PHYSICS L0.8

QENA STUDENT CLUB

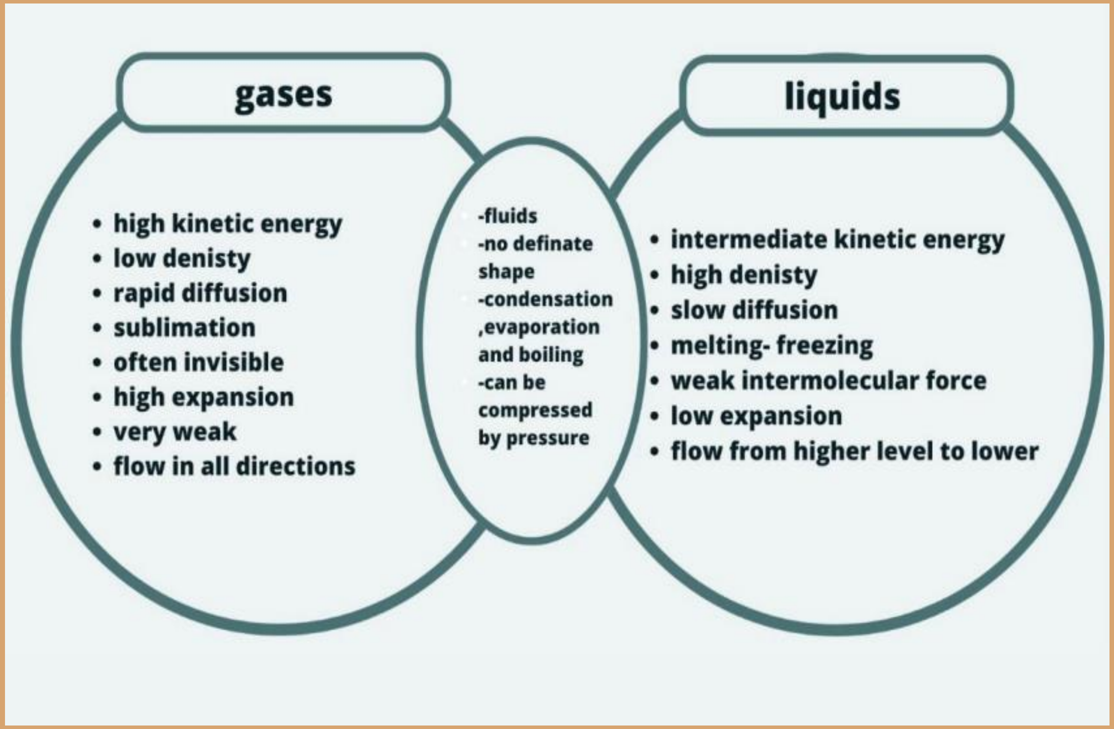
FLUIDS

Matter: is anything that takes up space and can be weighed such as Water and air are matter, while feelings and sound are not matter.

Comparison between properties of matter

Comparison	Solids	Liquids	Gases
Particles	Tightly packed	Loosely packed	Independent
Shape	Fixed	Not fixed	Not fixed
Volume	Fixed	Fixed	Not fixed
Rigidity	High	Less	Negligible
Forces	Strongest	Intermediate	Weakest
Fluidity	Not a chance	Yes	Yes
Compressibility	No	Slight	High
Density	High	Low	Very low
Diffusibility	No	Less	High
Kinetic energy	Low	Intermediate	High
Examples	Crystalline and Amorphous solids	All fluids	O_2, CO_2, SO_2, NO_2, etc

Compare between gases and solids



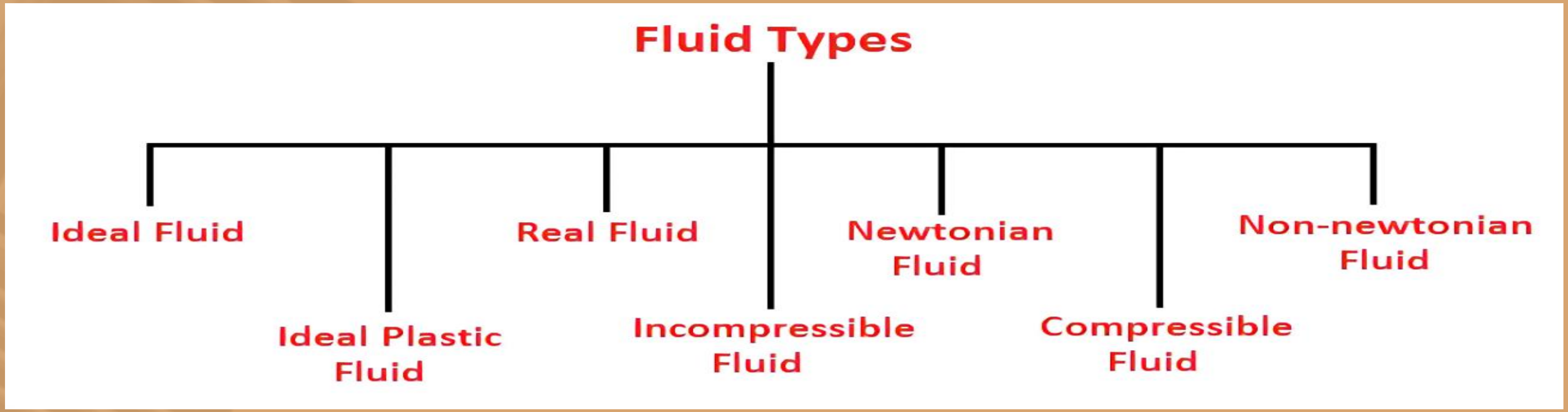
- Fluids: any liquid or gas or generally any material that cannot sustain a tangential, or shearing force when at rest and undergoes a continuous change in shape when subjected to such stress.

