Chapter = 07

PROPERTIES OF MATTER

Kinetic Molecular Model Of Matter

Definition: - It is a (Model) theory which explains the composition and behaviors of three states of matter.

Main Points Of Kinetic Model Of Matter:- According to kinetic model of matter

(i) Matter is composed of small particles called **"Molecules".**

(ii) All the molecules are always in state of motion.

(iii) The molecules **mutually attract** each other.

(iv) Matter exists in **three states** i-e solids, liquids and gases.

(v) The molecules **collides** with each other without any **loss of energy and momentum**.

(vi) The molecular **kinetic energy increases** with the **increase** in **temperature**.

EXPLAINATION OF THREE STATES OF MATTER ON THE BASE OF KINETIC MOLECULAR MODEL OF MATTER

SOLIDS

Definition:-That state of matter which has definite shape and definite volume is known as solid. OR

The lowest energy state of matter is known as solid.

Examples:- stone , iron , chair , table etc.

Properties: -

(i) They have **definite shape**.

(ii) They have **definite volume**.

(iii) They have **strongest inter molecular forces**.

(iv) They have **lowest kinetic energy**.

(v) They have **high density**.

(vi) Their molecules are **tightly bounded** to each other.

(vii) Their molecules perform only **vibratory motion**.

(viii)Their molecules cannot be **transferred** from one place to another.

(ix)Their **kinetic energy increases with the increase in temperature**.

LIQUIDS

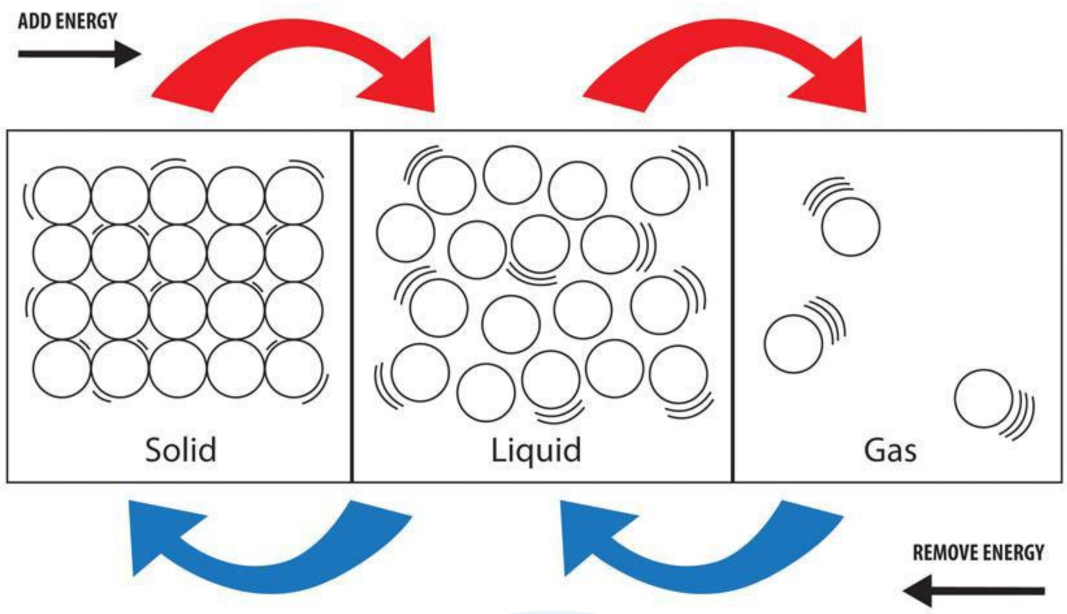
Definition:- That state of matter which has definite volume but have no definite shape is known as liquid.
Examples:- water , milk , oil , petrol etc .
Properties:-
(i) They have **indefinite shape**.
(ii) They have **definite volume**.
(iii) They have **moderate inter molecular forces**.
(iv) They have **moderate kinetic energy**.
(v) They have **moderate density**.
(vi) Their molecules are **loosely bounded** to each other.
(vii) Their molecules **perform all types of motion**.
(vii) Their molecules can **transferred** from one place to another.
(viii) Their **kinetic energy increases with the increase in temperature**.

Some questions about the topic:-

- What is difference between solids and liquids?
- What is the difference between solids and gases?
- What is difference between liquids and gases?
- Solids have fixed shapes and volume why? Explain.
- Why liquids adopts the shape of the container in which they are kept?
- Why gases are compressible?
- Why solids are rigid?

GASES

Definition:-That state of matter which has indefinite shape and indefinite volume is known as gas .OR
The highest energy state of matter is known as gas.
Examples:- Oxygen gas , Hydrogen gas , Helium gas etc .
Properties:-
(i) They have **indefinite shape**.
(ii) They have **indefinite volume**.
(iii) They have **weakest inter molecular forces**.
(iv) They have **highest kinetic energy**.
(v) They have **lowest density**.
(vi) Their molecules are not bounded to each other.
(vii) Their molecules perform all types of motion.
(viii) Their molecules can be transferred from one place to another.
(ix) Their kinetic energy increases with increases in temperature.



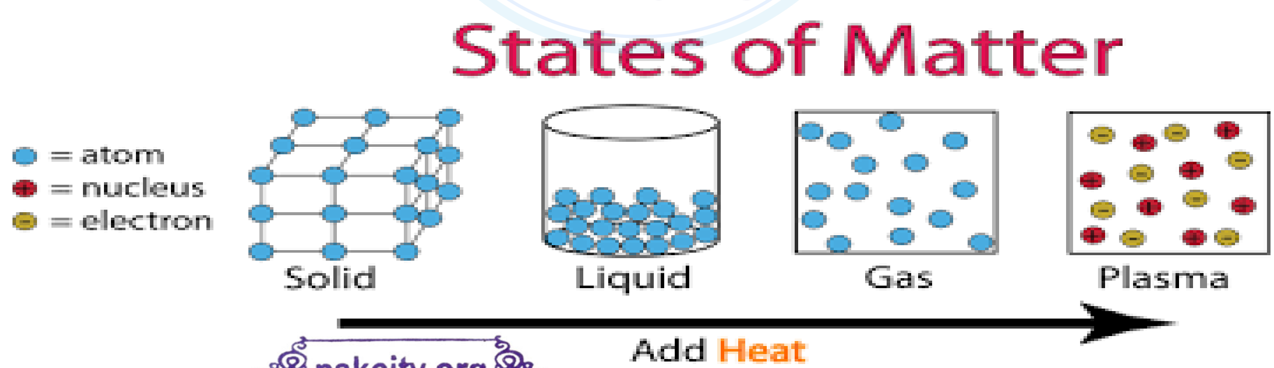
PLASMA

History: It was first of all introduced by **William Crooks in 1879**.

Definition:- Ionized gas mixture consisting of **ions** , **electrons** and **neutral atoms** is known as plasma. OR

The **fourth state** of matter which is a mixture of **neutral particles, positive ions** and **negative electrons** is known as plasma. OR

The highly conducting state of matter is known as plasma.



Explanation:-

- About **99 %** of **visible** universe is **made up of plasma**.
- It conducts **electric current**.
- It response to **magnetic field**.

Occurrence: It occurs at very high temperatures and is found in

- Fluorescent light bulbs.
- Atmosphere.
- Lightning strikes.
- Plasma TV,s etc

Production:- It can be produced by

- heating a substance.
- passing electric current through the air.
- nuclear thermal reaction.

Examples: -

- Sun
- Stars
- Flames
- Luminous clouds.
- Electric arc.
- Lightening etc .

Uses:- plasma is used in

- Fluorescent lamps
- Neon signs
- Display screen like " LED,s" .
- Cleaning and sterilization.
- Computers and electronic equipment etc .

DENSITY:-

Definition:- The mass of a substance per unit volume is known as density.

