetic material DNA and RNA in it. This porous membrane allows the transfer of material in the nucleus and cytoplasm. Nucleus contains a dense body called Nucleolus which actually contains Chromosomes, the genetic material.

Q.3 Which part of the cell contains organelles?
Ans. Cytoplasm.

Q.4 State a difference between eukaryotes and prokaryotes.
Ans. Prokaryotes do not have a well designed nuclear membrane while, eukaryotes have a well designed nuclear membrane.

Q.5 Where are the chromosomes found in cell? State their functions?
Ans. Chromosomes are found in the nucleus of a cell. Their function is to carry characteristic features of parent cells to the daughter cell means, from parent to offspring.

Q.6 Cells are the basic structural units of living organism. Explain.
Ans. In Biology, the basic unit of which all living thins are composed is knows as cell. The cell is the smallest structural unit of living matter that is capable of functioning independently. A single cell can be a complete organism in itself, as in bacteria and protozoans. A unicellular organism also captures and digests food, respires, excretes, grows, and reproduces. Similar functions in multi-cellular organisms are carried out by groups of specialized cell which are organized into tissues and organs such as, the higher plants and animals. Hence, 'cell' is known as the basic structural and functional unit of life.

Q.7 Explain why chloroplast are found only in plant cells.
Ans. Chloroplasts are found only in plant cells because they are required for photosynthesis.

EXERCISE - I UNSOLVED PROBLEMS

Q.1 Name the four types of animal tissue

Q.2 What is the importance of ribosomes?

Q.3 What is the function of mitochondria?

Q.4 Name the following:

(a) structural and function unit of life

(b) powerhouse of the cell

Q.5 Who discovered the cell and when ?

Q.6 Name two multicellular organisms.

Q.7 What are pseudopodia ?

Q.8 Mention three different shapes of cells in human body.

Q.9 Which part of the cell gives the shape to a cell.

Q.10 What are chromosomes ?

Q.11 Write the name of unit of inheritance in livings.

Q.12 Name the part of cell which help in control of the activities.

Q.13 Write the name of pigment found in chloroplasts.

Q.14 Why is the plasma membrane called selectively permeable

Q.15 Why lysosomer are called suicidal bags?

Q.16 How many types of organisms on the basis of number of cells ?

Q.17 What are tissues ?

Q.18 Why are mitochondria called the power house of the cell?

Q.19 What are the basic differences between plant cells and animal cells?

Q.20 Name the structural unit of an organism.

Q.21 Write the functions of cell wall.

Q.22 Explain the position and functions of a nucleus in a cell.

Q.23 How is rough ER different from smooth ER? What functions do they perform in a cell?

Exercise - II OLYMPIAD PROBLEMS

Q.1 Centriole is associated with –
(A) DNA synthesis
(B) Reproduction
(C) Spindle formation
(D) Respiration

Q.2 The cell organelle associated with cell secretion is
(A) Plastids (B) Mitochondria
(C) Golgi apparatus (D) Nucleolus

Q.3 Which of the following is an inclusion?
(A) Mitochondrion (B) Lysosome
(C) Golgi complex (D) Starch grain

Q.4 Which of the following would not be considered part of a cell's cytoplsm?
(A) Ribosome (B) Nucleus
(C) Mitochondrion (D) Microtubule

Q.5 Which of the following is called the brain of the cell?
(A) Nucleus (B) Mitochondria
(C) Ribosomes (D) Plasma membrane

Q.6 Which one is not a part of nucleus?
(A) Chromatin (B) Nucleolus
(C) Centrosome (D) Nucleoplasm

Q.7 The common feature amongst nucleus, chloroplast and mitochondrion is –
(A) DNA (B) Lamellae
(C) Cristae (D) All of these

Q.8 Nucleus is separated from surrounding cytoplasm by a nuclear envelope which is –
(A) Single and porous
(B) Double and porous
(C) Single and nonporous
(D) Double and nonporous

Q.9 Nucleoplasm is continuous with cytoplasm through –
(A) Centriole
(B) Golgi apparatus
(C) Nuclear pores
(D) Endoplasmic reticulum

Q.10 Nucleolus was discovered by
(A) Fontana (B) Schleiden
(C) Altmann (D) Robert Brown

Q.11 The function of the nucleolus in the cell is
(A) Secretory
(B) Synthesis of DNA
(C) Synthesis of RNA and ribosomes
(D) None of these

Q.12 Which of the following phenomena is commonly referred as 'cell drinking'?
(A) Exocytosis
(B) Pinocytosis
(C) Endocytosis
(D) Phagocytosis

Q.13 The cell organelle taking part in photorespiration is:
(A) Glyoxysome
(B) Dictyosome
(C) Peroxisome
(D) Endoplasmic reticulum

Q.14 Endoplasmic reticulum sometime contains –
(A) Ribosomes (B) Lysosomes
(C) Golgi bodies (D) None of these

Q.15 Ribosomes are composed of –
(A) 1 subunit (B) 5 subunits
(C) 2 subunits (D) 4 subunits

Q.16 Double membrane is absent in –
(A) Mitochondrion (B) Chloroplast
(C) Nucleus (D) Lysosome

Q.17 Animal cell is limited by–
(A) Plasma membrane
(B) Shell membrane
(C) Cell wall
(D) Basement membrane

Q.18 The radiant energy of sunlight is converted to chemical energy and stored as –

(A) AMP (B) ADP

(C) ATP (D) APP

Q.19 Root hair absorbs water from soil through –

(A) Osmosis (B) Active transport

(C) Diffusion (D) Endocytosis

Q.20 The barrier between the protoplasm and outer environment in a plant cell is –

(A) Cell membrane (B) Nuclear membrane

(C) Cell wall (D) Tonoplast

Q.21 An animal cell differs from a plant cell in respect of –

(A) ER (B) Cell wall

(C) Ribosomes (D) Cell membrane.

Q.22 If the nucleus is a cell's "control centre" and chloroplasts its "solar collectors". Which of the following might be called the cell's combination "food processor" and "garbage disposer"?

(A) Lysosome (B) Ribosome

(C) Golgi apparatus (D) Nucleolus

Q.23 The longest cell in human body is –

(A) Neuron (B) Muscle fibre

(C) Epithelial cell (D) Bone cell

Q.24 Identify human cells which lack nucleus–

(A) WBC (B) RBC

(C) Platelets (D) Nerve cells

Q.25 The energy currency of a cell is –

(A) ADP (B) AMP

(C) ATP (D) CTP

Q.26 Which organelle releases oxygen?

(A) Ribosome (B) Golgi apparatus

(C) Mitochondria (D) Chloroplast.

Q.27 The term "protoplasm" to the living substance present inside the cell, was given by

(A) Robert Hooke

(B) Robert Brown

(C) J.E. Purkinje

(D) W.Flemming

Q.28 Ribosomes are the centre for –

(A) Respiration

(B) Photosynthesis

(C) Protein synthesis

(D) Fat synthesis.

Q.29 Lysosomes are the reservoirs of

(A) Fat

(B) RNA

(C) Secretory glycoproteins

(D) Hydrolytic enzymes.

Q.30 The membrane surrounding the vacuole of a plant cell is called

(A) Tonoplast

(B) Plasma membrane

(C) Nuclear membrane

(D) Cell wall

ANSWER KEY

1.	C	**2.**	C	**3.**	D	**4.**	B
5.	A	**6.**	C	**7.**	A	**8.**	B
9.	C	**10.**	A	**11.**	C	**12.**	B
13.	C	**14.**	A	**15.**	C	**16.**	D
17.	A	**18.**	C	**19.**	A	**20.**	C
21.	B	**22.**	A	**23.**	A	**24.**	B
25.	C	**26.**	D	**27.**	C	**28.**	C
29.	D	**30.**	A				

RATIONAL NUMBERS & RADICALS

DEFINITION

A number $\frac{a}{b}$ is a rational number if 'a' and 'b' are integers and 'b' is not equal to zero. 'b' cannot be equal to zero because division by zero is not allowed. Further, a rational number is said to be in the standard form or simplest form when the numerator and denominator have no common factor other than 1.

PROPERTIES OF ADDITION OF RATIONAL NUMBERS CLOSURE PROPERTY

When two rational numbers are added, the result is always a rational number, i.e., if $\frac{a}{b}$ and $\frac{c}{d}$ is always a rational number. For example, $\frac{2}{5} + \frac{3}{6} = \frac{12+15}{30} = \frac{27}{30}$, which is also a rational number.

COMMUTATIVE PROPERTY

When two rational numbers are added, the order of addition does not matter, i.e., if $\frac{a}{b}$ and $\frac{c}{d}$ are two rational numbers, then $\frac{a}{b} + \frac{c}{d} = \frac{c}{d} + \frac{a}{b}$

For example, $\frac{3}{4} + \frac{4}{5} = \frac{15+16}{20} = \frac{31}{20}$ and $\frac{4}{5} + \frac{3}{4} = \frac{16+15}{20} = \frac{31}{20}$. Both results are equal.

ASSOCIATIVE PROPERTY

If $\frac{a}{b}$, $\frac{c}{d}$, and $\frac{e}{f}$ three rational numbers, then $\left(\frac{a}{b}+\frac{c}{d}\right) + \frac{e}{f} = \frac{a}{b} + \left(\frac{c}{d}+\frac{e}{f}\right)$. Consider the fractions $\frac{2}{5}$, $\frac{1}{4}$, and $\frac{2}{3}$.

$$\left(\frac{2}{5}+\frac{1}{4}\right)+\frac{2}{3},\quad \frac{2}{5}+\left(\frac{1}{4}+\frac{2}{3}\right)$$

$$= \left(\frac{8+5}{20}\right)+\frac{2}{3} = \frac{2}{5}+\left(\frac{3+8}{12}\right)$$

$$= \frac{13}{20}+\frac{2}{3} = \frac{2}{5}+\frac{11}{12} = \frac{39+40}{60}$$

$$= \frac{24+55}{60} = \frac{79}{60} = \frac{79}{60}$$

Additive identity If $\frac{a}{b}$ is a rational number, then there exists a rational number zero such that $\frac{a}{b} + 0 = \frac{a}{b}$. Zero is called the identity element of addition. Addition of zero does not change the value of the rational number.

Additive identity

If $\frac{a}{b}$ is a rational number, then there exists a rational number $\left(\frac{-a}{b}\right)$, called the additive inverse, such that $\frac{a}{b}+\left(\frac{-a}{b}\right)= 0$

The additive inverse is also referred to as 'negative' of the given number..

SUBTRACTION OF RATIONAL NUMBERS

When we have to subtract a rational number, say $\frac{5}{9}$ from $\frac{8}{9}$, we add the additive inverse of $\frac{5}{9}$, i.e., $\frac{-5}{9}$ to $\frac{8}{9}$. Thus, $\frac{8}{9} - \frac{5}{9} = \frac{8}{9} + \left(\frac{-5}{9}\right) = \frac{8-5}{9} = \frac{3}{9} = \frac{1}{3}$

MULTIPLICATION OF RATIONAL NUMBERS

Multiplication is the process of successive addition.

Like 6 × 8 = 8 + 8 + 8 + 8 + 8 + 8 = 48.

Similarly, $6 \times \frac{1}{3} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} + \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{6}{3} = 2$

Alternatively, $6 \times \frac{1}{3} = \frac{6}{1} \times \frac{1}{3} = \frac{6\times 1}{1\times 3} = \frac{6}{3} = \frac{2}{1}\, 2$

So, when we multiply two rational numbers, we multiply the numerator with the numerator and the denominator with the denominator.

Thus, $-5 \times (-7) = \frac{-5}{1} \times \left(\frac{-7}{1}\right) = \frac{(-5)(-7)}{1\times 1} = 35$

and $\frac{-2}{11} \times \frac{3}{5} = \frac{-2\times 3}{11\times 5} = \frac{-6}{55}$

PROPERTIES OF MULTIPLICATION OF RATIONAL NUMBER CLOSURE PROPERTY

The rational number are closed under multiplication. It means that the product of two rational numbers is always a rational number, i.e., if $\frac{a}{b}$ and $\frac{c}{d}$ are two rational numbers, $\frac{a}{b} \times \frac{c}{d} = \frac{ac}{bd}$ is always a rational number.

For example, $\frac{-3}{7} \times \frac{5}{8} = -\frac{15}{56}$ which is rational number.

COMMUTATIVE PROPERTY

If $\frac{a}{b}$ and $\frac{c}{d}$ are two rational numbers, then $\frac{a}{b} \times \frac{c}{d} = \frac{c}{d} \times \frac{a}{b}$, i.e., $\frac{ac}{bd} = \frac{ca}{db}$

ASSOCIATIVE PROPERTY

If $\frac{a}{b}, \frac{c}{d}$, and $\frac{e}{f}$ are three rational numbers, then $\left(\frac{a}{b}\times\frac{c}{d}\right) \times \frac{e}{f} = \frac{a}{b} \times \left(\frac{c}{d}\times\frac{e}{f}\right)$

i.e. $\frac{ac}{bd} \times \frac{e}{f} = \frac{a}{b} \times \frac{ce}{df}$ or $\frac{ace}{bdf} = \frac{ace}{bdf}$

Thus, rational numbers can be multiplied in any order.