- Gases are compressible (take the shape and volume of a container)

- Liquid is incompressible (have a fixed volume and take the shape of the container)

- Fluids statics: It is the mechanism of fluids at rest or non-motion, and the pressure in fluids exerted by fluids on anybody.

- Fluids dynamics – It involves the study of the flow of fluids in motion. Popular branches like aerodynamics and hydrodynamics are part of fluid dynamics.



TYPES OF FLUIDS

- **Ideal Fluid: A hypothetical fluid with no viscosity and no resistance to shear force.**
It's incompressible and doesn't exist.

- **Real Fluid: Any fluid that has viscosity and offers resistance to shear force. All the fluids we encounter in daily life are real fluids.**

- **Newtonian Fluid: A fluid where the shear stress is directly proportional to the rate of shear strain. Its viscosity remains constant regardless of the stress applied. Examples include water and air**

- **Non-Newtonian Fluid: A fluid where the shear stress is not proportional to the rate of shear strain. The viscosity can change with the stress applied. Examples include ketchup and quicksand**

- **Ideal Plastic Fluid: A theoretical fluid that behaves as a solid until a certain yield stress is applied, after which it flows like a fluid.**

- **Incompressible Fluid: A fluid whose density does not change significantly with pressure. Most liquids are considered incompressible under normal conditions.**

- **Compressible Fluid: A fluid whose density changes with pressure. Gases are typically compressible fluids.**

PROPERTIES OF FLUIDS

- **Density (ρ):** The mass per unit volume of a fluid. It's a measure of how compact the fluid is

  Density= volume/mass

- **Pressure (P):** The force exerted by the fluid per unit area. It's a measure of the fluid's impact on surfaces it contacts

  Pressure = area/force

- **Viscosity:** A measure of a fluid's resistance to flow. Fluids with high viscosity, like honey, flow more slowly than those with low viscosity, like water.
- **Surface Tension:** The cohesive force at the surface of a fluid that causes it to behave like an elastic sheet. It's why water forms droplets.
- **Specific Gravity:** The ratio of the density of the fluid to the density of a standard fluid (usually water).
- **Specific Volume:** The volume occupied by a unit mass of the fluid. It's the reciprocal of density.

  $V = \rho/1$

DENSITY

DENSITY: is basic property, the quantity of something per unit

- volume density expressed in g/cm3 or kg / m3
- Density is directly proportional to mass but inversely with volume.
- The volume is directly proportional to mass.
- for example, Density of water = 1000 kg / m3 = 1 g / cm3
- The density of gas varies according to pressure. So, bodies of less density float over more dense liquids

FACTORS AFFECTING DENSITY:

- Temperature: Change in temperature causes a change in the density of the substance. When density increases, the temperature decrease
- Change of state: If the state of a substance changes, the density changes. This is a result of change in temperature.
- Compression: If a body is subjected to compression, the density of the body will increase because volume for the same mass is reduced.
- When mentioned the same material, so density doesn't change, and density is not a physical property of gas

PRESSURE

PRESSURE : It is the perpendicular force acting in the object's surface per unit area. Pressure is a scalar quantity.

P = Force / Area

Units: N/m2 or Pascal

Unit	unitsymbol	corresponds to	Country/Region
Pascal	Pa	1 bar = 100,000 Pa	-
Bar	bar	1 bar = 1 bar	Western Europe
Kilopascal	kPa	1 bar = 100 kPa	Australia
Megapascal	MPa	1 bar = 0.1 MPa	China
Pound per square inch	psi	1 bar = 14.5 psi	North America
Kilogram per square centimetres	kg/cm^2 or $kg(f)/cm^2$	1 bar = 1.02 kg/cm^2	India, Korea
Inch of mercury column	inHg	1 bar = 29.53 inHg	North America

FACTORS AFFECTING DENSITY:

- The depth of that point from the surface.
- The density of the liquid.
- Acceleration due to gravity.
- Pressure increases as we go downward and decreases as we go upward.