Symbol:-It is denoted by **"ρ".**

Mathematical Form:- $\rho = m / V$ --------------------------- (1)

Unit:- Its **"S.I"** unit is **Kg/m^3 (Kgm^{-3}).**

Quantity:- It is a **scalar** quantity .

Nature:- It is a **derived** quantity .

Factors:- From equation (1) it is cleared that the density of substance depends upon the following two factors:-

(1)Mass of substance.

(2)Volume of substance .

(1) Mass of substance (m):- Greater the mass of the body greater will be its density and vice versa.

(2) **Volume of substance(V)**:- Greater the volume of the body less will be its density and vice versa.

Note:- In general solids are denser than liquids and liquids are denser than gases.

Examples:-

Densities of some materials and objects	
Materials/objects	**Density (kg/m^{-3})**
Iron	7900
Gold	19300
Ice	920
Polythene	900
Petrol	800
Pure water	1000
Mercury	13600
Air	1.3
Carbon dioxide	2.0

PRESSURE

Definition:- The force per unit area is known as pressure.

Symbol:- It is denoted by **"P".**

Mathematical Form:- Pressure = Force / Area

$$P = F / A \quad \text{------------- } (1)$$

Units:- Its **"S.I"** unit is **Pascal** (Pa) .

$$\mathbf{1\ Pa = 1N/\ m^2\ \ (1N\ m^{-2}).}$$

Quantity:- It is **scalar** quantity.

Nature:- It is a **derived** quantity .

Factors:- From equation (1) it is cleared that the pressure depends upon the following factors .

(1) Applied force (F).

(2)Area (A).

(1) Applied force (F):- Greater the applied force greater will be the pressure and vice versa.

(2) Area (A):-Greater the area less will be the pressure and vice versa.

ATMOSPHERE

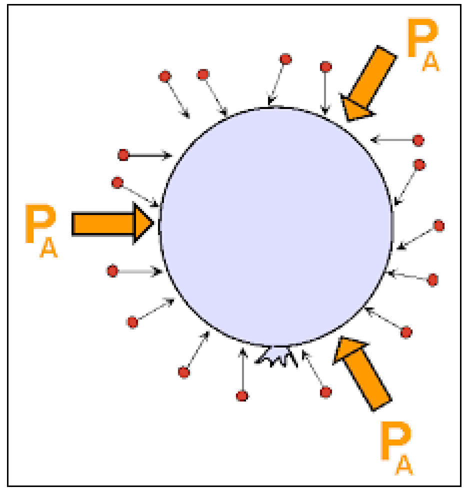
Definition: - The Earth is surrounded by a cover (layer) of air is known as atmosphere

Range:- It extends to a few hundred kilometers above the sea level .

Explanation:-We live at the bottom of a huge ocean of air. Air is a mixture of gases. The density of air in the atmosphere is not uniform. It decreases continuously as we go up.

ATMOSPHERIC PRESSURE

Definition: - The pressure that atmosphere exerts is known as atmospheric pressure. OR The pressure exerted by the thick layer of air surrounds the earth is known as atmospheric pressure.



Cause :- Due to weight of atmosphere.

Direction of Atmospheric Pressure :- It acts in all direction.

Symbol:- It is denoted by $\mathbf{P_{atm}}$.

Mathematical Form:- $P_{atm} = \rho g h$---------------------- (1)

Unit:- Its SI unit is **Pascal**.

Other Units:-

- Atmosphere (atm)
- Bar
- Millibar (used in weather map).
- Torr .

Measurement:- it is measured with the help of barometer .

Factors: - From equation(1) it is cleared that atmospheric pressure depends upon the following factors

(1)Density of air

(2)Vertical height from the upper most layer towards the earth.

(3)Value of g.

ACTIVITY: - Using atmospheric pressure to crush can:-

Apparatus:-

- Thin walled metal cane
- Vacuum pump

Procedure:-

(i) Attached thin-metal walled can with vacuum pump.

(ii) Before the air was pumped out the pressure inside the can is equal to the outside pressure.

(iii)the pressure inside the can is equal to the outside (atmospheric) pressure.

(iv) As the air is pumped out ,a partial vaccum of very low pressure forms inside the can

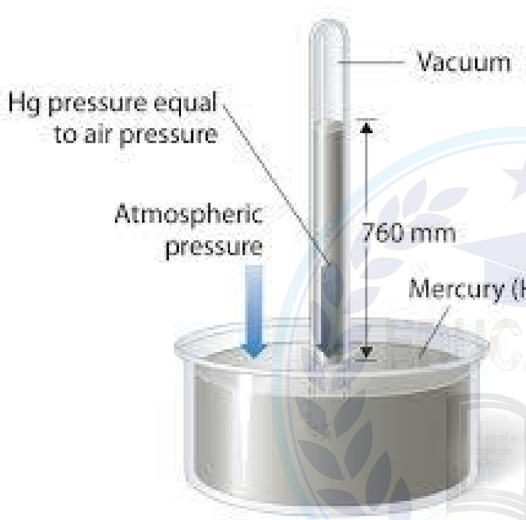
.(v) And immediately the external atmospheric pressure crushes the can.

(vi) It will only happen if the material of can is thin or flexible.

BAROMETER

History: - It was invented by an Italian mathematics **E . Torricelli in 1643**.
Definition:- A device which is used to measure the atmospheric pressure is known as barometer.
Other Name:- It is also called **Torricelli tube** .
Construction: - It consists of

- A 100cm (1m) long glass tube that is open at one end and closed at the other end.
- Dish of mercury (reservoir of mercury)
- Mercury



Working : -

- Place the barometer on plane surface.
- Take some amount of mercury in the dish (container).
- Filled the glass tube with mercury.
- To cover the open end of glass tube with a thumb.
- Place the mercury filled glass tube inverted in the mercury dish carefully.
- When the open end is completely immersed in the mercury dish then the thumb is removed.
- The mercury in the dish experiences pressure from two sides.
- One is the atmospheric pressure which is vertically downward that pushes the mercury of dish in the glass tube.
- Other is pressure of mercury column in glass tube which pushes the mercury of dish against the atmospheric pressure.

- Some of the mercury from the mercury column in the tube drops in the container due to greater column pressure than atmospheric pressure and leaving a space at the closed end.
- This space contains no air and is nearly a vacuum which is known as Torricelli vacuum.
- The out flow of mercury from the glass tube stops. When the atmospheric pressure becomes equal to the pressure of mercury column.
- The height of mercury in the glass tube gives us the value of atmospheric pressure.
- At sea level the mercury rise up in a tube to a height of 760 mm or 76 cm.

STANDARED ATMOSPHERIC PRESSURE

Definition:- The pressure of 760mm or 76cm column of mercury at $0C^0$ at sea level is known as standard atmospheric pressure or 1 atmosphere (1 atm).

Explanation:- As we known that

$$1 \text{ atm} = \rho g h \text{ ---------------------------- (P)}$$

- Density of mercury = 13600 kg/m^3
- $g = 9.8\ m/s^2$
- h = 760mm =76cm = 0.760m

Calculation: - By putting values in equation (P) we get

$$1 \text{ atm} = 13600 \times 9.8 \times 0.760$$

$$1 \text{ atm} = 101300 \text{ Pa} = 1.013\times10^5 \text{ Pa}$$

- In British engineering system:-
  1 atm =14.7 pound per square inch ($1b/in^2$).

Note:-

- 1 bar = 1000 mbar.
- 1 bar = 1.000×10^5 Pa.

ATMOSPHERIC PRE SSURE AND WEATHER

Atmospheric pressure **decreases** as we go up .The atmospheric pressure on mountains is lower that at sea level. At a height of about **30 km**, the atmospheric pressure becomes **7 mm** of mercury which is approximately **1000 Pa**. It would become **zero at an altitude** where is no **air**. Thus we can determine the altitude of a place by knowing the atmospheric pressure at that place.