Multiplicative identity :

When any rational number, say $\frac{a}{b}$, is multiplied by the rational number 1, the product is always $\frac{a}{b}$. $\frac{a}{b} \times 1 = \frac{a \times 1}{b} = \frac{a}{b}$

or $1 \times \frac{a}{b} = \frac{1 \times a}{b} = \frac{a}{b}$

Multiplicative inverse, or reciprocal :

For every non-zero rational number $\frac{a}{b}$, there exists a rational number $\frac{b}{a}$ such that $\frac{a}{b} \times \frac{b}{a} = 1$.

This is so, because $\frac{a}{b} \times \frac{b}{a}$

$= \frac{a \times b}{b \times a} = \frac{ab}{ba} = 1$

Distributive property :

If $\frac{a}{b}, \frac{c}{d}$ and $\frac{e}{f}$ are three rational numbers, then $\frac{a}{b} \times \left(\frac{c}{d} + \frac{e}{f}\right) = \frac{a}{b} \times \frac{c}{d} + \frac{a}{b} \times \frac{e}{f}$.

Multiplication of a Rational Number by Zero

When any rational number $\frac{a}{b}$ is multiplied by 0, the product is always zero.

$\frac{a}{b} \times 0 = \frac{a \times 0}{b} = \frac{0}{b} = 0$

DIVISION OF RATIONAL NUMBERS

Division is the inverse process of multiplication.

If $\frac{a}{b}$ and $\frac{c}{d}$ are two rational numbers, then $\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \times \frac{d}{c}$.

PROPERTIES OF DIVISION OF RATIONAL NUMBERS CLOSURE PROPERTY

When a rational number is divided by another rational number, the quotient is always a rational number.

Thus, if $\frac{a}{b}$ and $\frac{c}{d}$ are two rational numbers, then $\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \times \frac{d}{c} = \frac{ad}{bc}$, which is again a rational number since b, c, d are non-zero integers.

Division is not commutative :

If $\frac{a}{b}$ and $\frac{c}{d}$ are two rational numbers in which b, c and d ≠ 0, then $\frac{a}{b} \div \frac{c}{d} \neq \frac{c}{d} \div \frac{a}{b}$ because,

$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \times \frac{d}{c}$ and $\frac{c}{d} \div \frac{a}{b} = \frac{c}{d} \times \frac{b}{a} = \frac{cb}{da}$

So $\frac{a}{b} \div \frac{c}{d} \neq \frac{c}{d} \div \frac{a}{b}$

Ordering of Rational Numbers Law of Trichotomy :

Given two rational numbers $\frac{a}{b}$ and $\frac{c}{d}$, then either $\frac{a}{b} > \frac{c}{d}$, $\frac{a}{b} = \frac{c}{d}$, or $\frac{a}{b} < \frac{c}{d}$.

LAW OF TRANSITIVITY

If $\frac{a}{b}, \frac{c}{d}$, and $\frac{e}{f}$ are three rational numbers

(i) If $\frac{a}{b} > \frac{c}{d}$ and $\frac{c}{d} > \frac{e}{f}$, then $\frac{a}{b} > \frac{e}{f}$.

(ii) If $\frac{a}{b} < \frac{c}{d}$ and $\frac{c}{d} < \frac{e}{f}$, then $\frac{a}{b} < \frac{e}{f}$.

(iii) If $\frac{a}{b} = \frac{c}{d}$ and $\frac{c}{d} = \frac{e}{f}$, then $\frac{a}{b} = \frac{e}{f}$. (all are equivalent).

LAW OF ADDITION

Given $\frac{a}{b}, \frac{c}{d}$, and $\frac{e}{f}$ are three rational numbers.

(i) If $\frac{a}{b} > \frac{c}{d}$ then $\frac{a}{b} + \frac{e}{f} > \frac{c}{d} + \frac{e}{f}$.

(ii) If $\frac{a}{b} = \frac{c}{d}$ then $\frac{a}{b} + \frac{e}{f} = \frac{c}{d} + \frac{e}{f}$.

(iii) If $\frac{a}{b} < \frac{c}{d}$ then $\frac{a}{b} + \frac{e}{f} < \frac{c}{d} + \frac{e}{f}$.

PROPERTY OF MULTIPLICATION

Let $\frac{a}{b}, \frac{c}{d}$ and $\frac{e}{f}$ be three rational numbers.

If $\frac{e}{f}$ is a positive number, then

(i) If $\frac{a}{b} > \frac{c}{d}$, then $\frac{a}{b} \times \frac{e}{f} > \frac{c}{d} \times \frac{e}{f}$.

(ii) If $\frac{a}{b} < \frac{c}{d}$, then $\frac{a}{b} \times \frac{e}{f} < \frac{c}{d} \times \frac{e}{f}$.

(iii) If $\frac{a}{b} = \frac{c}{d}$, then $\frac{a}{b} \times \frac{e}{f} = \frac{c}{d} \times \frac{e}{f}$.

POWERS EXPONENTIAL NOTATION AND RATIONAL NUMBERS

Exponential notation can be extended to rational numbers. For example: $\left(\frac{4}{5}\right) \times \left(\frac{4}{5}\right) \times \left(\frac{4}{5}\right)$ can be written as $\left(\frac{4}{5}\right)^3$ which is read as $\frac{4}{5}$ raised to the power 3.

(i) $\left(\frac{3}{4}\right)^3 = \left(\frac{3}{4}\right) \times \left(\frac{3}{4}\right) \times \left(\frac{3}{4}\right) = \frac{3^3}{4^3} = \frac{27}{64}$

(ii) $\left(\frac{-5}{6}\right)^2 = \left(\frac{-5}{6}\right) \times \left(\frac{-5}{6}\right) \times \frac{(-5)^2}{6^2} = \frac{25}{36}$

(iii) $\left(\frac{-2}{3}\right)^3 = \left(\frac{-2}{3}\right) \times \left(\frac{-2}{3}\right) \times \left(\frac{-2}{3}\right) = \frac{(-2)^3}{3^3} = \frac{-8}{27}$

In general, if $\frac{x}{y}$ is a rational number and a is a positive integer, then

$$\boxed{\left(\frac{x}{y}\right)^a = \frac{x^a}{y^a}}$$

Reciprocals with Positive Integral Exponents:

The reciprocal of 2 is $\frac{1}{2}$, reciprocal of 2^3 is $\frac{1}{2^3}$.

Reciprocal of $\left(\frac{2}{3}\right)^4 = \frac{1}{\left(\frac{2}{3}\right)^4} = \frac{1}{\frac{2^4}{3^4}} = \frac{3^4}{2^4} = \left(\frac{3}{2}\right)^4$

Reciprocal of $\left(\frac{-4}{5}\right)^4 = \left(\frac{-5}{4}\right)^6$ and, Reciprocal of $\left(\frac{1}{3}\right)^5 = \left(\frac{3}{1}\right)^5 = 3^5$

Reciprocals with Negative Integral Exponents

Reciprocal of 2 $= \frac{1}{2} = \frac{1}{2^1}$. Therefore, the reciprocal of 2 is 2^{-1}. The reciprocal of $3^2 = \frac{1}{3^2} = 3^{-2}$.

Reciprocal of $\left(\frac{4}{5}\right)^2 = \left(\frac{4}{5}\right)^{-2}$, Reciprocal of $\left(\frac{-2}{3}\right)^3 = \left(\frac{-2}{3}\right)^{-3}$, etc.

In general, if x is any rational number other than zero and a is any positive integer, then:

$$\boxed{x^{-a} = \frac{1}{x^a}}$$

LAWS OF EXPONENTS

1. Consider the following.

(i) $3^3 \times 3^4 = 3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 = 3^7 = 3^{3+4}$

(ii) $\left(\frac{5}{2}\right)^2 \times \left(\frac{5}{2}\right)^3 = \frac{5}{2} \times \frac{5}{2} \times \frac{5}{2} \times \frac{5}{2} \times \frac{5}{2} = \left(\frac{5}{2}\right)^5 = \left(\frac{5}{2}\right)^{2+3}$

$\therefore$ $\boxed{x^a \times x^b = x^{a+b}}$

2. (i) $2^5 \div 2^2 = \frac{2\times2\times2\times2\times2}{2\times2} = 2 \times 2 \times 2 = 2^3 = 2^{5-2}$

(ii) $\left(\frac{2}{3}\right)^6 \div \left(\frac{2}{3}\right)^2 = \frac{\frac{2}{3}\times\frac{2}{3}\times\frac{2}{3}\times\frac{2}{3}\times\frac{2}{3}\times\frac{2}{3}}{\frac{2}{3}\times\frac{2}{3}} = \frac{2}{3}\times\frac{2}{3}\times\frac{2}{3}\times\frac{2}{3} = \left(\frac{2}{3}\right)^4 = \left(\frac{2}{3}\right)^{6-2}$

$\therefore$ $\boxed{x^a \div x^b = x^{a-b}}$

3. (i) $(2^3)^2 = (2 \times 2 \times 2)^2 = (2 \times 2 \times 2) \times (2 \times 2 \times 2) = 2^6 = 2^3 \times 2^3$

(ii) $\left\{\left(\frac{2}{3}\right)^3\right\}^2 = \left(\frac{2}{3}\times\frac{2}{3}\times\frac{2}{3}\right)^2 = \left(\frac{2}{3}\times\frac{2}{3}\times\frac{2}{3}\right) \times \left(\frac{2}{3}\times\frac{2}{3}\times\frac{2}{3}\right) = \left(\frac{2}{3}\right)^6 = \left(\frac{2}{3}\right)^{3\times2}$

$\therefore$ $\boxed{(x^a)^b = x^{ab}}$

4. (i) $2^4 \times 3^4 = (2 \times 2 \times 2 \times 2) \times (3 \times 3 \times 3 \times 3)$
$= (2 \times 3) \times (2 \times 3) \times (2 \times 3) \times (2 \times 3) = (2 \times 3)^4$

(ii) $\left(\frac{3}{5}\right)^4 \times \left(\frac{1}{2}\right)^4 = \left(\frac{3}{5}\times\frac{3}{5}\times\frac{3}{5}\times\frac{3}{5}\right) \times \left(\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\right) = \left(\frac{3}{5}\times\frac{1}{2}\right) \times \left(\frac{3}{5}\times\frac{1}{2}\right) \times \left(\frac{3}{5}\times\frac{1}{2}\right) \times \left(\frac{3}{5}\times\frac{1}{2}\right) = \left(\frac{3}{5}\times\frac{1}{2}\right)^4$

$\therefore$ $\boxed{x^a \times y^a = (x \times y)^a}$

5. (i) $2^4 \div 3^4 = \frac{2\times2\times2\times2}{3\times3\times3\times3} = \frac{2}{3}\times\frac{2}{3}\times\frac{2}{3}\times\frac{2}{3} = \left(\frac{2}{3}\right)^4$

(ii) $\left(\frac{3}{5}\right)^4 \div \left(\frac{1}{2}\right)^4 = \frac{\frac{3}{5}\times\frac{3}{5}\times\frac{3}{5}\times\frac{3}{5}}{\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}} = \left(\frac{\frac{3}{5}}{\frac{1}{2}}\right) \times \left(\frac{\frac{3}{5}}{\frac{1}{2}}\right) \times \left(\frac{\frac{3}{5}}{\frac{1}{2}}\right) \times \left(\frac{\frac{3}{5}}{\frac{1}{2}}\right) = \left(\frac{\frac{3}{5}}{\frac{1}{2}}\right)^4$

$\therefore$ $\boxed{x^a \div y^a = \left(\frac{x}{y}\right)^a}$

If x is any rational number different from zero and a, b are any integers, then,

Law I: $\boxed{x^a \times x^b = x^{a+b}}$

Law II: $\boxed{x^a \div x^b = x^{a-b}}$

Law III: $\boxed{(x^a)^b = x^{ab}}$

Law IV: $\boxed{x^a \times y^a = (x \times y)^a}$ (where y is also a non zero rational number)

Law I: $\boxed{x^a \div y^a = \left(\frac{x}{y}\right)^a}$ (where y is also a non- zero rational number)

SOLVED EXAMPLES

Ex.1 Add $\frac{3}{5}$ and $\frac{13}{5}$.

Sol. We have,

$\frac{3}{5}+\frac{13}{5}=\frac{3+13}{5}=\frac{16}{5}$ [$\because$ 3 + 13 = 16]

Ex.2 Add $\frac{7}{9}$ and $\frac{-12}{9}$.

Sol. We have,

$\frac{7}{9}+\frac{-12}{9}=\frac{7+(-12)}{9}=\frac{-5}{9}$

[$\because$ 7 + (–12) = – 5]

Ex.3 Add $\frac{-5}{9}$ and $\frac{-17}{9}$.

Sol. We have,

$\frac{-5}{9} + \frac{-17}{9} = \frac{(-5)-(17)}{9} = \frac{-22}{9}$

[$\because$ (–5) + (–17) = – 22]

Ex.4 Add $\frac{4}{-11}$ and $\frac{7}{11}$.

Sol. We first express $\frac{4}{-11}$ as a rational with positive denominator.

We have, $\frac{4}{-11} = \frac{4\times(-1)}{(-11)\times(-1)} = \frac{-4}{11}$

$\therefore$ $\frac{4}{-11} + \frac{7}{11} = \frac{-4}{11} + \frac{7}{11} = \frac{(-4)+7}{11}$

$= \frac{3}{11}$

[$\because$ (–4) + 7 = 3]

Ex.5 Add $\frac{5}{12}$ and $\frac{3}{8}$.

Sol. Clearly, denominator of the given numbers are positive.
The LCM of denominators 12 and 8 is 24.