ATMOSPHERIC PRESSURE: It the weight of air column over unit area of Earth's surface at sea level. Due to the collisions between mixture of gases found in air

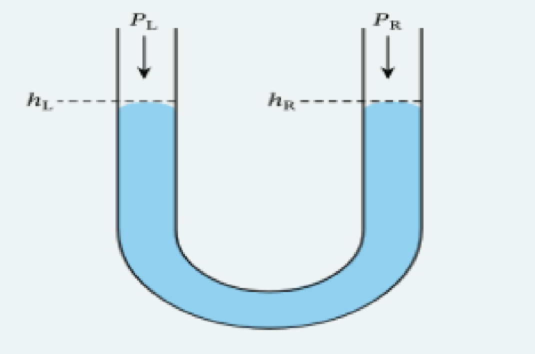
$$atm = 1.013 \times 10^5 pa$$

MANOMETER

- **A device to measure pressures of a gas.**
- **A U shaped tube of glass filled with some liquid.**

There are two types of manometer :

- **open end**
- **closed end**



- **Manometer with open end :-**

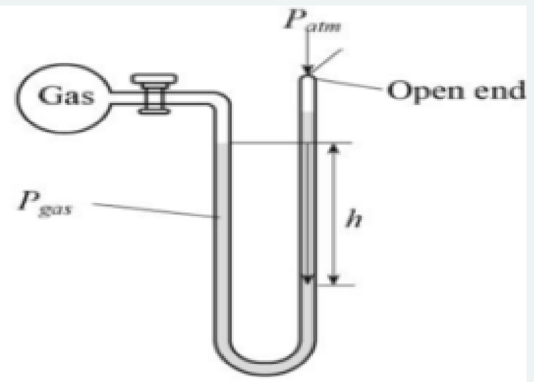
1- At the same level:

- **A manometer is opened so there are two pressures , atmospheric pressure and pressure of gas .**
- **At same level: Pg= ρgh**

- **ρ is a density**
- **G is a gravity that = 9.8**
- **H the height between two levels**

2- Level of liquid high at right (atmospheric):

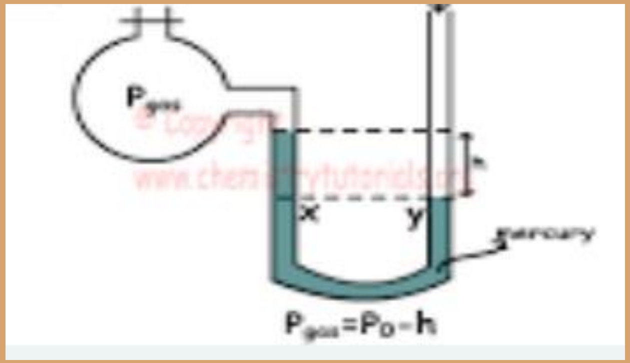
- **A liquid is high at right so this mean the pressure of gas is higher than atmospheric .**
- **P of gas = p atm + ρgh**



3- The level of liquid is high at left :

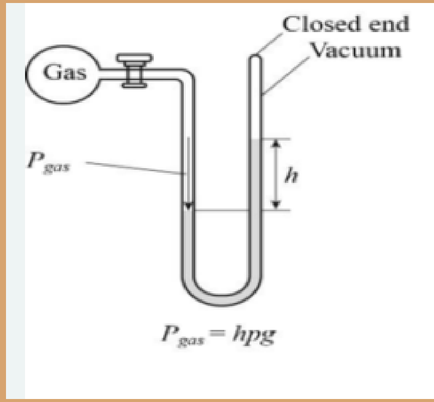
- The level of liquid is high at left that means the atmospheric pressure is higher than the pressure of gas.

- P gas = p atm -ρgh
- P atm =p gas + ρgh



Manometer with closed end :

- When a manometer be closed this means there is not atmospheric pressure acting on it .
- P gas = ρgh

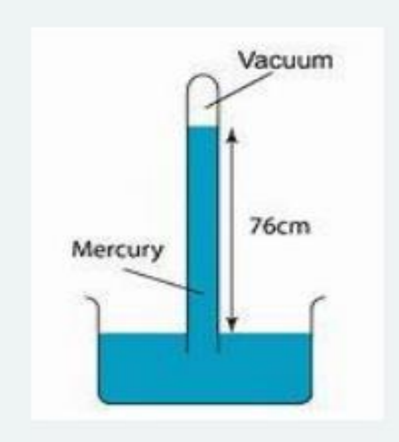


Note:

- A liquid that has a more density than other , its height will be lower than other

BAROMETER

- **Measure atmospheric pressure.**
- **Contains mercury because it has high density(13600kg/m3)**
- **We can’t use water (low density need h=10.4meter) the density of water is 13.6 times smaller than that of mercury, that means we would require a 13.6 times taller column of water than that of mercury to measure same pressure difference.**



UNITS OF ATMOSPHERIC PRESSURE

$1\ atm =$

$1.013 \times 10^5\ N/m^2$ (Pascal)