Effect of atmospheric pressure on weather: -

(i) On a hot day air above the earth becomes hot and expands .This causes a fall of atmospheric pressure in that region.

(ii). During chilly nights, air above the earth cools down. This causes an increase in atmospheric pressure.

Expected weather changes due to variation of atmospheric pressure:- The change in atmospheric pressure at a certain places indicates the expected changes in the weather conditions at that place.

Decrease in atmospheric pressure :-

(i)A gradual and average drop in atmospheric pressure means a low pressure in a neighboring locality.

(ii) Minor but rapid fall in atmospheric pressure indicates a windy and showery condition in the nearby region.

(iii) A decrease in atmospheric pressure accompanied by breeze and rain.

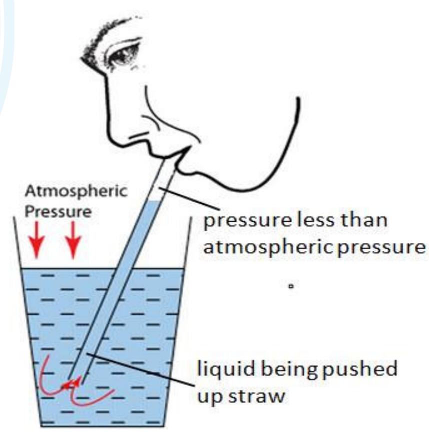
(iv)A sudden fall in atmospheric pressure often followed by a storm , rain and typhoon to occurs in few hours times.

Increase in atmospheric pressure:-

(i) An increase in atmospheric pressure with a decline later on predicts an intense weather conditions.

(ii)A gradual large increase in the atmospheric pressure indicates a long spell of pleasant weather.

(iii)A rapid increase in the atmospheric pressure means that it will soon be followed by a decrease in the atmospheric pressure indicating poor weather ahead.

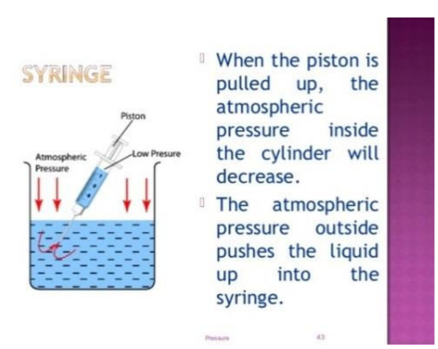


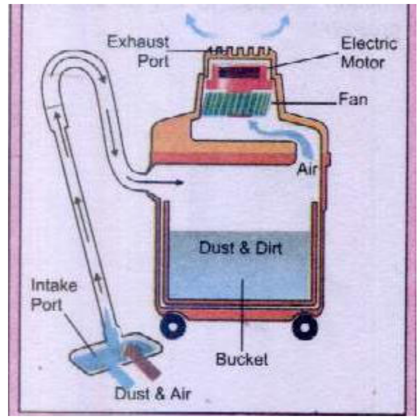
APPLICATIONS OF ATMOSPHERIC PRESSURE

(1)Drinking through straw: - The action of sucking increases the volume of lungs , thereby reducing the air pressure in the lungs and the mouth .The atmospheric pressure acting on the surface of the liquid will then be greater than the pressure in the mouth , thus forcing the liquid to rise up the straw into the mouth.

(2)Pulling liquid up the syringe:-

To draw liquid into the syringe as shown as figure (1) the position of the syringe is drawn back upwards .this decreases the pressure within the cylinder .atmospheric pressure acting on the surface of the liquid drives the liquid into the cylinder through the nozzle of syringe .thus atmospheric pressure helps the fluid to lift up cylinder.





(3)<u>Vacuum cleaner</u>:- It consists of an electric motor with fan, filter bag (dirt bag) and a tube. When the electric motor is switched on the fan in the vacuum cleaner lowers the air pressure in the dirt bag. The atmospheric air rushes into it carrying dust and dirt with it through its intake port. The dust and dirt particles are blocked by the filter while air escape out.

PASCAL PRINCIPLE

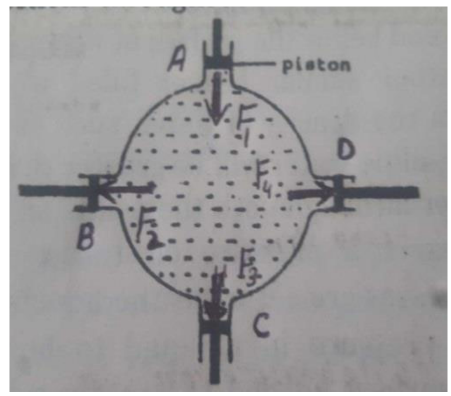
<u>History</u>:- This law was presented by a **FRENCH** scientist **Blaise Pascal in 1647**.

<u>Statement</u>:- An external pressure is applied to an enclosed fluid is transmitted unchanged to every point within the fluid. OR

Liquids exert same pressure in all directions. OR

Pressure applied at any point in a container is transmitted without loss to all other parts of the liquids. OR

The pressure applied to a portion of a liquid contained in a vessel is equally transmitted to all the portions of the liquid.



<u>DEMONSTRATION</u>:- Pascal's principle can be demonstrated with the help of an activity. Take a vessel which is connected with four similar movable pistons i-e **"A" , "B", "C" and "D".**

<u>Working</u>:- Fill it with water .Push the piston A in downward direction due to which pressure is exerted on the liquid which is trans mitted in all directions.as a result the pistons B , C and D will move outwards. This shows that liquid exert same pressure in all directions.

APPLICATIONS OF PASCAL's PRINCIPLE

(1) Hydraulic lift.
(2) Hydraulic break system.
(3) Hydraulic press.
(4) Hydraulic Jack.
(5) Hydraulic machine

(1) <u>Hydraulic lift</u>:-

<u>Definition</u>:- It is a device which is used for lifting heavy loads very easily.

<u>Principle</u>:- Its basic principle is Pascal's principle.

<u>Construction</u>: - It consists of :-

(i) Two cylinders of different cross-sectional areas.

(ii) They are fitted with pistons of cross-sectional area A_1 and A_2.
(iii) Some liquid is enclosed in it as shown in figure (H).

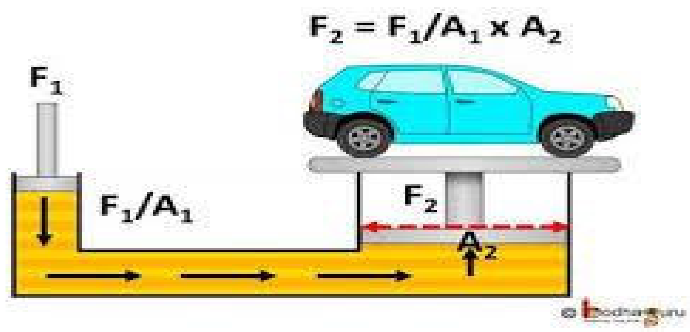


Fig (H)

Working:-

- When the F_1 is applied on the piston of small cross-sectional area in downward direction.
- The pressure P produced by small piston is transmitted equally to the large piston.
- A force F_2 acts on A_2 which is much larger than F_1.
- As a res ult the piston of cylinder moves upward.
- So in this way the load on the plate form piston can be lifted easily
- Pressure on piston of small area is $P_1 = F_1 / A_1$ ------------ (1)
- Pressure on piston of large area is $P_2 = F_2 / A_2$ ------------ (2)
- By Pascal's principle $P_1 = P_2$
- By comparing equation (1) and (2) we get
- $F_1 / A_1 = F_2 / A_2$
- So the net force will be $F_2 = F_1 \times A_2 / A_1$ ------------------------- (3)
- As the ratio A_2 / A_1 is greater than 1 , hence the force F_2 that acts on large piston will be greater than the force F_1 acting on the smaller piston.