Now, we express $\frac{5}{12}$ and $\frac{3}{8}$ into forms in which both of them have the same denominator 24.
We have,

$\frac{5}{12} = \frac{5\times 2}{12\times 2} = \frac{10}{24}$ and, $\frac{3}{8} = \frac{3\times 3}{8\times 3} = \frac{9}{24}$

$\therefore$ $\frac{5}{12} + \frac{3}{8} = \frac{10}{24} + \frac{9}{24} = \frac{10+9}{24} = \frac{19}{24}$

Ex.6 Add $\frac{7}{9}$ and 4.

Sol. We have, 4 = $\frac{4}{1}$.

Clearly, denominators of the two rational numbers are positive. We now rewrite them so that they ahve a common denominator 3equal to the LCM of the denominators.
LCM of 9 and 1 is 9.

We have, $\frac{4}{1} = \frac{4\times 9}{1\times 9} = \frac{36}{9}$

$\therefore$ $\frac{7}{9} + 4 = \frac{7}{9} + \frac{4}{1} = \frac{7}{9} + \frac{36}{9}$

$= \frac{7+36}{9} = \frac{43}{9}$

Ex.7 Add $\frac{3}{8}$ and $\frac{-5}{12}$.

Sol. The denominators of the given rational numbers are 8 and 12 respectively. The LCM of 8 and 12 is 24. Now we re-write the given ratinoal numbers into forms in which both of them have the same dnominator.

$\frac{3}{8} = \frac{3\times3}{8\times3} = \frac{9}{24}$ and, $\frac{-5}{12} = \frac{-5\times2}{12\times2} = \frac{-10}{24}$

$\therefore \quad \frac{3}{8} + \frac{-5}{12} = \frac{9}{24} + \frac{(-10)}{24} = \frac{9-10}{24} = \frac{-1}{24}$

Ex.8 Simplify : $\frac{8}{-15} + \frac{4}{-3}$.

Sol. We have,

$\frac{8}{-15} + \frac{4}{-3} = \frac{-8}{15} + \frac{-4}{3}$

$\left[\therefore \frac{8}{-15} = \frac{8\times-1}{(-15)\times(-1)} = \frac{-8}{15} \text{ and } \frac{4}{-3} = \frac{4\times-1}{(-3)\times(-1)} = \frac{-4}{3}\right]$

LCM of 15 and 3 is 15.

Re-writing $\frac{-4}{3}$ in the form in which is has denominator 15, we get

$\frac{-4}{3} = \frac{-4\times5}{3+5} = \frac{-20}{15}$

$\therefore \quad \frac{8}{-15} + \frac{4}{-3} = \frac{-8}{15} + \frac{-4}{3}$

$= \frac{-8}{15} + \frac{-20}{15} \qquad \left[\because \frac{-4}{3} = \frac{-20}{15}\right]$

$= \frac{-(-8)+(-20)}{15} = \frac{-28}{15}$

Ex.9 Express each of the following as a rational number of the form $\frac{p}{q}$:

(i) 5^{-3} (ii) $(-2)^{-5}$ (iii) $\left(\frac{4}{3}\right)^{-3}$ (iv) $\left(\frac{-2}{5}\right)^{-4}$ (v) $\frac{1}{2^{-3}}$

Sol. We know that, if a is a non-zero rational number and n is a positive integer, then $a^{-n} = \frac{1}{a^n}$

(i) $5^{-3} = \frac{1}{5^3} = \frac{1}{125} \qquad \left[\because a^{-n} = \frac{1}{a^n}\right]$

(ii) $(-2)^{-5} = \frac{1}{(-2)^5} = \frac{1}{-32} = -\frac{1}{32} \qquad \left[\because a^{-n} = \frac{1}{a^n}\right]$

(iii) $\left(\frac{4}{3}\right)^{-3} = \frac{1}{\left(\frac{4}{3}\right)^3} = \frac{1}{\frac{4^3}{3^3}} = \frac{1}{\frac{64}{27}} = \frac{27}{64}$

$\left[\because \left(\frac{a}{b}\right)^n = \frac{a^n}{b^n} \text{ when n is a whole number}\right]$

(iv) $\left(\frac{-2}{5}\right)^{-4} = \frac{1}{\left(\frac{-2}{5}\right)^4} = \frac{1}{\frac{(-2)^4}{5^4}} = \frac{1}{\frac{16}{625}} = \frac{625}{16} \qquad \left[\because \left(\frac{a}{b}\right)^n = \frac{a^n}{b^n} \text{ for } n > 0\right]$

(v) $\frac{1}{2^{-3}} = \frac{1}{\frac{1}{2^3}} = \frac{2^3}{1} = \frac{8}{1} = 8 \qquad \left[\because a^{-n} = \frac{1}{a^n}\right]$

Ex.10 Express each of the following as a rational number of the form $\frac{p}{q}$:

(i) $\left(\frac{3}{8}\right)^{-2} \times \left(\frac{4}{5}\right)^{-3}$ (ii) $\left(\frac{-2}{7}\right)^{-4} \times \left(\frac{-7}{5}\right)^{2}$

Sol. (i) We have,

$$\left(\frac{3}{8}\right)^{-2} \times \left(\frac{4}{5}\right)^{-3} = \frac{1}{\left(\frac{3}{8}\right)^{2}} \times \frac{1}{\left(\frac{4}{5}\right)^{3}}$$

$$\left[\because\ a^{-n} = \frac{1}{a^{n}}\right]$$

$$= \frac{1}{\frac{3^2}{8^2}} \times \frac{1}{\frac{4^3}{5^3}} \quad \left[\because \left(\frac{a}{b}\right)^{n} = \left(\frac{a^n}{b^n}\right)\right]$$

$$= \frac{1}{\frac{9}{64}} \times \frac{1}{\frac{64}{125}} = \frac{64}{9} \times \frac{125}{64} = \frac{125}{9}$$

(ii) We have, $\left(\frac{-2}{7}\right)^{-4} \times \left(\frac{-7}{5}\right)^{2}$

$$= \frac{1}{\left(\frac{-2}{7}\right)^{4}} \times \left(\frac{-7}{5}\right)^{2} = \frac{1}{\frac{(-2)^4}{7^4}} \times \frac{(-7)^2}{5^2}$$

$$= \frac{7^4}{(-2)^4} \times \frac{(-7)^2}{5^2} = \frac{7\times7\times7\times7}{16} \times \frac{-7\times-7}{25}$$

$$= \frac{7^6}{16\times25} = \frac{7^6}{16\times25} = \frac{7^6}{400} = \frac{117649}{400}$$

Ex.11 Express each of the following as power of a rational number with positive exponent :

(i) $\left(\frac{1}{4}\right)^{-3}$ (ii) $5^{-3} \times 5^{-6}$ (iii) $\left(\frac{-1}{4}\right)^{-5} \times \left(\frac{-1}{4}\right)^{-7}$

Sol. (i) We have,

$$\left(\frac{1}{4}\right)^{-3} = \frac{1}{\left(\frac{1}{4}\right)^{3}} = \frac{1}{\frac{1^3}{4^3}} = \frac{4^3}{1^3} = 4^3$$

(ii) We have,
$5^{-3} \times 5^{-6}$

$$= \frac{1}{5^3} \times \frac{1}{5^6} = \frac{1\times1}{5^3\times5^6} = \frac{1}{5^{3+6}} = \frac{1^9}{5^9} = \left(\frac{1}{5}\right)^{9}$$

(iii) We have, $\left(\frac{-1}{4}\right)^{-5} \times \left(\frac{-1}{4}\right)^{-7}$

$$= \frac{1}{\left(\frac{-1}{4}\right)^{5}} \times \frac{1}{\left(\frac{-1}{4}\right)^{7}} = \frac{1}{\frac{(-1)^5}{4^5}} \times \frac{1}{\frac{(-1)^7}{4^7}} \times \frac{1}{\frac{-1}{4^5}} \times \frac{1}{\frac{-1}{4^7}}$$

$$= \frac{4^5}{-1} \times \frac{4^7}{-1} = \frac{4^5\times4^7}{(-1)\times(-1)} = \frac{4^{5+7}}{1} = 4^{12}$$

Ex.12 Simplify:

(i) $\left(2^{-1} \div 5^{-1}\right)^2 \times \left(\frac{-5}{8}\right)^{-1}$ (ii) $\left(6^{-1} - 8^{-1}\right)^{-1} + \left(2^{-1} - 3^{-1}\right)^{-1}$

(iii) $\left(5^{-1} \times 3^{-1}\right)^{-1} \div 6^{-1}$ (iv) $\left(4^{-1} + 8^{-1}\right) \div \left(\frac{2}{3}\right)^{-1}$

Sol. (i) We have,

$$(2^{-1} \div 5^{-1})^2 \times \left(\frac{-5}{8}\right)^{-1}$$

$$= \left(\frac{1}{2} \div \frac{1}{5}\right)^2 \times \frac{1}{\left(\frac{-5}{8}\right)} = \left(\frac{1}{2} \times \frac{5}{1}\right)^2 \times \left(\frac{8}{-5}\right)$$

$$\left[\because a^{-1} = \frac{1}{a}\right]$$

$$= \left(\frac{5}{2}\right)^2 \times \left(\frac{8}{-5}\right) = \frac{5^2}{2^2} \times \frac{8}{-5} = \frac{5}{4} \times \frac{8}{-1}$$

$$= \frac{5}{1} \times \frac{2}{-1} = -10$$

(ii) We have, $(6^{-1} - 8^{-1})^{-1} + (2^{-1} - 3^{-1})^{-1}$

$$= \left(\frac{1}{6} - \frac{1}{8}\right)^{-1} + \left(\frac{1}{2} - \frac{1}{3}\right)^{-1}$$

$$= \left(\frac{4-3}{24}\right)^{-1} + \left(\frac{3-2}{6}\right)^{-1}$$

$$= \left(\frac{1}{24}\right)^{-1} + \left(\frac{1}{6}\right)^{-1} = \frac{1}{\frac{1}{24}} + \frac{1}{\frac{1}{6}} - \frac{24}{1} + \frac{6}{1} = 30$$

$$\left[\because a^{-1} = \frac{1}{a}\right]$$

(iii) We have, $(5^{-1} \times 3^{-1})^{-1} \div 6^{-1}$

$$= \left(\frac{1}{5} \times \frac{1}{3}\right)^{-1} \div \frac{1}{6}$$

$$= \left(\frac{1}{15}\right)^{-1} \div \frac{1}{6} = \frac{1}{\frac{1}{15}} \div \frac{1}{6} = 15 \div \frac{1}{6} = 15 \times \frac{6}{1} = 90$$

(iv) We have, $(4^{-1} + 8^{-1}) \div \left(\frac{2}{3}\right)^{-1}$

$$= \left(\frac{1}{4} + \frac{1}{8}\right) \div \frac{1}{\frac{2}{3}} = \left(\frac{2+1}{8}\right) \div \left(\frac{3}{2}\right)$$

$$= \frac{3}{8} \div \frac{3}{2} = \frac{3}{8} \times \frac{2}{3} = \frac{1}{4}$$

Ex.13 Simplify

(i) $\left(\frac{1}{4}\right)^{-2} + \left(\frac{1}{2}\right)^{-2} + \left(\frac{1}{3}\right)^{-2}$ (ii) $\left\{6^{-1}\left(\frac{3}{2}\right)^{-1}\right\}^{-1}$

Sol. (i) We have, $\left(\frac{1}{4}\right)^{-2} + \left(\frac{1}{2}\right)^{-2} + \left(\frac{1}{3}\right)^{-2}$

$= \dfrac{1}{\left(\frac{1}{4}\right)^2} + \dfrac{1}{\left(\frac{1}{2}\right)^2} + \dfrac{1}{\left(\frac{1}{3}\right)^2}$

$= \dfrac{1}{\frac{1^2}{4^2}} + \dfrac{1}{\frac{1^2}{2^2}} + \dfrac{1}{\frac{1^2}{3^2}} = \dfrac{4^2}{1^2} + \dfrac{2^2}{1^2} + \dfrac{3^2}{1^2}$

$= \dfrac{4^2}{1} + \dfrac{2^2}{1} + \dfrac{3^2}{1}$

$= 4^2 + 2^2 + 3^2 = 16 + 4 + 9 = 29$

(ii) We have, $\left\{6^{-1} + \left(\frac{3}{2}\right)^{-1}\right\}^{-1}$

$= \left\{6^{-1} + \dfrac{1}{\frac{3}{2}}\right\}^{-1} = \left(\dfrac{1}{6} + \dfrac{2}{3}\right)^{-1} = \left(\dfrac{1 + 2 \times 2}{6}\right)^{-1}$

$= \left(\dfrac{5}{6}\right)^{-1} = \dfrac{1}{\frac{5}{6}} = \dfrac{6}{5}$

Ex.14 Express each of the following as a rational number of the form $\frac{p}{q}$

(i) $(2^{-1} + 3^{-1})^2$ (ii) $(2^{-1} - 4^{-1})^2$ (iii) $\left\{\left(\frac{4}{3}\right)^{-1} - \left(\frac{1}{4}\right)^{-1}\right\}^{-1}$

Sol. We know that for any positive integer n and any rational number a, $a^{-n} = \dfrac{1}{a^n}$. Thus, we have

(i) $(2^{-1} + 3^{-1})^2 = \left(\dfrac{1}{2} + \dfrac{1}{3}\right)^2 = \left(\dfrac{3+2}{6}\right)^2$

$= \left(\dfrac{5}{6}\right)^2 = \dfrac{5^2}{6^2} = \dfrac{25}{36}$

(ii) $(2^{-1} - 4^{-1})^2 = \left(\dfrac{1}{2} - \dfrac{1}{4}\right)^2 = \left(\dfrac{2-1}{4}\right)^2 = \left(\dfrac{1}{4}\right)^2$

$= \dfrac{1^2}{4^2} = \dfrac{1}{16}$

(iii) $\left\{\left(\dfrac{4}{3}\right)^{-1} - \left(\dfrac{1}{4}\right)^{-1}\right\}^{-1}$

$= \left(\dfrac{1}{\frac{3}{4}} - \dfrac{1}{\frac{1}{4}}\right)^{-1} = \left(\dfrac{4}{3} - \dfrac{4}{1}\right)^{-1}$

$= \left(\dfrac{4 - 3 \times 4}{3}\right)^{-1} \left(\dfrac{-8}{3}\right)^{-1} = \dfrac{1}{\frac{-8}{3}} = \dfrac{3}{-8} = -\dfrac{3}{8}$

Ex.15 By what number should $(-8)^{-1}$ be multiplied so that the product may be equal to 10^{-1} ?