$0.76\ m.Hg$

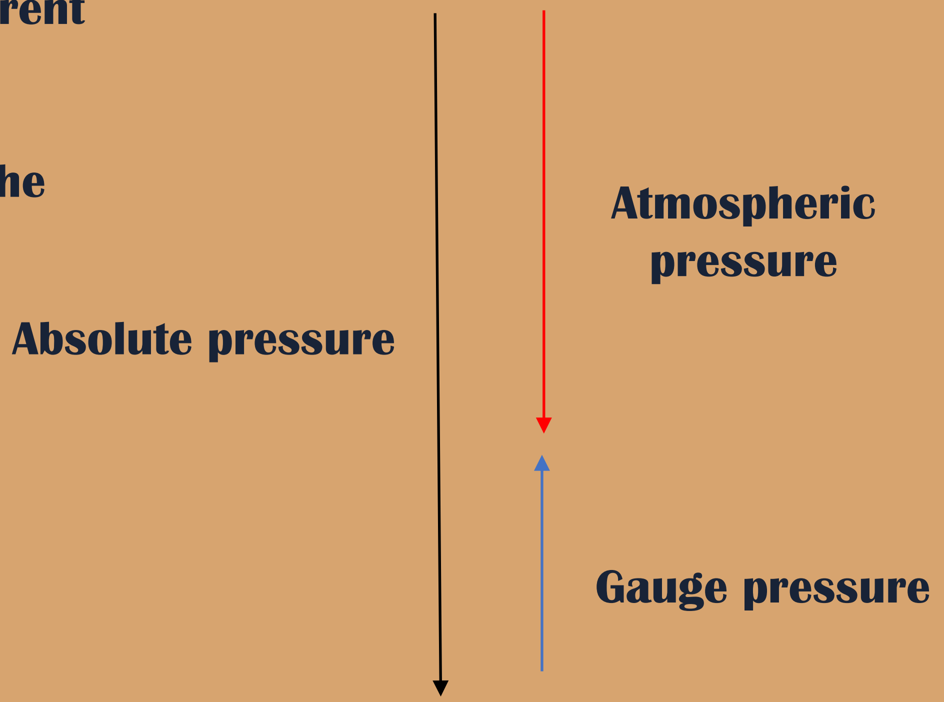
$760\ mm.Hg\ [Torr.]$

$76\ cm.Hg$

$1.013\ Bar$

GAUGE PRESSURE

- A pressure measured using a pressure measuring instrument
- Is the difference between the absolute pressure and the current atmospheric pressure
- It can be either positive or negative depending on whether the pressure is above or bellow the atmospheric pressure.



EFFECT OF ATMOSPHERICPRESSURE ON BOILING POINT OF WATER

Atmospheric (air) Pressure:

The weight of air column over unit area of earth surface at sea level.

- **1 atm ≈1.01325×10^5 Pa**
- **It exerted due to collisions between the mixture of gases found in the air**

Fluids pays a pressure in every direction

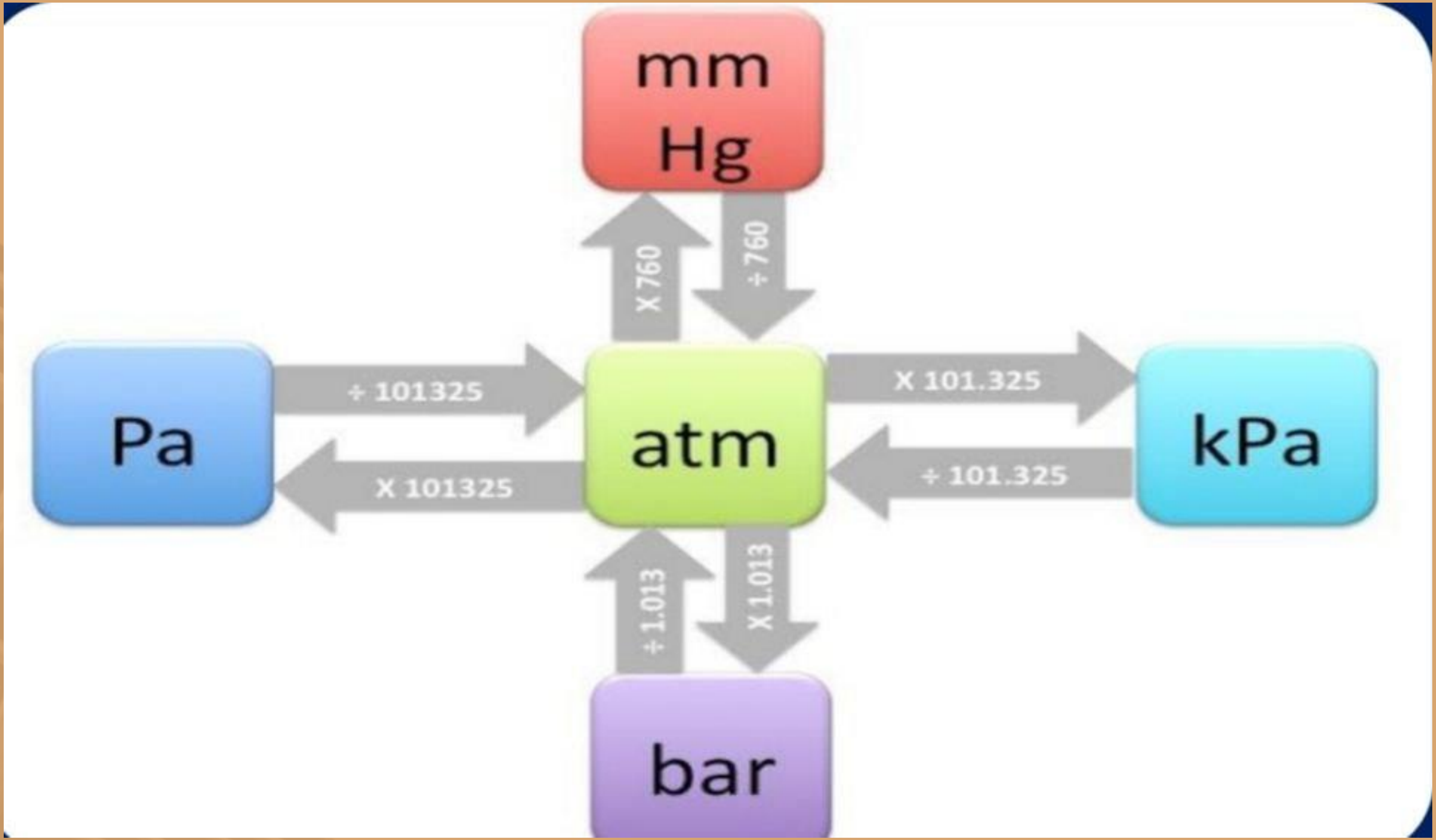
If air pressure always push us from outside, how come we keep balanced?!