  Note:-

Hydraulic brake operation:-

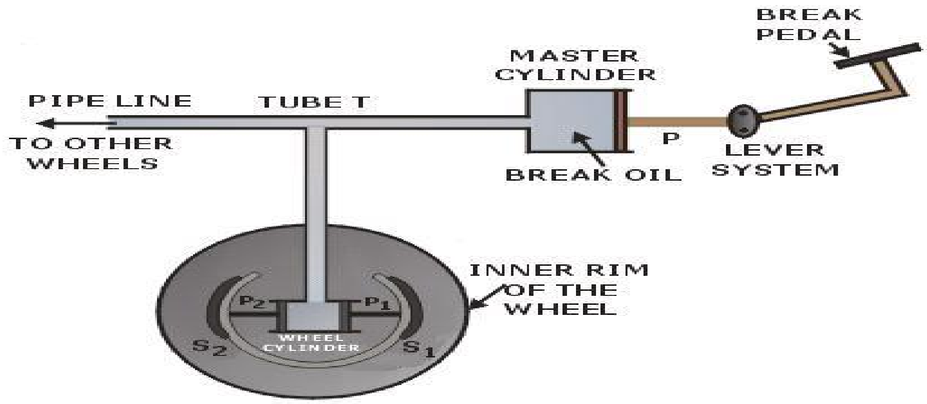
Definition:- It is a device which is used for stopping the wheels of the vehicles .

Principle:- Its basic principle is Pascal's principle.

Construction:-

- It consists of five cylinders.
- One of these is called master cylinder because it is large in size.
- Master cylinder is connected by tubes to four smaller cylinders or brake cylinders.

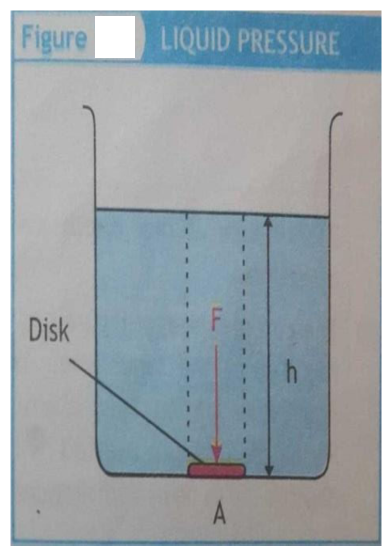
- These cylinders are fitted with oil tight pistons.
- The smaller cylinders are in contact with the wheels of the vehicles.



Hydraulic Brake

Working : - When brake pedal is pushed, it exerts a force on the master cylinder which increases the liquid pressure in it. The liquid pressure is transmitted equally through the liquid in the metal pipes to all pistons of other cylinder. Due to the increase in the liquid pressure, the piston in the cylinders move outward pressing the brake pads and the brake drums stops .The force of friction between the brake pads and the brakes drums stops the wheels.

LIQUID PRESSURE



Definition: -The pressure due to liquid is known as liquid pressure.
Symbol:- It is denoted by **"P".**
Mathematical Form:- **P = ρ g h**
Explanation: - Liquids exert pressure. The pressure of a liquid acts in all direction .If we take a pressure sensor (a device that measures pressure) inside a liquid.

Proof of P = ρ g h: - Let a disc is placed at the bottom of a tank in a fluid. The force acting on the disc is the weight of cylinder column of liquid of height **" h "** and area of cross section **"A".** This cylinder is shown by dotted lines as shown in figure (D).

From figure:-

Volume of cylinder :- Volume = V = Ah ....(i)

Density of fluid = Density = $\rho = \frac{m}{V}$ .... (ii)

Mass of fluid above the disc = m = ρ V .... (iii)

By putting equation (i) in equation (iii) we get

$$m = \rho \times Ah = \rho Ah \quad \text{.....................} \quad (iv)$$

Force acting on the disc = F = W = mg ……………………….(v)
By putting equation (iv) in equation (v) we get

$$F = \rho Ah \times g = \rho Ahg \text{ ……………… (vi)}$$

The pressure at the bottom on the disc = $P = \frac{F}{A}$ ………… (vii)
By putting equation (vi) in equation (vii) we get

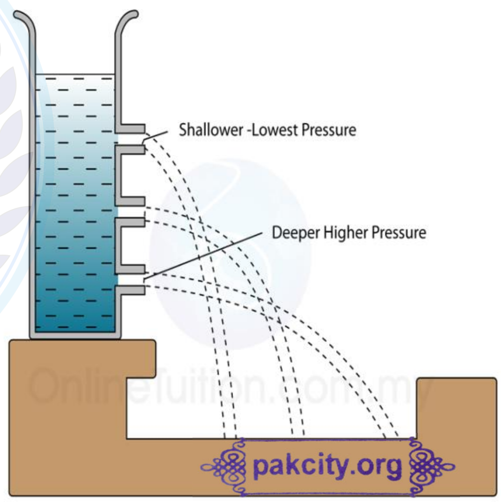
$$P = \frac{\rho Ahg}{A} = \rho hg = \rho gh$$

$$\mathbf{P = \rho g\, h} \text{ ………………… (viii)}$$

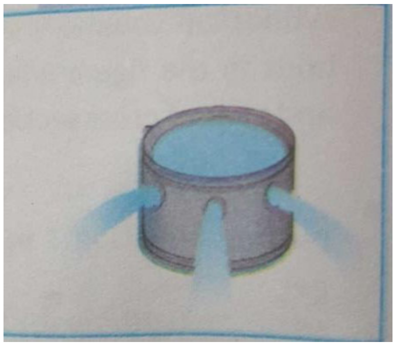
Equation the represents the pressure exerted by the liquid.
Results:-
(i) This pressure is called hydrostatic pressure because the fluid is at rest and not moving.
(ii) Pressure depends upon the density of fluids i-e $P \propto \rho$.
(iii) Pressure depends upon the depth below the surface i-e $P \propto h$.
(iv) The of fluids does not depends upon the **shape** of the container.

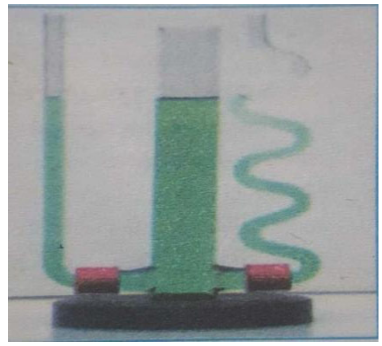
PROPERTIES OF FLUIDS AND PRESSURE

(1)Pressure in a liquid increases with depth:-
As we know that $\mathbf{P = \rho g\, h}$ **………….. (i)**
From equation (i) it is cleared that $P \propto$ depth (h)
Greater the depth (h) greater will be the pressure and smaller the depth (h) smaller will be the pressure.



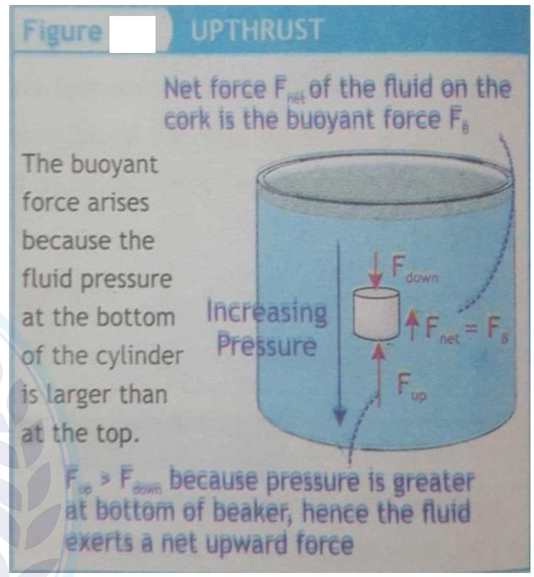
(2) Pressure at one depth acts equally in all directions:-
Consider a can of water having similar holes all round it at the same level (depth) as shown in figure 1a.
The water comes out equally fast and spurts far from each hole. Hence the pressure exerted by the water at this depth is the same in all directions.
(3)A liquid finds its own level:- In figure 1b the liquid is at the same level in each tube and conforms that the pressure at the bottom of a liquid depends only on the vertical depth of the liquid and not on the tube width or shape.