Sol. Let $(-8)^{-1}$ be multiplied by x to get 10^{-1}. Then, $x \times (-8)^{-1} = 10^{-1}$

$\Rightarrow \quad x = 10^{-1} \div (-8)^{-1}$

$\Rightarrow \quad x = \frac{1}{10} \div \frac{1}{-8} \qquad \left[\because a^{-1} = \frac{1}{a}\right]$

$\Rightarrow \quad x = \frac{1}{10} \times \frac{-8}{1} = \frac{-8}{10} = \frac{-4}{5}$

Hence, the required number is $\frac{-4}{5}$

Ex.16 Using the laws of exponents, simplify each of the following and express in exponential form:

(A) $3^7 \times 3^{-2}$ (B) $2^{-7} \div 2^{-3}$ (C) $(5^2)^{-3}$ (D) $2^{-3} \times (-7)^{-3}$ (E) $\frac{3^{-5}}{4^{-5}}$

Sol. Using laws of exponents, we have:

(i) $3^7 \times 3^{-2} = 3^{7+(-2)} = 3^5 \qquad [\because a^m \times a^n = a^{m+n}]$

(ii) $2^{-7} \div 2^{-3} = \frac{2^{-7}}{2^{-3}} = 2^{-7-(-3)} = 2^{-7+3} = 2^{-4} \qquad \left[\because \frac{a^m}{a^n} = a^{m-n}\right]$

(iii) $(5^2)^{-3} = 5^{2\times-3} = 5^{-6} \qquad [\because (a^m)^n = a^{mn}]$

(iv) $2^{-3} \times (-7)^{-3} = (2\times(-7))^{-3} = (-14)^{-3} \qquad [\because a^n \times b^n = (ab)^n]$

(v) $\frac{3^{-5}}{4^{-5}} = \left(\frac{3}{4}\right)^{-5} \qquad \left[\because \frac{a^n}{b^n} = \left(\frac{a}{b}\right)^n\right]$

Ex.17 Using the laws of exponents simplify and express each of the following in exponential form with positive exponent:

(i) $(-4)^4 \times (-4)^{-10}$ (ii) $2^{-5} \div 2^2$ (iii) $3^{-4} \times 2^{-4}$

(iv) $\left(\frac{1}{2^3}\right)^2$ (v) $(3^{-7} \div 3^{-10}) \times 3^{-5}$ (vi) $(-3)^4 \times \left(\frac{5}{3}\right)^4$

Sol. (i) We have, $(-4)^4 \times (-4)^{-10} = (-4)^{4+(-10)} \qquad [\because a^m \times a^n = a^{m+n}]$

$= (-4)^{-6}$

$= \frac{1}{(-4)^6} \qquad \left[\because a^{-n} = \frac{1}{a^n}\right]$

$= \frac{1^6}{(-4)^6} \qquad [\because 1^6 = 1]$

$= \left(\frac{1}{-4}\right)^6 \qquad \left[\because \frac{a^n}{b^n} = \left(\frac{a}{b}\right)^n\right]$

$= \left(\frac{-1}{4}\right)^6 \qquad \left[\because \frac{1}{-4} = \frac{-1}{4}\right]$

(ii) We have,

$2^{-5} \div 2^2 = \frac{2^{-5}}{2^2} = 2^{-5-2} \qquad \left[\because \frac{a^m}{a^n} = a^{m-n}\right] \qquad = 2^{-7} = \frac{1}{2^7} \qquad \left[\because a^{-n} = \frac{1}{a^n}\right] \qquad = \frac{1^7}{2^7} = \left(\frac{1}{2}\right)^7$

(iii) We have,

$3^{-4} \times 2^{-4} = (3 \times 2)^{-4}$ $\qquad [\because a^n \times b^n = (ab)^n]$

$= 6^{-4} = \frac{1}{6^4} \quad \left[\because a^{-n} = \frac{1}{a^n}\right] \qquad = \frac{1^4}{6^4} \quad [\because 1^4 = 1]$

$= \left(\frac{1}{6}\right)^4 \qquad \left[\because \frac{a^n}{b^n} = \left(\frac{a}{b}\right)^n\right]$

(iv) We have,

$$\left(\frac{1}{2^3}\right)^2 = \left(\frac{1^3}{2^3}\right)^2 \left\{\left(\frac{1}{2}\right)^3\right\}^2 = \left(\frac{1}{2}\right)^{3\times2} = \left(\frac{1}{2}\right)^6$$

(v) We have, $(3^{-7} \div 3^{-10}) \times 3^{-5}$

$= \left(\frac{3^{-7}}{3^{-10}}\right) \times 3^{-5} = 3^{-7-(-10)} \times 3^{-5}$

$= 3^{-7+10} \times 3^{-5} = 3^3 \times 3^{-5} = 3^{3+(-5)} = 3^{-2}$

$= \frac{1}{3^2} = \frac{1^2}{3^2} = \left(\frac{1}{3}\right)^2$

(vi) We have,

$(-3)^4 \times \left(\frac{5}{3}\right)^4 = (-1 \times 3)^4 \times \left(\frac{5}{3}\right)^4 \qquad [\because -3 = -1 \times 3]$

$= \{(-1)^4 \times 3^4\} \times \frac{5^4}{3^4}$

$\left[\because (ab)^n = a^n b^n \text{ and } \left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}\right]$

$= (1 \times 3^4) \times \frac{5^4}{3^4} \qquad [\because (-1)^4 = 1]$

$= 3^4 \times \frac{5^4}{3^4} = 3^{4\ 4} \times 5^4 = 3^0 \times 5^4 = 1 \times 5^4 = 5^4$

Ex.18 Simplify and write the answer in the exponetial form:

(i) $(2^5 \div 2^8)^5 \times 2^{-5}$ (ii) $(-4)^3 \times (5)^{-3} \times (-5)^{-3}$ (iii) $\frac{1}{8} \times 3^{-3}$

Sol. (i) We have, $(2^5 \div 2^8)^5 \times 2^{-5}$

$= \left(\frac{2^5}{2^8}\right)^5 \times 2^{-5} = (2^{5-8})^5 \times 2^{-5}$

$= (2^{-3})^5 \times 2^{-5} = 2^{-3\times5} \times 2^{-5}$

$= 2^{-15} \times 2^{-5} = 2^{-15-5} = 2^{-20}$

(ii) We have, $(-4)^{-3} \times 5^{-3} \times (-5)^{-3}$

$= \{-4 \times 5 \times (-5)\}^{-3} \qquad [\because a^n \times b^n \times c^n = (abc)^n]$

$= (100)^{-3} = (10^2)^{-3} = 10^{2\ \times -3} = 10^{-6}$

(iii) We have,

$$\frac{1}{8}\times 3^{-3} = \frac{1}{2^3}\times 3^{-3} = 2^{-3}\times 3^{-3} = (2\times 3)^{-3} = 6^{-3}$$

Ex.19 Simplify each of the following :

(i) $\left[\left\{\left(\frac{-1}{5}\right)^{-2}\right\}^{2}\right]^{-1}$ (ii) $\left\{\left(\frac{1}{3}\right)^{-2} - \left(\frac{1}{2}\right)^{-3}\right\} \div \left(\frac{1}{4}\right)^{-2}$

Sol. We have,

(i) $\left[\left\{\left(\frac{-1}{5}\right)^{-2}\right\}^{2}\right]^{-1} = \left\{\left(\frac{-1}{5}\right)^{-2}\right\}^{2\times -1}$ $\left[\because (a^m)^n = a^{mn}\right]$

$= \left\{\left(\frac{-1}{5}\right)^{-2}\right\}^{-2} = \left(\frac{-1}{5}\right)^{(-2)\times(-2)}$

$= \left(\frac{-1}{5}\right)^{4} = \frac{(-1)^4}{5^4} = \frac{1}{625}$

(ii) We have,

$\left\{\left(\frac{1}{3}\right)^{-2} - \left(\frac{1}{2}\right)^{-3}\right\} \div \left(\frac{1}{4}\right)^{-2}$ $\left\{\left(\frac{3}{1}\right)^{2} - \left(\frac{2}{1}\right)^{3}\right\} \div \left(\frac{4}{1}\right)^{2}$ $\left[\because \left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^{n}\right]$

$= \left\{\frac{3^2}{1^2} - \frac{2^3}{1^3}\right\} \div \frac{4^2}{1^2} = (9 - 8) \div 16$

$= 1 \div 16 = \frac{1}{16}$

Ex.20 Simplify :

(i) $\left(\frac{5}{8}\right)^{-7}\times\left(\frac{8}{5}\right)^{-5}$ (ii) $\left(\frac{-2}{3}\right)^{-2}\times\left(\frac{4}{5}\right)^{-3}$ (iii) $\left(\frac{3}{4}\right)^{-4}\div\left(\frac{3}{2}\right)^{-3}$ (iv) $\left(\frac{3}{7}\right)^{-2}\times\left(\frac{7}{6}\right)^{-3}$

Sol. (i) We have,

$\left(\frac{5}{8}\right)^{-7}\times\left(\frac{8}{5}\right)^{-5} = \frac{5^{-7}}{8^{-7}}\times\frac{8^{-5}}{5^{-5}} = \frac{5^{-7}}{5^{-5}}\times\frac{8^{-5}}{8^{-7}}$

$= 5^{-7-(-5)} \times 8^{-5-(-7)}$

$= 5^{-7+5} \times 8^{-5+7} = 5^{-2} \times 8^{2} = \frac{8^2}{5^2} = \frac{64}{25}$

(ii) We have, $\left(\frac{-2}{3}\right)^{-2}\times\left(\frac{4}{5}\right)^{-3} = \frac{(-2)^{-2}}{3^{-2}}\times\frac{4^{-3}}{5^{-3}}$

$= \frac{3^2}{(-2)^2}\times\frac{5^3}{4^3} = \frac{9}{4}\times\frac{125}{64} = \frac{9\times 125}{4\times 64} = \frac{1125}{256}$

(iii) We have,

$$\left(\frac{3}{4}\right)^{-4} \div \left(\frac{3}{2}\right)^{-3} = \left(\frac{3}{4}\right)^{-4} \times \frac{1}{\left(\frac{3}{2}\right)^{-3}} = \left(\frac{3}{4}\right)^{-4} \times \left(\frac{3}{2}\right)^{3}$$

$$= \frac{3^{-4}}{4^{-4}} \times \frac{3^3}{2^3}$$

$$= \frac{3^{-4} \times 3^3}{(2^2)^{-4} \times 2^3} = \frac{3^{-4} \times 3^3}{2^{-8} \times 2^3} = \frac{3^{-4+3}}{2^{-8+3}} = \frac{3^{-1}}{2^{-5}} = \frac{2^5}{3^1} = \frac{32}{3}$$

(iv) We have, $\left(\frac{3}{7}\right)^{-2} \times \left(\frac{7}{6}\right)^{-3} = \frac{3^{-2}}{7^{-2}} \times \frac{7^{-3}}{6^{-3}}$ $\left[\because \left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}\right]$

$$= \frac{3^{-2}}{7^{-2}} \times \frac{7^{-3}}{(2 \times 3)^{-3}}$$

$$= \frac{3^{-2}}{7^{-2}} \times \frac{7^{-3}}{2^{-3} \times 3^{-3}}$$

$$= \frac{3^{-2}}{3^{-3}} \times \frac{7^{-3}}{7^{-2}} \times \frac{1}{2^{-3}}$$

$$= 3^{-2+3} \times 7^{-3+2} \times 2^3$$

$$= 3 \times 7^{-1} \times 2^3 = 3 \times \frac{1}{7} \times 8 = \frac{24}{7}$$

Ex.21 Evaluate: $\frac{8^{-1} \times 5^3}{2^{-4}}$

Sol. We have,

$$\frac{8^{-1} \times 5^3}{2^{-4}} = \frac{(2^3)^{-1} \times 5^3}{2^{-4}} = \frac{2^{3 \times -1} \times 5^3}{2^{-4}} = \frac{2^{-3} \times 5^3}{2^{-4}}$$

$$= 2^{-3+4} \times 5^3 \; 2^1 \times 5^3 = 2 \times 125 = 250$$

Ex.22 Simplify:

(i) $\frac{25 \times a^{-4}}{5^{-3} \times 10 \times a^{-8}}$ (ii) $\frac{3^{-5} \times 10^{-5} \times 125}{5^{-7} \times 6^{-5}}$

Sol. (i) We have,

$$\frac{25 \times a^{-4}}{5^{\ 3} \times 10 \times a^{\ 8}} = \frac{5^2 \times a^{-4}}{5^{\ 3} \times (2 \times 5) \times a^{\ 8}} = \frac{5^2 \times a^{-4}}{5^{\ 3+1} \times 2 \times a^{\ 8}}$$

$$= \frac{5^2 \times a^{-4}}{5^{-2} \times 2 \times a^{-8}} = \frac{5^{2-(-2)} \times a^{-4+8}}{2} = \frac{5^4 \times a^4}{2} = \frac{5^4}{2} \times a^4 = \frac{625}{2} a^4$$

(ii) We have,

$$\frac{3^{-5} \times 10^{-5} \times 125}{5^{-7} \times 6^{-5}} = \frac{3^{-5} \times (2 \times 5)^{-5} \times 5^3}{5^{-7} \times (2 \times 3)^{-5}}$$

$$= \frac{3^{-5} \times 2^{-5} \times 5^{-5} \times 5^3}{5^{-7} \times 2^{-5} \times 3^{-5}}$$

$$= 3^{-5-(-5)} \times 2^{-5-(-5)} \times 5^{-5+3-(-7)}$$

$$= 3^0 \times 2^0 \times 5^{-5+3+7} = 1 \times 1 \times 5^5 = 5^5$$

Ex.23 By what number should $(-4)^{-2}$ be multiplied so that the product may be equal to 10^{-2} ?