- **When atmospheric pressure increase the boiling point will increase , too.**
- **Atmospheric pressure has a direct relation with boiling point**

DIFFERENT ATM PRESSURE UNITS

Unit		Conversion
Weight	Newton/m^2	1 atm = 101,325 = 1.013 x 10^5 N/m^2
	Pascal (Pa)	1 atm = 1.013 x 10^5 N/m^2 1 N/m^2 = 1 Pascal
	Psi (lb/in^2)	1 atm = 14.7 psi (Pound per square inch)
	Bar	1 atm = 1.013 bar 1 bar = 10^5 N/m^2
Length	cm Hg	1 atm = 76 cm Hg = 760 mm Hg = 29.92 inHg
	Torr	1 atm = 760 torr 1 torr = 1 mm Hg 1 Torr = 101325/760 Pascal (≈ 133.3 Pa)

CONVERTING BETWEEN DIFFERENT PRESSURE UNITS



THINK AND ASWER

TO BE REMINDER: 1 ATM =760.0 mm Hg
1ATM=101.325 KPA

Convert 0.875 atm to mmHg.

ANS1:0.875 atm x 760.0 mmHg / atm = 665 mmHg

Convert 745.0 mmHg to atm.

ANS2:745.0 mmHg x atm / 760.0 mmHg = 0.980 atm

Convert 0.955 atm to kPa

ANS3:0.955 atm x 101.325 kPa / atm = 96.76 kPa

Convert 98.35 kPa to atm

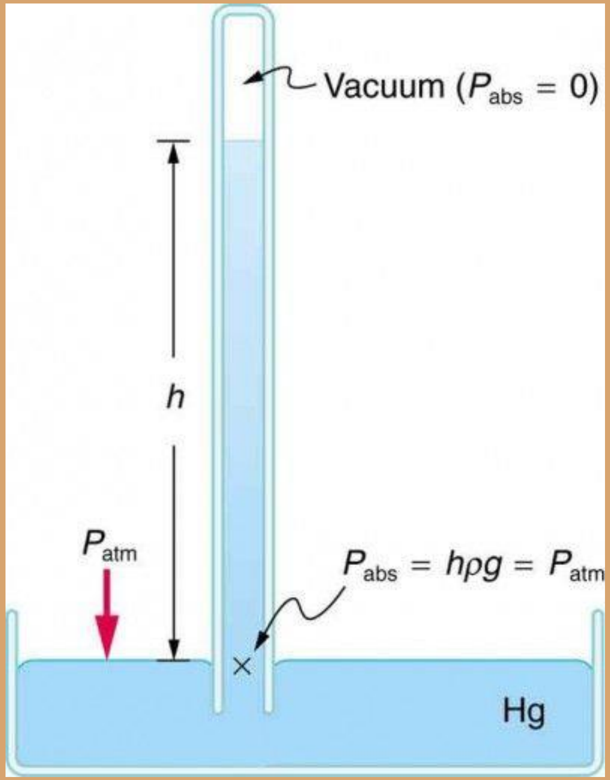
ANS4:98.35 kPa x atm / 101.325 kPa = 0.970 atm

ABSOLUTE PRESSURE

-A pressure measured relative to a perfect vacuum.