(1a)

(1b)



UP-THRUST AND BUOYANCY

Meaning: - The word up-thrust means **" An upward push".**

Definition:-The upward force that a liquid or gas exerts on a body floating in it is known as up-thrust. OR
The force acting on an object due to buoyant of a liquid is known as up-thrust

Other Name:- It is also called **buoyant force**.

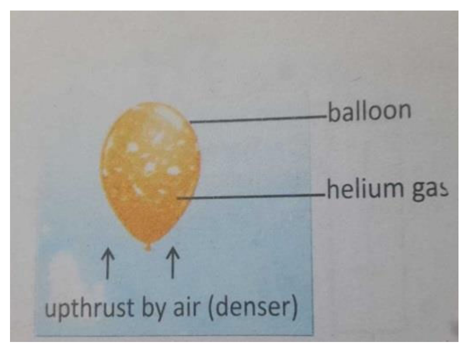
Symbol:- It is denoted by F_b .

Mathematical Form:- $F_b = \rho V g$

Unit:- Its SI unit is **newton** (N).

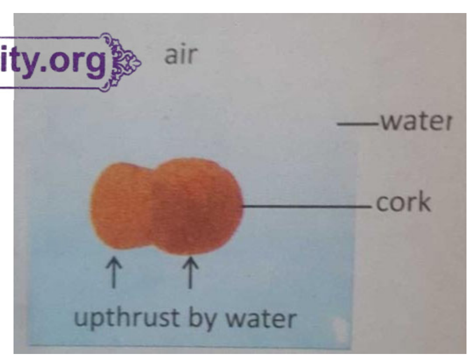
Cause:- It arises because of the fluid pressure at the bottom of the cylinder is larger than at the top.

Explanation:- when an object is immersed in a fluid the pressure on the lower surface of the object is higher than the pressure on the upper surface .The difference in pressures leads to an upward net force acting the object due to the fluid pressure called up-thrust or buoyant force and the phenomena is known as buoyancy.



Examples:-

(i) A balloon filled with helium (a gas lighter than air) will be pushed upwards by the denser air when it is released .this because up-thrust is greater than the total downward weight of helium and the material of the balloon as shown in figure.



(ii) If we immersed a piece cork in water it will rise to the surface of water and floats .This is because that the water is denser than the cork.

ARCHIMEDES PRINCIPLE

History:- This principle was presented by a **Greek scientist ARCHIMEDES** .

Statement:- The buoyant force acting on an object fully or partially submerged in a fluid is equal to the weight of the fluid displaced by the object .OR

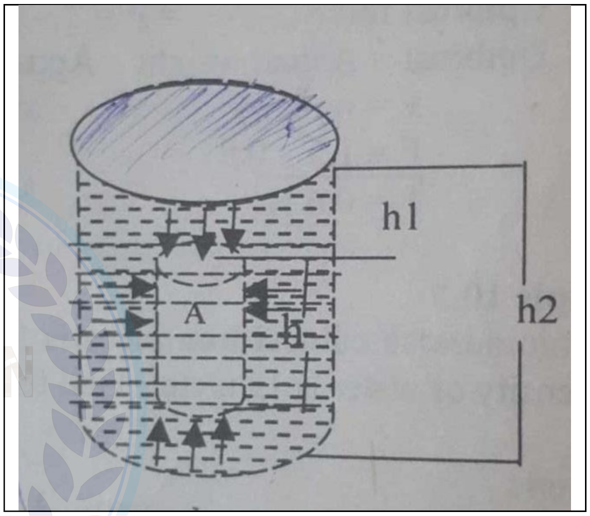
When an object is wholly or partially immersed in a liquid it experiences a buoyant force which is equal to the weight of liquid displaced by the object . OR

When an object is totally or partially immersed in a liquid an up-thrust acts on it equal to the weight of the liquid it displaces.

Mathematical Form:-

Magnitude of Buoyant force = Weight of fluid displaced

F_b = W OR F_b = mg



DERIVATION OF F_b = mg :-

Consider a solid body cylinder of cross-section area **"A"** and height **"h"** is immersed in liquid of density of **"ρ"** as shown in figure.

From figure:-

(i) Depth of upper end of cylinder from the upper surface of water = h_1

(ii) Depth of lower end of cylinder from the upper surface of water = h_2

Force acting on the upper end of cylinder due to fluid = F_1= A$h_1\rho$g…………… (1)

Force acting on the upper end of cylinder due to fluid = F_2= A$h_2\rho$g ………… (2)

Net Force = Up-thrust = F_b = F_2 - F_1 ……………. (3)

By putting equation (1) and (2) we get

F_b = F_2 - F_1 = A$h_2\rho$g - A$h_1\rho$g = A ρg (h_2 - h_1) Take A ρg common

F_b = A ρgh ………………………… (3) h_2 - h_1 = h

F_b = Vρg ……………………………(4) Ah = V

F_b = mg ………………………….. (5) Vρ = m

OR F_b = mg = W ……………………. (6)

Eq (5) is the required proof of Archimedes Principle.

Note:- Archimedes Principle is applicable on liquids as well as gases.

LAW OF FLOTATION

Statement :- "**A floating objects displaces its own weight of the fluid in which it floats**".
Purpose:-
Explanation:- Consider a body of mass "m" , density "ρ" and volume "V" be immersed in a fluid of "$\rho^{/}$".
Let the volume of the fluid displaced be "$V^{/}$", which is also to part of the object submerged in the fluid.Then according to law of floatation.

Weight of the object = weight of the fluid displaced

$$mg = \rho^{/} V^{/} g$$
$$V\rho g = \rho^{/} V^{/} g = V\rho \not{g} = \rho^{/} V^{/} \not{g}$$
$$V\rho = \rho^{/} V^{/}$$

OR $$\frac{\rho}{\rho^{/}} = \frac{V^{/}}{V} \quad \text{.......................} (1)$$

Results: - From equation (1):- (i) If $\rho < \rho^{/}$ then $V^{/} < V$. This means that if the density of an object is less than the density of the fluid in which it is immersed it will float in the fluid and will be partially immersed . In case of $\rho = \rho^{/}$ then $V^{/} = V$ the object will float in the fluid and will be completely immersed.
Fluids:-
Definition:- Any substance which has ability to flow is fluid.
Examples:- All the liquids and gases are the fluids because they have ability to flow.

ELASTICITY

Definition:-The property of solids materials to return to their original shape and size after the removal of deforming of force is known as elasticity. OR
The property of a body which enables the body to regain its original dimensions when the deforming force acting on the body is removed is known as elasticity.
Deforming force:- The applied force which changes the shape , length or volume of a substance is known as deforming force.
Factor of elasticity:- The elasticity of a substance depends upon the strength of intermolecular forces. Stronger the inter molecular forces among the molecules greater will be the elasticity of a substance and vice versa.
Explanation: - The elastic behavior of a material can be explained by the kinetic theory of matter. Since the molecules in a solid are very close to each other, there exist strong inter attractive forces between them. Thus when the force is removed the attractive force

between the molecules pull then back again and material is restored to its original shape. Materials have different elasticities depending upon the nature of the material. For elastic substances more effort is required to produce a change in their shape, volume or length. Therefore steel is more elastic than rubber because more effort is needed to bring a permanent change in steel than in rubber.

Examples:-

(i)The length of Spring increase on stretching due to elasticity.