Sol. Let $(-4)^{-2}$ = be multiplied by x to get 10^{-2}.

Then, $x \times (-4)^{-2} = 10^{-2}$

$\Rightarrow x = 10^{-2} \div (-4)^{-2}$

$\Rightarrow x = 10^{-2} \times \dfrac{1}{(-4)^{-2}}$

$\Rightarrow x = \dfrac{10^{-2}}{(-4)^{-2}}$

$\Rightarrow x = \dfrac{(-4)^2}{10^2} = \dfrac{16}{100} = \dfrac{4}{25}$

Hence, required number is $\dfrac{4}{25}$

Ex.24 By what number should $(-12)^{-1}$ be divided so that the quotient may be $\left(\dfrac{2}{3}\right)^{-1}$?

Sol. Let the required number be x. Then,

$(-12)^{-1} \div x = \left(\dfrac{2}{3}\right)^{-1}$

$\Rightarrow \dfrac{(-12)^{-1}}{x} = \left(\dfrac{2}{3}\right)^{-1}$ $\Rightarrow x = (-12)^{-1} \div \left(\dfrac{2}{3}\right)^{-1}$

$\Rightarrow x = \dfrac{1}{-12} \div \left(\dfrac{3}{2}\right)$ $\Rightarrow x = \dfrac{1}{-12} \times \dfrac{2}{3} = \dfrac{1}{-18} = \dfrac{-1}{18}$ $\left[\because a^{-1} = \dfrac{1}{a} \text{ and } \left(\dfrac{a}{b}\right)^{-1} = \dfrac{b}{a}\right]$

Ex.25 By what number should $\left(\dfrac{-3}{2}\right)^{-3}$ be divided so that the quotient may be $\left(\dfrac{4}{27}\right)^{-2}$?

Sol. Let the required number be x. Then,

$\left(\dfrac{-3}{2}\right)^{-3} \div x = \left(\dfrac{4}{27}\right)^{-2}$

$\Rightarrow \left(\dfrac{-3}{2}\right)^{-3} \times \dfrac{1}{x} = \left(\dfrac{4}{27}\right)^{-2}$ $\Rightarrow x = \left(\dfrac{-3}{2}\right)^{-3} \div \left(\dfrac{4}{27}\right)^{-2}$

$\Rightarrow x = \left(\dfrac{2}{-3}\right)^{3} \div \left(\dfrac{27}{4}\right)^{2}$ $\left[\because \left(\dfrac{a}{b}\right)^{n} = \left(\dfrac{b}{a}\right)^{n}\right]$ $\Rightarrow x = \left(\dfrac{2}{-3}\right)^{3} \times \dfrac{1}{\left(\dfrac{27}{4}\right)^{2}}$

$\Rightarrow x = \dfrac{2^3}{(-3)^3} \times \dfrac{1}{\dfrac{27^2}{4^2}}$ $\Rightarrow x = \dfrac{8}{-27} \times \dfrac{4^2}{27^2} = \dfrac{-8}{27} \times \dfrac{4^2}{27^2} = \dfrac{-2 \times 4^3}{27^3}$

$= -2 \times \left(\dfrac{4}{27}\right)^{3}$

EXERCISE - I UNSOLVED PROBLEMS

Q.1 What number should be added to $\frac{-5}{11}$ so as to get $\frac{26}{33}$?

Q.2 What number should be added to $\frac{-5}{7}$ to get $\frac{-2}{3}$?

Q.3 What number should be subtracted from $\frac{-5}{3}$ to get $\frac{5}{6}$?

Q.4 What number should be subtracted from $\frac{3}{7}$ to get $\frac{5}{4}$?

Q.5 What should be added to $\left(\frac{2}{3}+\frac{3}{5}\right)$ to get $\frac{-2}{15}$?

Q.6 What should be added to $\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{5}\right)$ to get 3?

Q.7 What should be subtracted from $\left(\frac{3}{4}-\frac{2}{3}\right)$ to get $\frac{-1}{6}$?

Q.8 Simply each of the following and write as a rational number of the from $\frac{p}{q}$:

(i) $\frac{3}{4}+\frac{5}{6}+\frac{-7}{8}$ (ii) $\frac{2}{3}+\frac{-5}{6}+\frac{-7}{9}$

Q.9 Express each of the following as a rational number of the form $\frac{p}{q}$:

(i) $\frac{-8}{3}+\frac{-1}{4}+\frac{-11}{6}+\frac{3}{8}-3$

(ii) $\frac{6}{7}+1+\frac{-7}{9}+\frac{19}{21}+\frac{-12}{7}$

Q.10 Simplify:

(i) $\frac{-3}{2}+\frac{5}{4}-\frac{7}{4}$ (ii) $\frac{5}{3}-\frac{7}{6}+\frac{-2}{3}$

Q.11 Multiply:

(i) $\frac{7}{11}$ by $\frac{5}{4}$ (ii) $\frac{5}{7}$ by $\frac{-3}{4}$

Q.12 Multiply:

(i) $\frac{-5}{17}$ by $\frac{51}{-60}$ (ii) $\frac{-6}{11}$ by $\frac{-55}{36}$

Q.13 Simplify each of the following and express the result as a rational number in standard form:

(i) $\frac{-16}{21}\times\frac{14}{5}$ (ii) $\frac{7}{6}\times\frac{-3}{28}$

Q.14 Simplify:

(i) $\left(\frac{25}{8}\times\frac{2}{5}\right)-\left(\frac{3}{5}\times\frac{-10}{9}\right)$ (ii) $\left(\frac{1}{2}\times\frac{1}{4}\right)+\left(\frac{1}{2}\times 6\right)$

Q.15 Simplify:

(i) $\left(\frac{3}{2}\times\frac{1}{6}\right)+\left(\frac{5}{3}\times\frac{7}{2}\right)-\left(\frac{13}{8}\times\frac{4}{3}\right)$

(ii) $\left(\frac{1}{4}\times\frac{2}{7}\right)-\left(\frac{5}{14}\times\frac{-2}{3}\right)+\left(\frac{3}{7}\times\frac{9}{2}\right)$

Q.16 Express each of the following as a rational number in the form $\frac{p}{q}$:

(i) 6^{-1} (ii) $(-7)^{-1}$

(iii) $\left(\frac{1}{4}\right)^{-1}$ (iv) $(-4)^{-1}\times\left(\frac{-3}{2}\right)^{-1}$

Q.17 Simplify

(i) $\{4^{-1}\times 3^{-1}\}^2$ (ii) $\{5^{-1}\div 6^{-1}\}^3$

Q.18 Express each of the following rational numbers with a negative exponent:

(i) $\left(\frac{1}{4}\right)^3$ (ii) 3^5

Q.19 Express each of the following rational numbers with a positive exponent:

(i) $\left(\frac{3}{4}\right)^{-2}$ (ii) $\left(\frac{5}{4}\right)^{-3}$

Q.20 Simplify

(i) $\left\{\left(\frac{3}{2}\right)^{-3}-\left(\frac{1}{2}\right)^{-3}\right\}\div\left(\frac{1}{4}\right)^{-3}$

(ii) $(3^2-2^2)\times\left(\frac{2}{3}\right)^{-3}$

Q.21 By what number should 5^{-1} be multiplied so that the product may be equal to $(-7)^{-1}$?

Q.22 By what number should $\left(\frac{1}{2}\right)^{-1}$ be multiplied so that the product may be equal to $\left(\frac{-4}{7}^{-1}\right)$?

Q.23 By what number should $(-15)^{-1}$ be divided so that the quotient may be equal to $(-5)^{-1}$?

Q.24 By what number should $\left(\frac{5}{3}\right)^{-2}$ be multiplied so that the product may be $\left(\frac{7}{3}\right)^{-1}$?

Q.25 Find x, if

(i) $\left(\frac{1}{4}\right)^{-4}\times\left(\frac{1}{4}\right)^{-8}=\left(\frac{1}{4}\right)^{-4x}$

(ii) $\left(\frac{-1}{2}\right)^{-19}\div\left(\frac{-1}{2}\right)^{8}=\left(\frac{-1}{2}\right)^{-2x+1}$

Q.26 If $x=\left(\frac{3}{2}\right)^{2}\times\left(\frac{2}{3}\right)^{-4}$, find the value of x^{-2}.

Q.27 Find the value of x for which $5^{2x}\div5^{-3}=5^5$.

Q.28 Express the following numbers in standard form:
(i) 602000000000000
(ii) 0.00000000000942

Q.29 Write the following numbers in the usual form:
(i) 4.83×10^7 (ii) 3.02×10^{-6}
(iii) 4.5×10^4 (iv) 3×10^{-8}

ANSWER KEY

1. $\frac{41}{33}$ **2.** $\frac{1}{21}$ **3.** $\frac{-5}{2}$ **4.** $\frac{47}{28}$

5. $\frac{-7}{5}$ **6.** $\frac{59}{30}$ **7.** $\frac{1}{4}$

8. (i) $\frac{17}{24}$ (ii) $\frac{-17}{18}$

9. (i) $-7\frac{3}{8}$ (ii) $\frac{17}{63}$

10. (i) -2 (ii) $\frac{-1}{6}$

11. (i) $\frac{35}{44}$ (ii) $\frac{-15}{28}$

12. (i) $\frac{1}{4}$ (ii) $\frac{5}{6}$

13. (i) $-2\frac{2}{15}$ (ii) $\frac{-1}{8}$

14. (i) $1\frac{11}{12}$ (ii) $3\frac{1}{8}$

15. (i) $3\frac{11}{12}$ (ii) $2\frac{5}{21}$

16. (i) $\frac{1}{6}$ (ii) $\frac{-1}{7}$ (iii) 4 (iv) $\frac{1}{6}$

17. (i) $\frac{1}{144}$ (ii) $\frac{216}{125}$

18. (i) 4^{-3} (ii) $\left(\frac{1}{3}\right)^{-5}$

20 (i) $\frac{-13}{108}$ (ii) $\frac{135}{8}$

21. $\frac{-5}{7}$ **22.** $(-56)^{-1}$ **23.** $(3)^{-1}$

24. $\frac{25}{21}$

25. (i) 3 (ii) 14

26. $\left(\frac{2}{3}\right)^{12}$

27. 1
28 (i) 6.02×10^{15} (ii) 9.42×10^{-12}
29 (i) 48300000 (ii) 0.00000302
(iii) 45000 (iv) 0.00000003

EXERCISE – II SCHOOL EXAM/BOARD

Q.1 Simplify : $\frac{4}{3}+\frac{3}{5}+\frac{-2}{3}+-\frac{11}{5}$

Q.2 Is 0.3 the multiplicative inverse of $3\frac{1}{3}$? Why or why not?

Q.3 Represent these numbers on the number line : (i) $\frac{7}{4}$ (ii) $\frac{-5}{6}$

Q.4 Represent $\frac{-2}{11},\frac{-5}{11},\frac{-9}{11}$ on the number line.

Q.5 Write five rational numbers which are smaller than 2.

Q.6 Find ten rational numbers between $\frac{-2}{5}$ and $\frac{1}{2}$

Q.7 Find five rational numbers between (i) $\frac{2}{3}$ and $\frac{4}{5}$ (ii) $\frac{-3}{2}$ and $\frac{5}{3}$ (iii) $\frac{1}{4}$ and $\frac{1}{2}$

Q.8 Write five rational numbers greater than –2.

Q.9 Simplify : $\frac{-3}{10}+\frac{7}{15}+\frac{3}{-20}-\frac{9}{10}+\frac{13}{15}+\frac{13}{-20}$

Q.10 The sum of two rational numbers is – 6 and one of them is $\frac{-7}{2}$. Find the other.

Q.11 Subtract the sum of the two numbers is $\frac{-8}{5}$ and $\frac{-5}{3}$ from the sum of $\frac{3}{2}$ and $\frac{-31}{28}$.