-knowing the relationship among absolute pressure, gauge pressure, and atmospheric pressure

$$P_{abs} = P_{atm} -/+ P_{gage}$$



NOTE:

P abs : Absolute pressure

P atm : Atmospheric pressure

P gage : Gage pressure = ρ g h

HYDROSTATIC PRESSURE

-Hydroststic means at rest

Static Fluid pressure:

Atmospheric pressure is a good example of static pressure as its ultimate source is gravity.

- **The pressure exerted by a static fluid depends only upon**

1) The depth of the fluid (h)
2) The density of the fluid (ρ)
3) The acceleration of gravity (g)

PASCAL LAW

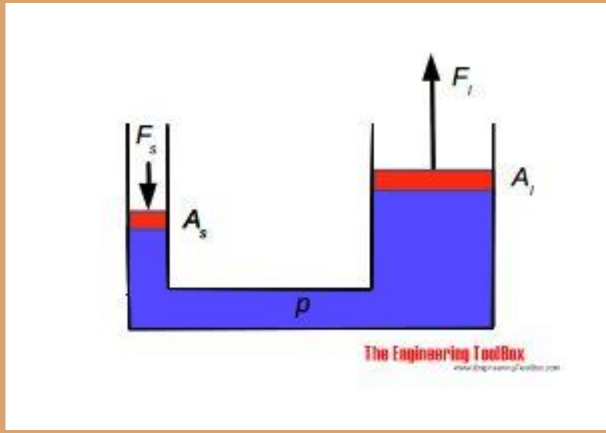
o French mathematician Blaise Pascal stated the Pascal law in 1653.
o Pascal's law says that pressure applied to an enclosed fluid will be transmitted without a change in magnitude to every point of the fluid and the walls of the container.
o The pressure at any point in the fluid is equal in all directions.

$\rho 1 = \rho 2$

$F1 / A1 = F2 / A2$

Formula of Pascal law:

• Hydraulic Lift: It works based on the principle of equal pressure transmission throughout a fluid (Pascal's Law).



A PREESURE AT A POINT INSIDE THE LIQUID

-Imagine a horizontal plate (x) of area (A) at depth (h) inside a liquid of density (ρ).

-This plate acts as the base of a column of the liquid.

-The force acting on the plate (x) is the weight of the column of the liquid whose height (h) and cross section area (A)

*THE FORCE RESULTING FROM THE LIQUID PRESSURE BALANCES WITH THE WEIGHT OF THE COLUMN OF THE LIQUID

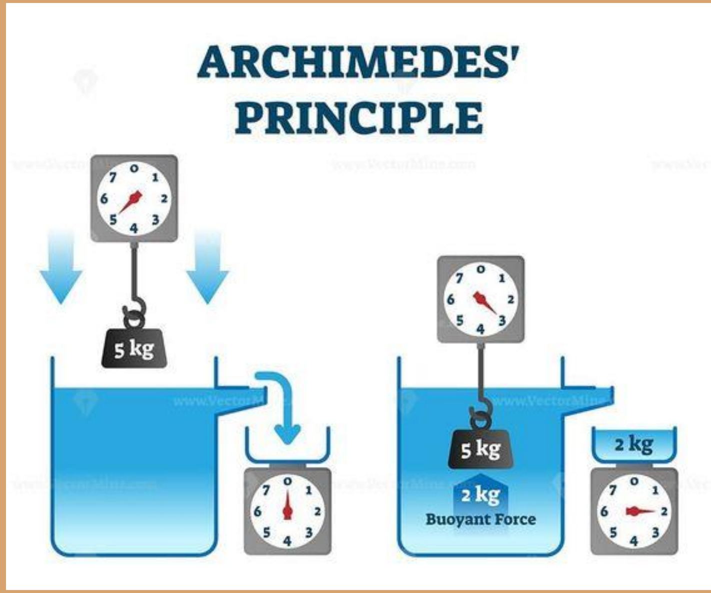
$Pl=\rho gh$ $\quad\quad$ $pt=pa+\rho gh$

NOTE

-PA IS THE ATMOSPHIRC PRESSURE

ARCHIMEDES' PRINCIPLE

Greek mathematician Archimedes discovered the Archimedes' principle.
- states that an object submerged in a fluid, fully or partially, experiences an upward buoyant force that is equal in magnitude to the force of gravity (weight) on the displaced fluid.
- Buoyant Force: the upward force exerted on an object partly immersed in a fluid so body submerged partially or fully in a fluid appears to lose its weight



Factors affect buoyant force:
-the density of the fluid
-the volume of the fluid displaced
-the local acceleration due to gravity

Archimedes' principle Formula
- Fb = ρ x g x Volume

Apparent weight= Weight of object (in the air) – Thrust force (buoyancy)
- Fg – Fb (bouyancy) = apparent weight

- **For a fluid whose density remains approximately constant throughout, the pressure increases linearly with depth:**

$P = P_0 + PFGh$

where

P **is the pressure at the bottom of the column of the fluid**

P_0 **is the pressure at the top of the column,** g **is the acceleration due to gravity,**

ρ_F **is the density of the fluid** = m/V

h **is the height of the column of the fluid.**

IF YOU ARE IN A CAR THAT IS SUBMERGED IN A FLOOD, HOW HARD WILL IT BE TO OPEN YOUR DOOR?