(ii) The length of rubber increase on stretching due to elasticity etc.

Classification of material on the base of elasticity: - On the base of elasticity all the materials are divided into two types which are given below.

(1) Elastic Material.

(2) Non-Elastic Material.

(1)Elastic Material:-

Definition:- Those materials which restore their original size and shape after the removal of the applied force known as elastic materials.

Examples:- Rubber , Steel , Iron etc.

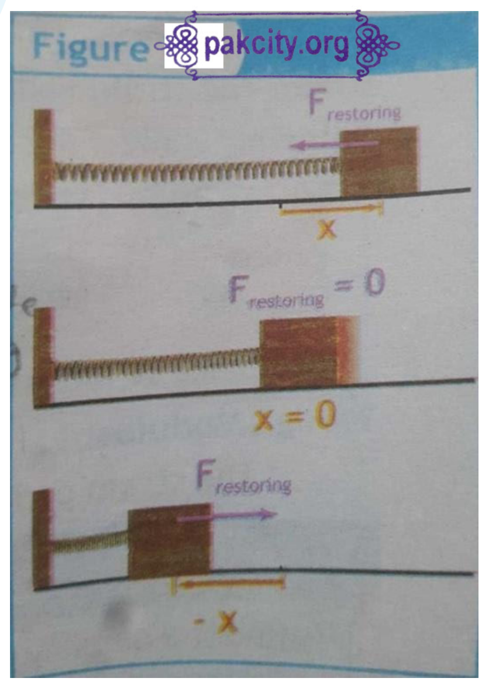
(2) Non-Elastic Material:-

Definition:- Those materials which do not restore their original size and shape after the removal of the applied force known as elastic materials.

Examples:- Plasticine, Clay , dough etc.

Elastic Limit :- The limit with in which a body recovers its original shape after removing deforming forces is known as elastic limit.

Explanation:- It tells the maximum stress that can be safely applied on a body without causing permanent deformation its length, volume or shape.



HOOK'S LAW

History: - This law was presented by an **English Physicists Hooke in 1678**.

Purpose: - To find the relationship between restoring force and compression or extension.

Statement:-"Within elastic limits the extension (or compression) is directly proportional to the restoring force".

Other Name:- This law is called Law of elasticity.

Mathematical Form: - Restoring force ∝ Extension

$$F_{res} \propto -X$$

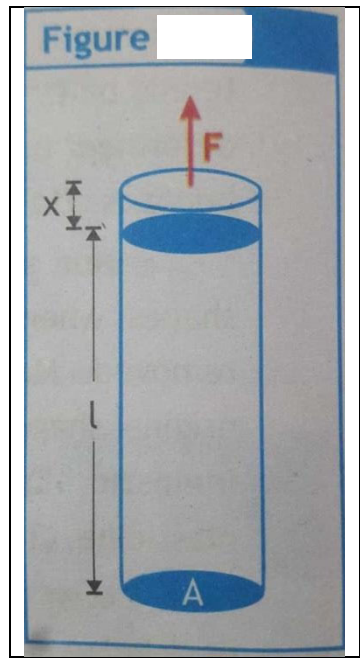
$$F_{res} = \text{constant}\,(-X)$$

$$F_{res} = K(-X)$$
$$F_{res} = -KX \text{ ------------------- } (1)$$

Equation (1) represents the mathematical form of Hooks law.
In equation (1):-
(i)"K" is the constant of proportionality and is known as force constant having unit N/m (Nm^{-1}).
(ii) The negative sign shows that force is directed against displacement.
(iii) This relationship is also true for a wire under tension.
Application: - This law is applicable to all kinds of deformation and all types of matter i-e solids, liquids and gasses within certain limit.

STRESS

Definition:-The deforming force acting per unit area is known as strain. OR
Symbol:- It is denoted by (Greek letter sigma) **" σ " .**



Mathematical Form: - $\text{Stress} = \frac{\text{force}}{\text{area of cross section}}$

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

Unit: - Its **SI** unit is **N/m^2 or Nm^{-2} OR Pascal.**
Quantity:- It is a **scalar** quantity.
Nature:- It is a **derived** quantity.
Factors:- From equation (1) it is cleared that the strain has two factors which are given below.
(1) Force **(F).**
(2) Area of cross section **(A).**

STRAIN

Definition: - The extension per unit length is known as strain.
Symbol: - It is denoted by (Greek letter epsilon) "**Є** ".

Mathematical Form: - $\text{Strain} = \frac{\text{Extension}}{\text{Original length}}$

$$\epsilon = \frac{X}{L}$$

Unit: - It has no unit because it is the ratio between two similar quantities.
Quantity: - It is a **scalar** quantity.
Nature: - It is a **derived** quantity.

PRESSURE	STRESS
It is denoted by "P".	It is denoted by " σ " .
Mathematically: $P = \frac{F}{A}$	*Mathematically* : $\sigma = \frac{F}{A}$
It consider in case of fluids.	It consider in case of solids.
Its value is always positive.	Its value can be positive as well as positive.
It is a scalar quantity.	It is a tensor quantity.
It acts only perpendicular.	It acts only perpendicular as well as parallel.

Tensor Quantity:- A quantity which has magnitude as well as direction but not follow the vector laws of addition.

YOUNG'S MODULUS

Definition: - The ratio of stress to strain is known as young's modulus.

Symbol:-It is denoted by **"Y".**

Mathematical Form: - Young 's Modulus = $\frac{Stress}{Strain}$

$$Y = \frac{\sigma}{\epsilon} \text{ ----------------------- (1)}$$

As we know that

- $\sigma = \frac{F}{A}$ and
- $\epsilon = \frac{X}{L}$

By putting equations (2) and (3) in equation (1) we get

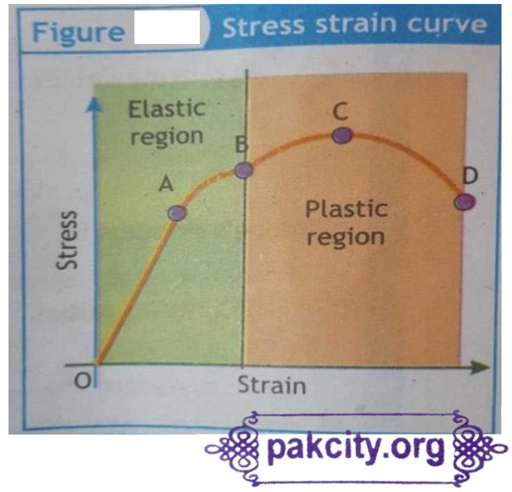
$$Y = \frac{\frac{F}{A}}{\frac{X}{L}} = \frac{F\,L}{AX}$$

Or $Y = \frac{F\,L}{AX}$ .... (1)

Unit: - Its **SI** unit is **Pascal**.

MODULUS FOR SELECTED MATERIALS			
Materials	**Young's Modulus**	**Materials**	**Young's Modulus**
Aluminum	7.0×10^{10}	Lead	1.6×10^{10}
Brass	9.0×10^{10}	Nickel	21×10^{10}
Copper	11.0×10^{10}	Steel	20×10^{10}
Crown glass	6.0×10^{10}	Rubber	1.4×10^{6}
Iron	21.0×10^{10}	Tungsten	36×10^{10}

STRESS - STRAIN CURVES



Definition:- The graph which is plotted between the stress and strain of a material is known as stress – strain graph.

Explanation:-Stress and Strain curves are measured by stress tester.The stress-Strain curve for a typical wire as shown in figure.

When the stress increases the strain also increases.

From the given figure:-

(i).Point "A" shows the limit of proportionality, the limit up to which Hooks is obeyed.

(ii) Point "B" shows the elastic limit, the limit up to which materials shows elastic behavior.

(iii) Point "C" shows the maximum stress wire can be with stand without breaking.