Q.12 Rimmi bought $4\frac{3}{4}$ litres milk and used $3\frac{7}{8}$ litres to prepare a sweet dish. How much milk is left?

Q.13 A train goes 80 km in one hour. How much distance will it cover in 45 minutes?

Q.14 A man has Rs. 100 with him. He bought $3\frac{1}{2}$ litres of milk at Rs. $16\frac{1}{2}$ per litre. How much money is left with him.

Q.15 Praneeta bought $3\frac{1}{2}$ m ribbon at Rs. $5\frac{3}{7}$ per metre, $4\frac{3}{4}$ m cloth at Rs. $27\frac{1}{2}$ per metre. How much money did she spend?

Q.16 By taking $x = \frac{-3}{4}$, $y = \frac{2}{3}$ and $z = \frac{-5}{6}$, verify that :
(i) $x \times (y + z) = x \times y + x \times z$
(ii) $x(y - z) = x \times y - x \times z$

Q.17 The product of two numbers is $-17\frac{1}{2}$. If one of them is $1\frac{1}{6}$, find the other.

Q.18 Divide the sum of $\frac{-3}{4}$ and $\frac{-5}{12}$ by their product.

Q.19 A shirt needs $2\frac{1}{4}$ m cloth. How many shirts can be made from $31\frac{1}{2}$ m cloth?

Q.20 The length of 21 skipping ropes is $36\frac{3}{4}$ m. Find the length of 1 rope.

ANSWER KEY

1. $-\frac{14}{15}$

2. Yes, because the product is 1

5. $1, -\frac{1}{2}, 0, -1, -\frac{1}{2},$

9. $-\frac{2}{3}$

10. $-\frac{5}{2}$

11. $3\frac{17}{84}$

12. $\frac{7}{8}$ Litre

13. 60 km

14. $42\frac{1}{4}$

15. Rs. $149\frac{5}{8}$

17. – 15

18. $-\frac{56}{15}$

19. 14 shirts

20. $\frac{7}{4}$

EXERCISE - III MULTIPLE CHOICE QUESTIONS

Q.1 If x = $0.1\overline{6}$, then 3x is -

(A) $0.4\overline{8}$ (B) $0.4\overline{9}$

(C) $0.\overline{5}$ (D) 0.5

Q.2 Find the value of x when $\left(\frac{3}{5}\right)^{2x-3} = \left(\frac{5}{3}\right)^{x-3}$

(A) x = 2 (B) x = – 2

(C) x = 1 (D) x = – 1

Q.3 If $2^x - 2^{x-1} = 4$, then x^x is equal to

(A) 1 (B) 27

(C) 3 (D) None of these

Q.4 The value of $\frac{(0.6)^0 - (0.1)^{-1}}{(3/2^3)^{-1}(3/2)^3 + \left(-\frac{1}{3}\right)^{-1}}$ is

(A) 3/2 (B) – 3/2

(C) 2/3 (D) –1/2

Q.5 What must be added to the sum of $4x^2 + 3x - 7$ and $3x^2 + 6x + 5$ to get : 1?

(A) $7x^2 + 9x - 3$ (B) $3 - 9x - 7x^2$

(C) $7x^2 + 9x - 2$ (D) None of these

Q.6 $1.\overline{3}$ is equal to –

(A) 3/4 (B) 2/3

(C) 4/3 (D) 2/5

Q.7 $0.\overline{585}$ is equal to –

(A) $\frac{585}{99}$ (B) $\frac{585}{999}$

(C) $\frac{999}{585}$ (D) none of these

Q.8 $5.\overline{2}$ is equal to –

(A) 45/9 (B) 46/9

(C) 47/9 (D) None of these

Q.9 Which of the following numbers is different from others ?

(A) $\sqrt{2}$ (B) $\sqrt{3}$

(C) $\sqrt{4}$ (D) $\sqrt{5}$

Q.10 Which of the following numbers is different from others ?

(A) $\sqrt{7}$ (B) $\sqrt{8}$

(C) $\sqrt{13}$ (D) $\sqrt{16}$

Q.11 If x = $0.\overline{7}$, then 2x is -

(A) $1.\overline{4}$ (B) $1.\overline{5}$

(C) $1.\overline{54}$ (D) $1.\overline{45}$

Q.12 Evaluate $\sqrt[3]{\left(\frac{1}{64}\right)^{-2}}$

(A) 4 (B) 16

(C) 32 (D) 64

Q.13 The value of $(256)^{0.16} \times (256)^{0.09}$ is -

(A) 64 (B) 256.25

(C) 16 (D) 4

Q.14 If a = $2 + \sqrt{3}$ and b = $2 - \sqrt{3}$, then $\frac{1}{a} + \frac{1}{b}$ is equal to -

(A) $2\sqrt{3}$ (B) $-2\sqrt{3}$

(C) 4 (D) – 4

Q.15 If a = $2 + \sqrt{3}$ and b = $2 - \sqrt{3}$, then $\frac{1}{a^2} - \frac{1}{b^2}$ is equal to

(A) 14 (B) – 14

(C) $8\sqrt{3}$ (D) $-8\sqrt{3}$

Q.16 If a = $\frac{2+\sqrt{3}}{2-\sqrt{3}}$, b = $\frac{2-\sqrt{3}}{2+\sqrt{3}}$, then the value of a + b is -

(A) 14 (B) – 14

(C) $8\sqrt{3}$ (D) $-\sqrt{3}$

Q.17 If x = $3 + \sqrt{8}$ and y = $3 - \sqrt{8}$, then $\frac{1}{x^2} + \frac{1}{y^2}$ is equal to -

(A) 34 (B) – 34

(C) $12\sqrt{8}$ (D) $-12\sqrt{8}$

Q.18 $\frac{2^{n+3}-2(2^n)}{2(2^{n+2})}$ when simplified is -

(A) $1 - 2\ (2^n)$ (B) $2^{n+3} - \frac{1}{4}$

(C) $1 - \frac{1}{4}$ (D) $1 - \frac{1}{2}$

Q.19 $\left(\frac{1}{64}\right)^0 + 64^{-1/2} - (-32)^{4/5}$ is equal to

(A) $-15\frac{7}{8}$ (B) $16\frac{1}{8}$

(C) $-14\frac{7}{8}$ (D) $17\frac{1}{8}$

Q.20 A rational number between $\sqrt{2}$ and $\sqrt{3}$ is

(A) $\frac{\sqrt{2}-\sqrt{3}}{2}$ (B) $\frac{\sqrt{2}\sqrt{3}}{2}$

(C) 1.4 (D) 1.5

Q.21 If $x = \frac{\sqrt{3}+\sqrt{2}}{\sqrt{3}-\sqrt{2}}$ and $y = 1$, the value of $\frac{x-y}{x-3y}$ is –

(A) $\frac{\sqrt{6}+4}{5}$ (B) $\frac{5}{\sqrt{6}-4}$

(C) $\frac{5}{\sqrt{6}+4}$ (D) $\frac{\sqrt{6}-4}{5}$

Q.22 If $A = x - \frac{1}{x}$, then the value of $\left(A+\frac{1}{A}\right)$ is

(A) $\frac{x^4-x^2+1}{x(x^2-1)}$ (B) $\frac{x^4+x^2+1}{x(x^2-1)}$

(C) $\frac{x^4+1}{x^3-x^2}$ (D) 1

Q.23 The value of $\frac{1+x}{1-x}-\frac{1-x}{1+x}+\frac{4x}{1+x^2}$ is –

(A) $\frac{8x}{1+x^4}$ (B) $\frac{8x}{1-x^4}$

(C) $\frac{8}{1-x^4}$ (D) $\frac{-8}{1-x^4}$

Q.24 The expression to be added to $(5x^2 - 7x + 2)$ to produce $(7x^2 - 1)$ is –

(A) $2x^2 + 7x + 3$ (B) $2x^2 + 7x - 3$

(C) $12x^2 - 7x + 1$ (D) $2x^2 - 3$

Q.25 What must be added to $1 - x + x^2 - 2x^3$ to obtain x^3 ?

(A) $x^3 - x^2 + x - 1$

(B) $-1 + x + x^2 - 3x^3$

(C) $3x^3 - x^2 + x - 1$

(D) None of these

Q.26 The product of $4\sqrt{6}$ and $3\sqrt{24}$ is –

(A) 124 (B) 134

(C) 144 (D) 154

Q.27 If $a = \frac{1}{3-2\sqrt{2}}$, $b = \frac{1}{3+2\sqrt{2}}$ then the value of $a^2 + b^2$ is –

(A) 34 (B) 35

(C) 36 (D) 37

Q.28 If $a = \frac{1}{3-2\sqrt{2}}$, $b = \frac{1}{3+2\sqrt{2}}$ then the value of $a^3 + b^3$ is –

(A) 194 (B) 196

(C) 198 (D) 200

Q.29 If $x = (7 + 4\sqrt{3})$, then the value of $x^2 + \frac{1}{x^2}$ is –

(A) 193 (B) 194

(C) 195 (D) 196

Q.30 If $\sqrt{5}$ = 2.236 and $\sqrt{10}$ = 3.162, the value of $\frac{\sqrt{10}-\sqrt{5}}{\sqrt{2}}$ on simplifying is –

(A) 0.455 (B) 0.855
(C) 0.655 (D) 0.755

Q.31 The value of $5\sqrt{3}-3\sqrt{12}+2\sqrt{75}$ on simplifying is –

(A) $5\sqrt{3}$ (B) $6\sqrt{3}$
(C) $\sqrt{3}$ (D) $9\sqrt{3}$

Q.32 If $\frac{\sqrt{3}-1}{\sqrt{3}+1}$ = a + b$\sqrt{3}$, then the value of a and b is–

(A) a = 2, b = –1
(B) a = 2, b = 1
(C) a = –2, b = 1
(D) a = –2, b = –1

Q.33 The rational form of $2.74\overline{35}$ is –

(A) $\frac{27161}{9999}$ (B) $\frac{27}{99}$
(C) $\frac{27161}{9900}$ (D) $\frac{27161}{9000}$

Q.34 The sum of a number and its reciprocal is 125/22. The number is –

(A) 2/11 (B) 1/11
(C) 3/11 (D) None of these

Q.35 What must be added to x/y to make it y/x ?

(A) $\frac{y-x}{y^2x^2}$ (B) $\frac{y^2-x^2}{xy}$
(C) $\frac{xy}{x+y}$ (D) $\frac{x^2y^2}{x^2+y^2}$

ANSWER KEY

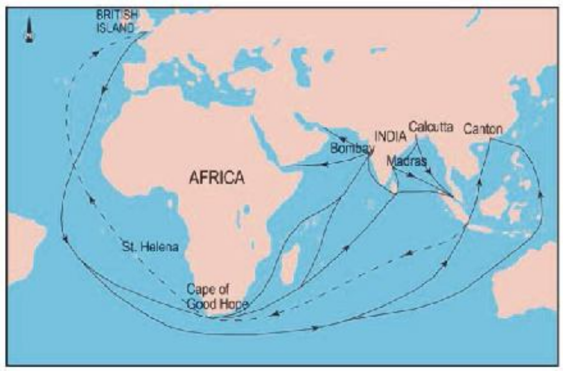
1.	D	**2.**	A	**3.**	B	**4.**	B
5.	B	**6.**	C	**7.**	B	**8.**	C
9.	C	**10.**	D	**11.**	B	**12.**	B
13.	D	**14.**	C	**15.**	D	**16.**	A
17.	A	**18.**	C	**19.**	C	**20.**	D
21.	A	**22.**	A	**23.**	B	**24.**	B
25.	C	**26.**	C	**27.**	A	**28.**	C
29.	B	**30.**	C	**31.**	D	**32.**	A
33.	C	**34.**	A	**35.**	B		

FROM TRADE TO TERRITORY

CONTIGENCIES OF MUGHAL EMPIRE

Aurangzeb was the last of the powerful Mughal rulers. He established control over a very large part of the territory that is now known as India. After his death in 1707, many Mughal governors (subadars) and big zamindars began asserting their authority and establishing regional kingdoms. As powerful regional kingdoms emerged in various parts of India, Delhi could no longer function as an effective centre.

By the second half of the eighteenth century, however, a new power was emerging on the political horizon – the British. Did you know that the British originally came as a small trading company and were reluctant to acquire territories? How then did they come to be masters of a vast empire?



Routes to India in the eighteenth century

EAST INDIA COMPANY COMES EAST

In 1600, the East India Company acquired a charter from the ruler of England, Queen Elizabeth I, granting it the sole right to trade with the East. This meant that no other trading group in England could compete with the East India Company. With this charter the Company could venture across the oceans, looking for new lands from which it could buy goods at a cheap price, and carry them back to Europe to sell at higher prices. The Company did not have to fear competition from other English trading companies. Mercantile trading companies in those days made profit primarily by excluding competition, so that they could buy cheap and sell dear.

The royal charter, however, could not prevent other European powers from entering the Eastern markets. By the time the first English ships sailed down the west coast of Africa, round the Cape of Good Hope, and crossed the Indian Ocean, the Portuguese had already established their presence in the western coast of India, and had their base in Goa. In fact, it was **Vasco da Gama**, a Portuguese explorer, who had discovered this sea route to India in 1498. By the early seventeenth century, the Dutch too were exploring the possibilities of trade in the Indian Ocean. Soon the French traders arrived on the scene.