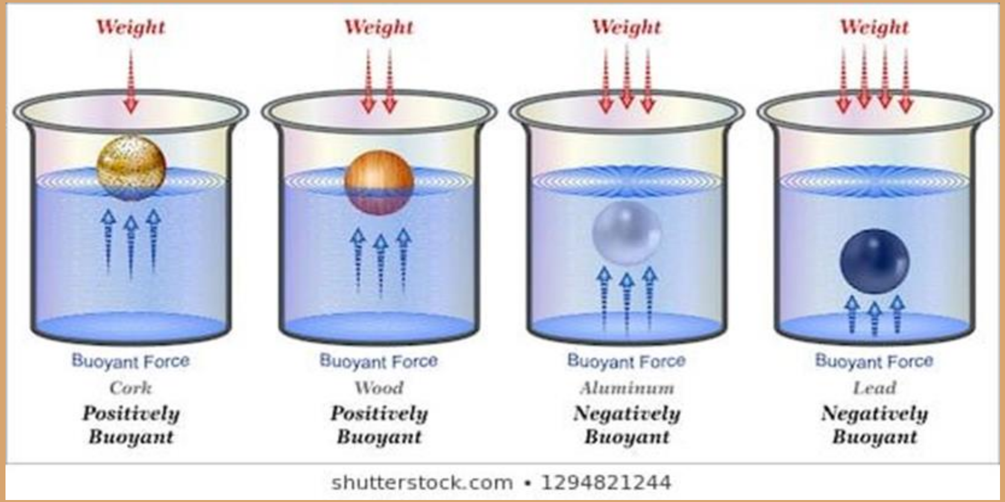
ARCHEMEDES' PRINCIPAL APPLACTIONS

Hydrometer:

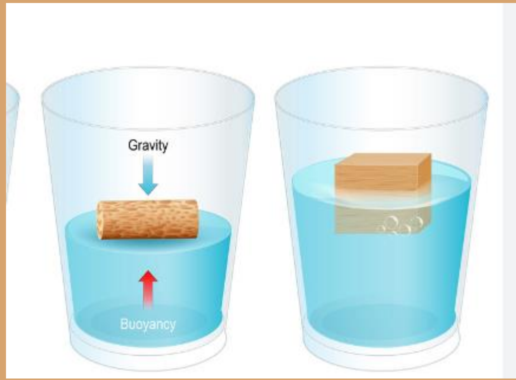
A hydrometer is an instrument used for measuring the relative density of liquids. Hydrometer consists of lead shots which makes them float vertically on the liquid. The lower the hydrometer sinks, the lesser is the density of the liquid.

THREE TYPES OF BUOYANCY

1. Positive buoyancy is when the immersed object is lighter than the fluid displaced, and this is the reason why the object floats.
2. Negative buoyancy is when the immersed object is denser than the fluid displaced which results in the sinking of the object.
3. Neutral buoyancy takes place when the weight of the immersed object is equal to the fluid displaced.



ARCHIMEDE CASES



1) on floating:

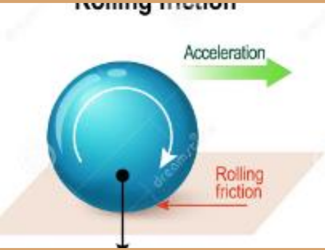
Fb = Fg

=ρliquid*g*v immersed = ρsolid*g*v total

ρ = density

v = volume

g = gravity

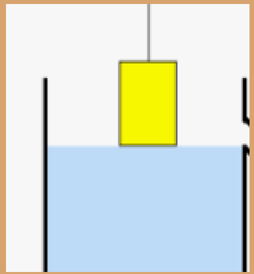


2) Floating with additional part:

Fb = Fg(solid) + Fg(odd)

= ρliquid*g*v immersed = ρsolid*g*v total

3)Tension force acting on it above :

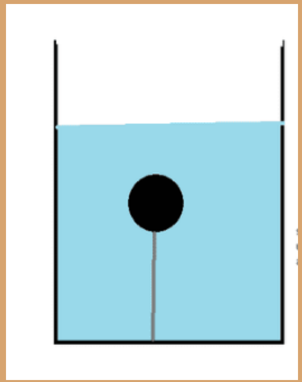


Fb + Ft = Fg

Ft = Fg – Fb

Ft = ρsolid*g*v total – ρliquid*g*v total

4)Tension force acting on it down :