(iv) Point "D" shows the breaking point where material breaks.

CONCEPTUAL QUESTIONS

Give a brief response to the following questions.

(1) If you climbed a mountain carrying a mercury barometer, would the level of the mercury column in the glass tube of the barometer increase or decrease as you climb the mountain? Explain.

Ans:- **Statement**:- The level of the mercury column in the glass tube of the barometer will be decreases as you climb the mountain.

Reason:- It is due to decrease in atmospheric pressure.

Explanation:- As we know that We live at the bottom of a huge ocean of air . Air is a mixture of gases. The density of air in the atmosphere is not uniform. It decreases continuously as we go up. The atmospheric pressure also decreases. The level of mercury column in the glass tube of the barometer depends upon the atmospheric pressure. Greater the atmospheric pressure greater will be the height of the mercury column in the glass tube and vice.

Conclusion:- As a result we can conclude that the level of the mercury column in the glass tube of the barometer will be decreases as you climb the mountain.

(2) Walnuts can be broken down in the hand by squeezing two together but not one. why?

Ans: Statement:-Walnuts can be broken down in the hand by squeezing two together but not one.

Reason:- Stress $\propto \frac{1}{Area}$

$$\sigma \propto \frac{1}{A}$$

Explanation:- As we know that

$$\sigma = \frac{F}{A} \text{ .... (i)}$$

From equation (i) it is cleared to come to know that :-

(a) Greater the force greater will be the stress and vice versa.
(b) Smaller the area greater the will be the stress and vice versa.

Conclusion:- As a result by taking two Walnuts in the hand decreases the area of contact and the stress increases. Thus due greater stress the walnuts break easily.

(3) Why is the cutting edge of the knife made very thin?

Ans:- **Statement**:- The cutting edge of the knife is made very thin.

Reason:- $P \propto \frac{1}{A}$

Explanation:- As we know that

$$P = \frac{F}{A} \text{ .... (i)}$$

From equation (i) it is an established fact that :-
(a) Greater the applied force greater will the pressure and vice versa.
(b) Smaller the area greater will be the pressure and vice versa.

Conclusion:- As a result we can conclude that by increasing the pressure the cutting edge of the knife is made very thin for easily cutting of a substance.

(4) Why water tanks are constructed at the highest level in your houses?

Ans:- **Statement**:- Water tanks are constructed at the highest level in our houses.

Reason:- Pressure of fluid(water) $\propto Height$.

Explanation:- As we know that

$$P = \rho g h \text{ .... (i)}$$

From equation (i) it is an established fact that :-

(a) Greater the height of the fluid greater will be its pressure and vice versa.

Conclusion:- As a result the pressure of water in the pipe system increases with height. So for an easy flow of water in pipe system the water tanks are constructed / installed at the highest level in our houses.

(5) Why dose a small needle sinks in water and huge ships travel easily in water without sinking?

Ans:- **Statement**:- A small needle sinks in water and huge ships travel easily over water surface without sinking.

Reason:- It is because

(i) Weight of needle > Up thrust force.
(ii) Weight of ship < Up thrust force.

Explanation:- From Archimedes Principle :-

(a) If the weight of an object is greater than the up-thrust force then object will sink in water.
(b) If the weight of an object is less than the up-thrust force then object will float on the surface of water.

Conclusion:- As a result the needle sinks in water and the huge ship travels easily in water without sinking.

(6) Explain how and why camels have adapted them to allow to walk more easily on desert condition?

Ans:- **Statement**:-The camels have adapted themselves to walk more easily on desert condition.

Reason:- It is because of $P \propto \frac{1}{A}$

Explanation: - As we know that

$$P = \frac{F}{A} \quad \text{...} \quad (i)$$

From equation (i) it is an established fact that:-

(a) Greater the force the greater will be the pressure and vice versa.
(b) Smaller the area the greater will be the pressure and vice versa.

Conclusion:- As the feet of camel is flat and wide. This increases, Its contact area on the ground in the desert condition and exert a little pressure due to which they can walk easily in the desert.

(7) You would have probably experienced your ears 'popping' while driving in the mountains. Why ear pops?

Ans:- Statement:- We have experienced our ears 'popping' while driving in the mountainous areas.

Reason:- It is due to decrease in atmospheric pressure.

Explanation:- As we know that in plane area the pressure of air inside the ears and outsides remains the same. In the mountains the atmospheric pressure decreases. In this case the air pressure inside the ears is greater than the outside pressure which cause the popping in the ear while driving in the mountains.

Conclusion:- As a result we conclude that we experience our ears 'popping' while driving in the mountains.

(8) If you fill an air tight balloon at the top of a mountain would the balloon expand or contract as you descend the mountain? Explain.

Ans:- **Statement**:- The balloon will contract when we fill an air- tight balloon at the top of a mountain and when we come down.

Reason:- It is because of increase in atmospheric pressure.

Explanation:- As we know that When we fill a balloon up at the top of the mountains the external atmospheric pressure and internal pressure on the balloons walls by air balances each other. But when moves downward from the mountain top the atmospheric pressure increases. Thus the outer atmospheric pressure becomes higher than the atmospheric pressure inside the balloon. Due to this effect the balloon contracts and its volume decreases.

Conclusion:- As a result we can conclude that the balloon will be contract when we fill an air- tight balloon at the top of a mountain and then bring it down.

(9) A rowboat is floating in a swimming pool when the anchor is dropped over the side. when the anchors is drooped, will the water level in the swimming pool increase ,decrease ,remain the same ?Explain

Ans:- **Statement**:- A rowboat is floating in a swimming pool when the anchor is dropped over the side (into the water) . The water level of water in the swimming pool will be decreases.

Explanation:- As we know that when the anchor is in the boat the mass of the anchor is the part of the mass of boat. The whole weight of is supported and the amount of is displaced balances the weight. When the anchor is dropped into water it sinks and displace water whose volume is equal to the volume of the anchor. So the water level falls and volume of water decreases in the pool.

Conclusion:- As a result we can conclude that a rowboat is floating in a swimming pool when the anchor is dropped over the side (into the water) . The water level of water in the swimming pool will decrease.

(10) Which material the most elastic steel or a rubber and why?

Ans:- **Statement**:- Steel is more elastic than rubber.

Reason:- It is because Elasticity $\propto Stress$

Explanation:- As we known that the elasticity of the material depends the magnitude of stress i-e. Greater the stress required for a material greater will be its elasticity and vice versa. So for the given stress the strain produce in steel is much smaller than that produce in rubber.

Conclusion:- As a result we conclude that steel is more elastic than rubber.

NUMERICAL QUESTIONS

Q #01 :- A rectangular glass block of dimensions 30cm by 5cm by 10cm weight 37.5N. Calculate the least and the greatest pressure it can exert when resting on a horizontal body?

Ans:- Solution:-

Given data:-

Force on glass rectangular block = F = 37.7 N

Length of block = L = 30 cm = $\frac{30}{100}$ m = 0.3m

Width of block = w = 5cm = $\frac{5}{100}$ m = 0.05m

Height of block = h = 10cm = $\frac{10}{100}$ m = 0.1m

Required data:-

(i) Least (minimum) Pressure = $P_{minimum}$ = ?

(ii) Greatest (maximum) Pressure = $P_{maximum}$ = ?