The problem was that all the companies were interested in buying the same things. The fine qualities of cotton and silk produced in India had a big market in Europe. Pepper, cloves, cardamom and cinnamon too were in great demand. Competition amongst the European companies inevitably pushed up the prices at which these goods could be purchased, and this reduced the profits that could be earned. The only way the trading companies could flourish was by eliminating rival competitors. The urge to secure markets therefore led to fierce battles between the trading companies. Through the seventeenth and eighteenth centuries they regularly sank each other's ships, blockaded routes, and prevented rival ships from moving with supplies of goods. Trade was carried on with arms and trading posts were protected through fortification.

This effort to fortify settlements and carry on profitable trade also led to intense conflict with local rulers. The company therefore found it difficult to separate trade from politics.

EAST INDIA COMPANY BEGINS TRADE IN BENGAL

The first English factory was set up on the banks of the river Hugli in 1651. This was the base from which the Company's traders, known at that time as "factors", operated. The factory had a warehouse where goods for export were stored, and it had offices where Company officials sat. As trade expanded, the Company persuaded merchants and traders to come and settle near the factory. By 1696 it began building a fort around the settlement. Two years later it bribed Mughal officials into giving the Company zamindari rights over three villages. One of these was Kalikata, which later grew into the city of Calcutta or Kolkata as it is known today. It also persuaded the Mughal emperor Aurangzeb to issue a farman granting the Company the right to trade duty free.

The Company tried continuously to press for more concessions and manipulate existing privileges. Aurangzeb's farman, for instance, had granted only the Company the right to trade duty free. But officials of the Company, who were carrying on private trade on the side, were expected to pay duty. This they refused to pay, causing an enormous loss of revenue for Bengal.

Local boats bring goods from ships in Madras, painted by William Simpson, 1867

HOW TRADE LED TO BATTLES

Through the early eighteenth century the conflict between the Company and the nawabs of Bengal intensified. After the death of Aurangzeb, the Bengal nawabs asserted their power and autonomy, as other regional powers were doing at that time. Murshid Quli Khan was followed by Alivardi Khan and then Sirajuddaulah as the Nawab of Bengal. Each one of them was a strong ruler. They refused to grant the Company concessions, demanded large tributes for the Company's right to trade, denied it any right to mint coins, and stopped it from extending its fortifications. Accusing the Company of deceit, they claimed that the Company was depriving the Bengal government of huge amounts of revenue and undermining the authority of the nawab. It was refusing to pay taxes, writing disrespectful letters, and trying to humiliate the nawab and his officials.

Robert Clive

The Company on its part declared that the unjust demands of the local officials were ruining the trade of the Company, and trade could flourish only if the duties were removed. It was also convinced that to expand trade it had to enlarge its settlements, buy up villages, and rebuild its forts.

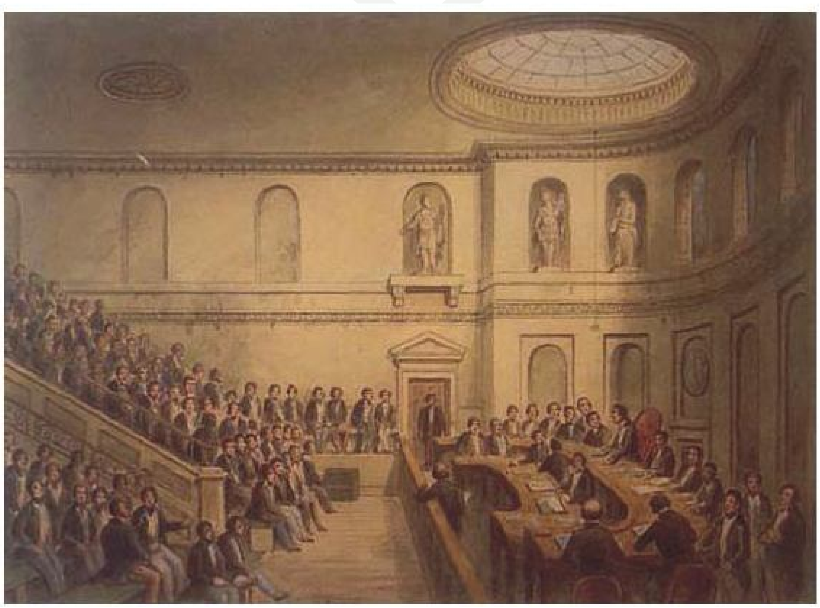
THE BATTLE OF PLASSEY

When Alivardi Khan died in 1756, Sirajuddaulah became the nawab of Bengal. The Company was worried about his power and keen on a puppet ruler who would willingly give trade concessions and other privileges. So it tried, though without success, to help one of Sirajuddaulah's rivals become the nawab. An infuriated Sirajuddaulah asked the Company to stop meddling in the political affairs of his dominion, stop fortification, and pay the revenues. After negotiations failed, the Nawab marched with 30,000 soldiers to the English factory at Kassimbazar, captured the Company officials, locked the warehouse, disarmed all Englishmen, and blockaded English ships. Then he marched to Calcutta to establish control over the Company's fort there.

Company officials in Madras sent forces under the command of Robert Clive, reinforced by naval fleets. Prolonged negotiations with the Nawab followed. Finally, in 1757, Robert Clive led the Company's army against Sirajuddaulah at Plassey. One of the main reasons for the defeat of the Nawab was that the forces led by Mir Jafar, one of Sirajuddaulah's commanders, never fought the battle. Clive had managed to secure his support by promising to make him nawab after crushing Sirajuddaulah. The Battle of Plassey became famous because it was the first major victory the Company won in India.

When Mir Jafar protested, the Company deposed him and installed Mir Qasim in his place. When Mir Qasim complained, he in turn was defeated in a battle fought at Buxar (1764), driven out of Bengal, and Mir Jafar was reinstalled. The Nawab had to pay Rs 500,000 every month but the Company wanted more money to finance its wars, and meet the demands of trade and its other expenses. It wanted more territories and more revenue. By the time Mir Jafar died in 1765 the mood of the Company had changed. Having failed to work with puppet nawabs, Clive declared: "We must indeed become nawabs ourselves."

Finally, in 1765 the Mughal emperor appointed the Company as the Diwan of the provinces of Bengal. The Diwani allowed the Company to use the vast revenue resources of Bengal. This solved a major problem that the Company had earlier faced. From the early eighteenth century its trade with India had expanded. But it had to buy most of the goods in India with gold and silver imported from Britain. This was because at this time Britain had no goods to sell in India. The outflow of gold from Britain slowed after the Battle of Plassey, and entirely stopped after the assumption of Diwani. Now revenues from India could finance Company expenses. These revenues could be used to purchase cotton and silk textiles in India, maintain Company troops, and meet the cost of building the Company fort and offices at Calcutta.



The General Court Room, East India House, Leadenhall Street

COMPANY OFFICIALS BECOME 'NABOBS"

After the Battle of Plassey the actual nawabs of Bengal were forced to give land and vast sums of money as personal gifts to Company officials. Robert Clive himself amassed a fortune in India. He had come to Madras (now Chennai) from England in 1743 at the age of 18. When in 1767 he left India his Indian fortune was worth £401,102. Interestingly, when he was appointed Governor of Bengal in 1764, he was asked to remove corruption in Company administration but he was himself cross-examined in 1772 by the British Parliament which was suspicious of his vast wealth. Although he was acquitted, he committed suicide in 1774.

However, not all Company officials succeeded in making money like Clive. Many died an early death in India due to disease and war and it would not be right to regard all of them as corrupt and dishonest.

Those who managed to return with wealth led flashy lives and flaunted their riches. They were called “nabobs”.

COMPANY RULE EXPANDS

The Company rarely launched a direct military attack on an unknown territory. Instead it used a variety of political, economic and diplomatic methods to extend its influence before annexing an Indian kingdom.

After the Battle of Buxar (1764), the Company appointed Residents in Indian states. They were political or commercial agents and their job was to serve and further the interests of the Company. Through the Residents, the Company officials began interfering in the internal affairs of Indian states. They tried to decide who was to be the successor to the throne, and who was to be appointed in administrative posts. Sometimes the Company forced the states into a “subsidiary alliance”.

According to the terms of this alliance, Indian rulers were not allowed to have their independent armed forces. They were to be protected by the Company, but had to pay for the “subsidiary forces” that the Company was supposed to maintain for the purpose of this protection. If the Indian rulers failed to make the payment, then part of their territory was taken away as penalty. For example, when Richard Wellesley was Governor- General (1798-1805), the Nawab of Awadh was forced to give over half of his territory to the Company in 1801, as he failed to pay for the “subsidiary forces”. Hyderabad was also forced to cede territories on similar grounds.

TIPU SULTAN THE "TIGER OF MYSORE"

Mysore had grown in strength under the leadership of powerful rulers like Haidar Ali (ruled from 1761 to 1782) and his famous son Tipu Sultan (ruled from 1782 to 1799). Mysore controlled the profitable trade of the Malabar coast where the Company purchased pepper and cardamom. In 1785 Tipu Sultan stopped the export of sandalwood, pepper and cardamom through the ports of his kingdom, and disallowed local merchants from trading with the Company.

Tipu Sultan

He also established a close relationship with the French in India, and modernised his army with their help.

The Britishers saw Haider and Tipu as ambitious, arrogant and dangerous – rulers who had to be controlled and crushed. Four wars were fought with Mysore (1767-69, 1780-84, 1790-92 and 1799). Only in the last – the Battle of Seringapatam – did the Company ultimately win a victory. Tipu Sultan was killed defending his capital Seringapatam, Mysore was placed under the former ruling dynasty of the Wodeyars and a subsidiary alliance was imposed on the state.

WAR WITH THE MARATHAS

From the late eighteenth century the Company also sought to curb and eventually destroy Maratha power. With their defeat in the Third Battle of Panipat in 1761, the Marathas' dream of ruling from Delhi was shattered. They were divided into many states under different chiefs (sardars) belonging to dynasties such as Sindhia, Holkar, Gaikwad and Bhonsle. These chiefs were held together in a confederacy under a Peshwa (Principal Minister) who became its effective military and administrative head based in Pune. Mahadji Sindhia and Nana Phadnis were two famous Maratha soldiers and statesmen of the late eighteenth century.

The Marathas were subdued in a series of wars. In the first war that ended in 1782 with the Treaty of Salbai, there was no clear victor. The Second Anglo- Maratha War (1803-05) was fought on different fronts, resulting in the British gaining Orissa and the territories north of the Yamuna river including Agra and Delhi. Finally, the Third Anglo-Maratha War of 1817-19 crushed Maratha power. The Peshwa was removed and sent away to Bithur near Kanpur with a pension. The Company now had complete control over the territories south of the Vindhyas.

Cornwallis receiving the sons of Tipu Sultan as hostages, painted by Daniel Orme, 1793

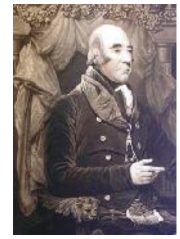
THE CLAIM TO PARAMOUNTCY

From the early nineteenth century the Company pursued an aggressive policy of territorial expansion. Under Lord Hastings (Governor- General from 1813 to 1823) a new policy of "paramountcy" was initiated. Now the Company claimed that its authority was paramount or supreme, hence its power was greater than that of Indian states.

This process, however, did not go unchallenged. For example, when the British tried to annex the small state of Kitoor (in Karnataka today), Rani Channamma took to arms and led an anti-British resistance movement. She was arrested in 1824 and died in prison in 1829. But Rayanna, a poor chowkidar of Sangoli in Kitoor, carried on the resistance. With popular support he destroyed many British camps and records. He was caught and hanged by the British in 1830.

In the late 1830s the East India Company became worried about Russia. It imagined that Russia might expand across Asia and enter India from the north-west. Driven by this fear, the British now wanted to secure their control over the north-west. They fought a prolonged war with Afghanistan between 1838 and 1842 and established indirect Company rule there. Sind was taken over in 1843. Next in line was Punjab. But the presence of Maharaja Ranjit Singh held back the Company. After his death in 1839, two prolonged wars were fought with the Sikh kingdom. Ultimately, in 1849, Punjab was annexed.

THE DOCTRINE OF LAPSE

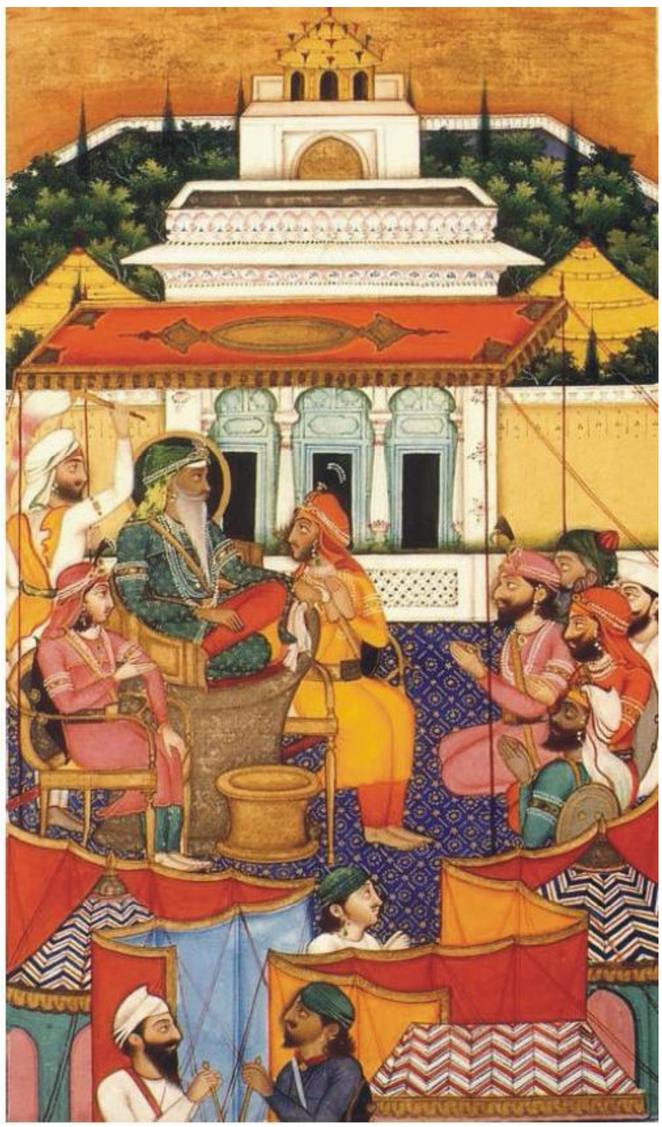


Lord Hastings

This was introduced under the reign of Lord Dalhousie, who was Governor-General from 1848 to 1856.

He devised a policy that came to be known as the Doctrine of Lapse. The doctrine declared that if an Indian ruler died without a male heir his kingdom would "lapse", that is, become part of Company territory. One kingdom after another was annexed simply by applying this doctrine: Satara (1848), Sambalpur (1850), Udaipur (1852), Nagpur (1853) and Jhansi (1854).

Finally, in 1856, the Company also took over Awadh. This time the British had an added argument – they said they were "obliged by duty" to take over Awadh in order to free the people from the "misgovernment" of the Nawab! Enraged by the humiliating way in which the Nawab was deposed, the people of Awadh joined the great revolt that broke out in 1857.



Maharaja Ranjit Singh holding court

SETTING UP A NEW ADMINISTRATION

Warren Hastings (Governor-General from 1773 to 1785) was one of the many important figures who played a significant role in the expansion of Company power. By his time the Company had acquired power not only in Bengal, but also in Bombay and Madras. British territories were broadly divided into administrative units called Presidencies. There were three Presidencies: Bengal, Madras and Bombay. Each was ruled by a Governor. The supreme head of the administration was the Governor-General. Warren Hastings, the first Governor-General, introduced several administrative reforms, notably in the sphere of justice.

From 1772 a new system of justice was established. Each district was to have two courts – a **criminal court (faujdari adalat)** and a **civil court (diwani adalat)**. Maulvis and Hindu pandits interpreted Indian laws for the European district collectors who presided over civil courts. The criminal courts were still under a qazi and a mufti but under the supervision of the collectors.

A major problem was that the Brahman pandits gave different interpretations of local laws based on different schools of the dharmashastra. To bring about uniformity, in 1775 eleven pandits were asked to compile a digest of Hindu laws. N.B. Halhed translated this digest into English. By 1778 a code of Muslim laws was also compiled for the benefit of European judges. Under the Regulating Act of 1773, a new Supreme Court was established, while a court of appeal – the Sadar Nizamat Adalat – was also set up at Calcutta.

The principal figure in an Indian district was the Collector. As the title suggests, his main job was to collect revenue and taxes and maintain law and order in his district with the help of judges, police officers and darogas. His office – the Collectorate – became the new centre of power and patronage that steadily replaced previous holders of authority.

❖ THE COMPANY ARMY

The Mughal army was mainly composed of cavalry (sawars: trained soldiers on horseback) and infantry, that is, paidal (foot) soldiers. They were given training in archery (teer-andazi) and the use of the sword. The cavalry dominated the army and the Mughal state did not feel the need to have a large professionally trained infantry.

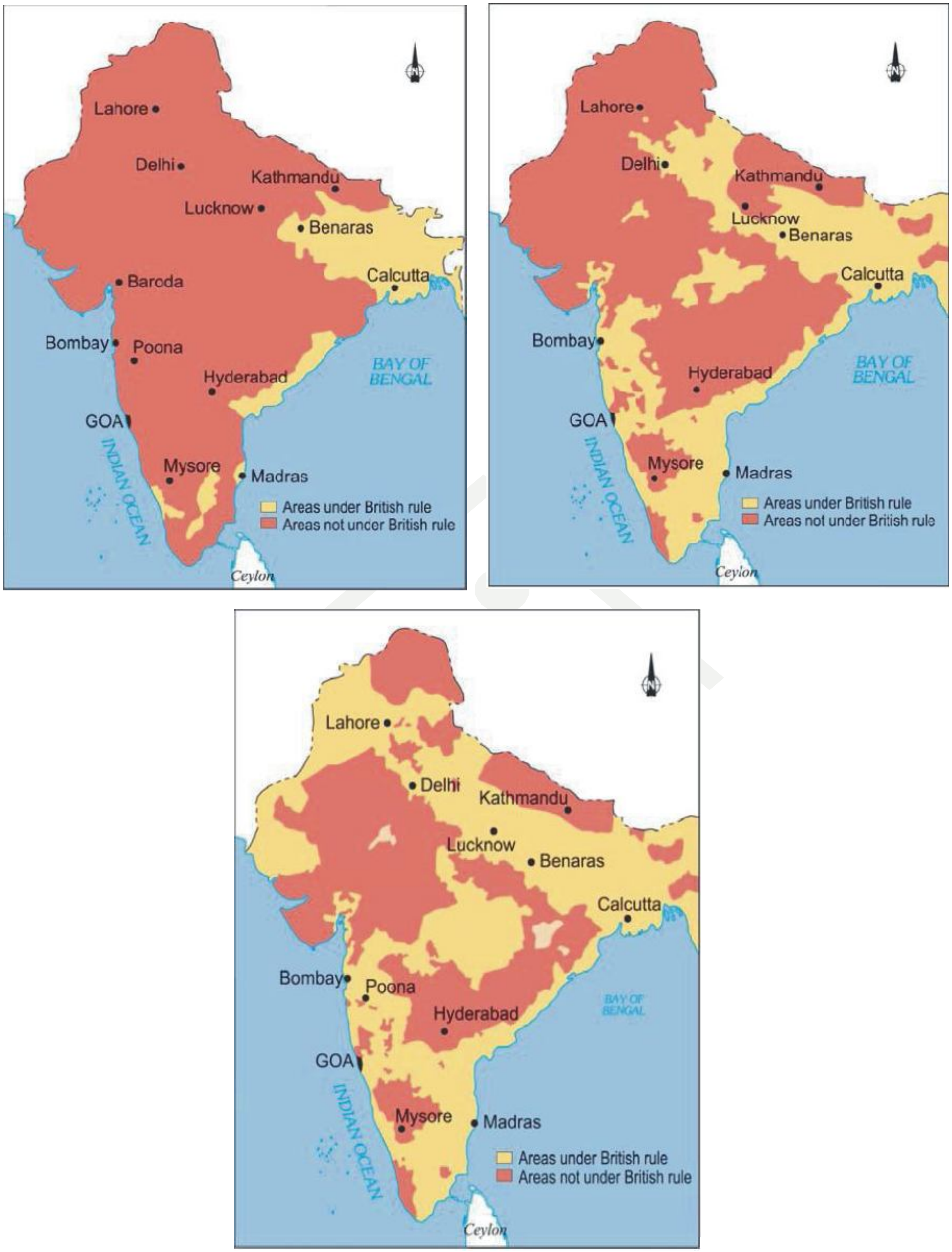
A change occurred in the eighteenth century when Mughal successor states like Awadh and Benaras started recruiting peasants into their armies and training them as professional soldiers. The East India Company adopted the same method when it began recruitment for its own army, which came to be known as the sepoy army (from the Indian word sipahi, meaning soldier).

As warfare technology changed from the 1820s, the cavalry requirements of the Company's army declined. This is because the British empire was fighting in Burma, Afghanistan and Egypt where soldiers were armed with muskets and matchlocks. The soldiers of the Company's army had to keep pace with changing military requirements and its infantry regiments now became more important.

CONCLUSION

The East India Company was transformed from a trading company to a territorial colonial power. The arrival of new steam technology in the early nineteenth century also aided this process. Till then it would take anywhere between six and eight months to travel to India by sea. Steamships reduced the journey time to three weeks enabling more Britishers and their families to come to a far-off country like India.

By 1857 the Company came to exercise direct rule over about 63 per cent of the territory and 78 per cent of the population of the Indian subcontinent. Combined with its indirect influence on the remaining territory and population of the country, the East India Company had virtually the whole of India under its control.



Expansion of British territorial power in India

Exercise - I — UNSOLVED PROBLEMS

VERY SHORT ANSWER TYPE QUESTIONS:

Q.1 After the death of which Mughal emperor, powerful regional kingdoms emerged in various parts of India?

Q.2 What led to intense conflicts between local rulers and various trading companies?

Q.3 Why did the English turn hostile towards Mir Qasim?

Q.4 When was Tipu Sultan killed?

Q.5 Who issued the Charter granting monopoly rights to trade with India?

Q.6 What was the main cause of the defeat of Sirajuddaulah in the battle of Plassey?

Q.7 Who were 'nabobs'? Why they were called so?

Q.8 In which battle, the British defeated Tipu Sultan?

SHORT ANSWER TYPE QUESTIONS:

Q.9 What were the mercantile companies?

Q.10 Briefly describe the composition of the British army in India.

Q.11 What was the policy of Paramountcy?

Q.12 Describe the various changes in Judiciary brought by Warren Hastings.

Q.13 What were the causes of trade rivalries?

Q.14 On what pretext was Awadh annexed?

Q.15 What were the results of the Fourth Mysore War?

Q.16 Describe the conditions prior to battle of Plassey.

LONG ANSWER TYPE QUESTIONS:

Q.17 Describe the new administration set up by British.

Q.18 What were the terms of Subsidiary alliance?

Q.19 What do you understand by the 'Doctrine of Lapse'? Who introduced it?

Q.20 Briefly write about the Battle of Plassey.

Exercise - II OLYMPIAD PROBLEMS

Q.1 Who was the last of the powerful Mughal emperors?
(A) Akbar (B) Aurangzeb
(C) Babur (D) Humayun

Q.2 Who succeeded Siraj-ud-daulah as the Nawab of Bengal?
(A) Mir Qasim (B) Jagat Seth
(C) Mir Jafar (D) Khadim Khan

Q.3 Vasco da Gama discovered the sea route to India in-
(A) 1478 (B) 1488
(C) 1498 (D) None of these

Q.4 At which place the first English factory was established?
(A) Hyderabad (B) Tanjore
(C) Mysore (D) Hugli

Q.5 When was the Battle of Plassey fought?
(A) 1752 (B) 1754
(C) 1757 (D) None of these

Q.6 Which policy was introduced by Lord Dalhousie?
(A) Zamindare
(B) Diwani
(C) Doctrine of Lapse
(D) None of these

Q.7 Who asked the Company to stop meddling in the political affairs of Bengal?
(A) Sirajuddualah
(B) Aurangzeb
(C) Murshid Quli Khan
(D) Mir Jaffar

Q.8 Aurangzeb died in-
(A) 1680 (B) 1707
(C) 1709 (D) 1711

Q.9 When was Charter granted by Queen of England to English East India Company?
(A) 1600 (B) 1607
(C) 1650 (D) 1617

Q.10 Under whose command the British fought the battle of Plassey?
(A) Hastings (B) Watson
(C) Robert Clive (D) Lord Dalhousie

Q.11 Who replaced Mir Jafar as the Nawab of Bengal?
(A) Mir Qasim (B) Sirajuddualah
(C) Roberty Clive (D) None of the above

Q.12 Which European was first to reach India through sea route?
(A) Amerigo (B) Magellan
(C) Vasco da Gama (D) Columbus

Q.13 After which battle the company started appointing Residents in Indian states?
(A) Battle of Plassey
(B) Battle of Panipat
(C) Battle of Wandiwas
(D) Battle of Buxar

Q.14 Before the battle of Plassey Sirajuddualah attacked on-
(A) Company's factory at Kassimbazar
(B) The fort of company
(C) Clive's Residence
(D) (A) and (B) both

Q.15 The battle of Buxar was fought in-
(A) 1756 (B) 1757
(C) 1764 (D) 1766

Q.16 Who was the Tiger of Mysore?
(A) Haider Ali (B) Tipu Sultan
(C) Wadeyars (D) None

Q.17 In British period the Supreme Court was established in -
(A) 1759 (B) 1772
(C) 1775 (D) 1773

Q.18 Satara was annexed in-
(A) 1848 (B) 1852
(C) 1853 (D) 1854

Q.19 Which Queen protested against British in Kitoor?
(A) Ranu Laxmi Bai
(B) Begum Hajrat Mahal
(C) Rani Chinnamma
(D) Rani Jinghan

Q.20 Punjab was annexed in-
(A) 1839 (B) 1848
(C) 1849 (D) None

ANSWER KEY

1.	B	**2.**	C	**3.**	C	**4.**	D
5.	C	**6.**	C	**7.**	A	**8.**	B
9.	A	**10.**	C	**11.**	A	**12.**	C
13.	D	**14.**	A	**15.**	C	**16.**	B
17.	C	**18.**	A	**19.**	C	**20.**	C