Formula:- As we know that

(i)For Least (minimum) Pressure = $P_{minimum}$:- Then equation (i) becomes

$$P_{minimum} = \frac{F}{A_{maximum}} = \frac{F}{L \ x \ h} \text{ .... (ii)}$$

$A_{maximum}$ = L x h

Calculation:- By putting values in equation (ii) we get

$$P_{minimum} = \frac{37.5}{0.3 \ x \ 0.1} = \frac{37.5}{0.03} = 1250 \text{ Pa}$$

(ii)Greatest (maximum) Pressure = $P_{maximum}$:- Then equation (i) becomes we get

$$P_{maximum} = \frac{F}{A_{minimum}} = \frac{F}{h \ x \ w} \text{ .... (iii)}$$

A_{minium} = h x w

Calculation:- By putting values in equation (iii) we get

$$P_{maximum} = \frac{37.5}{0.1 \ x \ 0.05} = \frac{37.5}{0.005} = 7500 \text{ Pa}$$

Result:- So as a result (i) $P_{minimum}$ = = 1250 Pa and (ii) $P_{maximum}$ = 7500 Pa

Q #2 : what is the height of a water barometer at atmospheric ?

Ans:- Solution:-

Given data:-

Atmospheric Pressure = P = 1.013 x10^5 Pa

Density of water = ρ = 1000 kg / m^3 .

Gravitational acceleration = g = 9.8 m/s^2

Required data:-

Height of water in barometer = h = ?

Formula:- As we know that

$$P = \rho g h \quad \text{OR} \quad h = \frac{P}{g\rho} \quad \text{.....................} \quad (i)$$

Calculation: - By putting the values in equation (i) we get

$$h = \frac{1.013 \, x 10^5}{9.8 \; x \; 10^3} = 0.103 \text{ x } 10^{5-3} = 0.103 \text{ x } 10^2 = 0.103 \text{ x } 100 = 10.3\text{m}$$

Result: - So as a result the height of water in the barometer is = h = 10.3m

Q #03: The small piston of hydraulic lift has an area of 0.20 m^2. A car weighing 1.20 x 10^4 N sits on a rack mounted on the large piston. The large piston has an area of 0.90 m^2 .How large a force must be applied to the small piston to support the car?

Ans:- Solution:-

Given data:-

Area of small piston = A_1 = 0.20 m^2

Area of large piston = A_2 = 0.90 m^2

Force on large piston = F_2 = 1.20 x 10^4 N

Required data:-

Force on small Piston = F_1 = ?

Formula:- From Pascal Principle

$$P_1 = P_2 \quad \text{OR} \quad \frac{F_1}{A_1} = \frac{F_2}{A_2} \quad \text{OR} \quad F_1 = \frac{F_2}{A_2} \text{ x } A_1 \quad \text{...................} \quad (i)$$

Calculation:- By putting values in equation (i) we get

$$F_1 = \frac{1.20 \times 10^4}{0.90} \text{ x } 0.20 = \frac{1.20 \times 0.20 \times 10^4}{0.90} = \frac{0.24 \times 10^4}{0.90} = 0.266 \text{ x } 10^4\text{N} = 2.66 \text{ x } 10^3\text{N}.$$

Result: - So as a result the force on small piston is = F_1 = 0.266 x 10^4N = 2.66 x 10^3N

Q # 4:- The deepest point in the ocean is 11km below sea level, deeper than Mount Everest is tall. What is the pressure in the atmospheres at this depth?

Ans:- Solution:-

Given data:-

Depth = h = 11 km = 11×10^3m

Gravity = g = 9.8 m/sec^2

Density of water = ρ = 1000 kg / m^3 = 10^3 kg /m^3

Required Data:-

Pressure = P =?

As we know that

$$P = \rho gh$$
$$P = 10^3 \times 9.8 \times 11 \times 10^3$$
$$P = 107.8 \times 10^6 \text{ pascal}$$
$$P = 1.1 \times 10^8 \text{ pascal}$$

Question#05: A block is fully immersed in water. Before the immersion the block weighed 30N and while immersed its apparent weighed was found to be 25N. Calculate

(a) Upthrust on the block,

(b) The weight of the water displaced,

(c) The volume of water displaced,

(d) The volume of the block,

(e) The density of the block.

Ans: Solution:

Given Data

Weight of block in air = W_1 = 30 N

Apparent weight of block in water = W_2= 25 N.

Required Data:-

(a) Up thrust on block = F_{up}= ?

(b) Weight of displaced water = W_w = ?

(c) Volume of displaced water = V_w = ?

(d)Volume of block = V_b

(e) Density of block = ρ_b = ?

(a) Up thrust on block = F_{up}:-

Formula:- According to Archimedes principle,

Up-thrust on block = weight in air – weight in water

F_{up} = W_1 - W_2.................... (1)

Calculation:-By putting values in equation (1) we get

F_{up} = W_1 - W_2 = 30 – 25 = 5N

(b)For Weight of displaced water = W_w: - We also know that

Weight of fluid displaced = up-thrust

W_w = F_{UP} = 5 N

(c) **Volume of displaced water** = V_w :- As we know that

$\rho = \frac{m}{V_w}$ **OR** $V_w = \frac{m}{\rho}$ .... **(2)**

First we find the value mass of displaced water= m :- As we know that

W = mg = 5N **OR** mg = 5N OR **$m = \frac{5}{g} = \frac{5}{10}$ = 0.5 kg.**

Now by putting values in equation (2) we get

$V_w = \frac{0.5}{1000}$ = 0.0005 kg m^{-3} OR V_w = 5 X 10^4 kg m^{-3}

(d) For Volume of block = V_b:- As we know that

Volume of block = volume displaced water

V_b = 5 X 10^4 m^3

(e)**Density of block = ρ_b** :- As we know that $\rho_b = \frac{m_b}{V_b}$ .... (3)

First we find the value of m_b:- $W_1 = m_b g$ OR $m_b = \frac{W_1}{g} = \frac{30}{10}$ = 3 kg

By putting values in equation (3) get

$\rho_b = \frac{m_b}{V_b} = \frac{3}{5\times10^{-4}}$ = 0.6 x 10^4 kg m^{-3}.

Q #6: When a weight of block 30N is hung from a wire of original length 2.0m.its new length become 2.20m calculate the force constant for the wire, if the elastic limited is not exceeded?

Ans:- Solution:-

Given data:-

Weight = F = 30 N

Initial length of wire = L_1 = 2.0 m

Final length of wire = L_2 = 2.20 m

X = $L_2 - L_1$ = 2.20 – 2.0 = 0.20 m

Required data:-

Force constant = K = ?

Formula:- From Hook's law

F = K x OR $K = \frac{F}{X}$ .... (i)

Calculation:- By putting the values in equation (i)

$K = \frac{F}{X} = \frac{30}{0.20}$ = 150 N/s (Nm^{-1})

Result:- So as result the force constant is= K= 150 N/s (Nm^{-1})

Q #7: An 80-cm long, 1.0-mm-diameter steel guitar string must be tightened to a tension of 2000N by turning the turning screws. By how much is the string stretched?

Ans:- Solution:-

Given data:-

Length of guitar string = L = 80 cm = $\frac{80}{100}$ m = 0.8 m

Diameter of guitar string = d = 1.0 mm = 1.0 x 10^{-3}m

Radius of wire = r = $\frac{d}{2}$ = $\frac{1.0\times10^{-3}}{2}$ = 0.5 x 10^{-3}m

Young's Modulus of steal = Y = 20 x 10^{10} Pa

Tension in guitar string = T = F = 2000N

Required data:-

Extension in guitar string = X = ?

Formula:- As we know that Y = $\frac{F\times L}{A\times X}$ OR X = $\frac{F\times L}{\pi r^2\times Y}$.................. (1)

Calculation:- By putting values in equation (1) we get

$$X = \frac{F\times L}{\pi r^2\times Y} = \frac{2000\times0.8}{3.14\times(0.5\times10^{-3})^2\times20\times10^{10}} = \frac{1600}{3.14\times0.25\times10^{-6}\times20\times10^{10}}$$

$$X = \frac{1600}{3.14\times0.25\times20\times10^{-6+10}} = \frac{1600}{15.7\times10^4} = 101.9 \times 10^{-4}\ m$$

X = 0.01m = 0.01 x 100cm = 1cm

Result:- Extension in guitar string = X = 1cm.