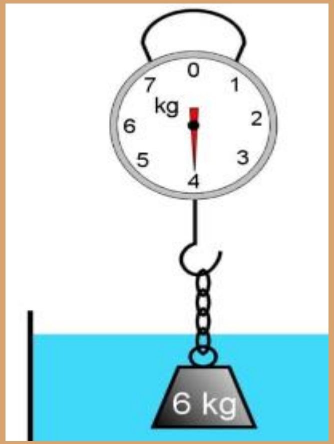


Ft + Fg =Fb

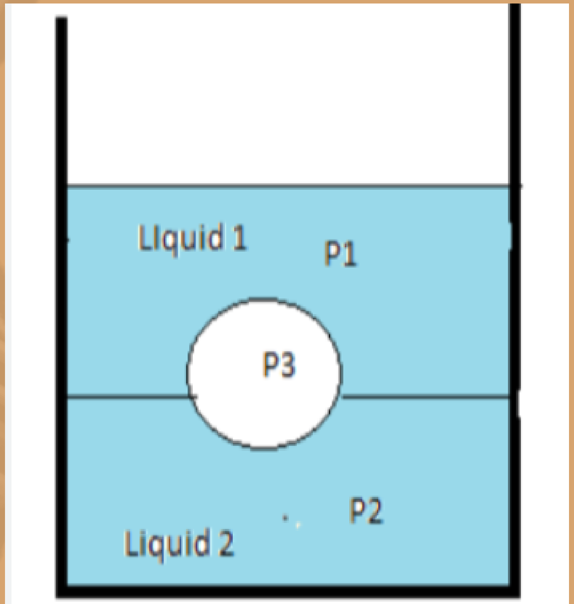
Ft = Fb – Fg

Ft = ρliquid*g*v total – ρsolid*g*v total

(5)
Fb = Fg (air) – Fg (liquid)



(6) Ball into two liquids:
Fb1+Fb2 =Fg



Note

- If the weight of object Equal or less than up thrust then object Float
- If the weight of the object more than up thrust then the object Sink

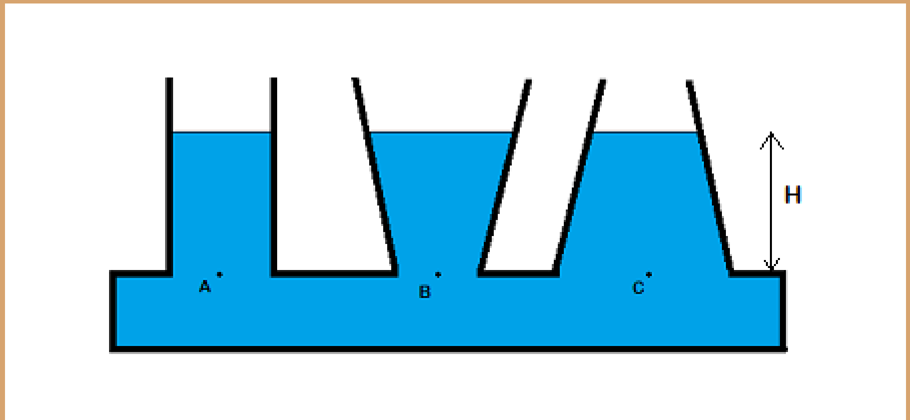
DO YOU KNOW What happens to a ship if it switches from freshwater to saltwater?

1. The same for buoyant force
2. Immersed portion: decrease
3. Obviously part: Increase

CONNECTED TUBES:

-When a liquid is poured into a set of connected tubes of different shapes, it rises up until the levels are the same in all the tubes.

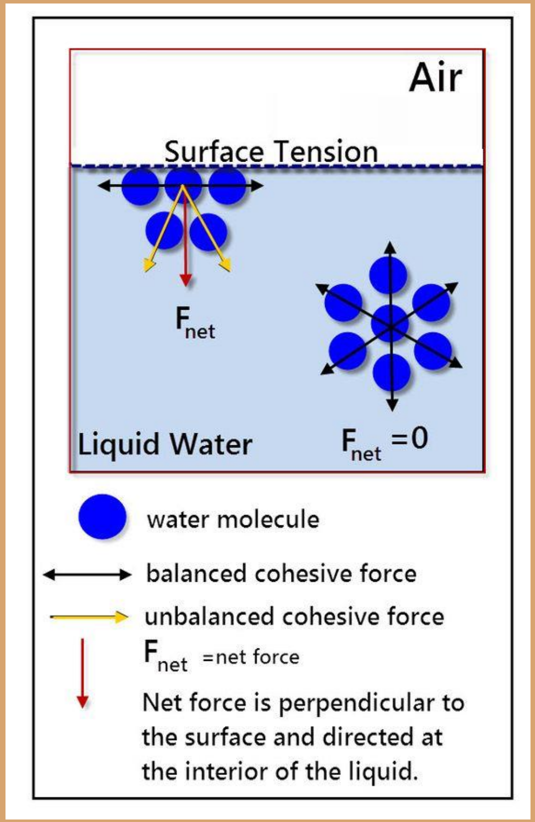
-Then the pressure at the same level are equal



SURFACE TENSION

The property of the surface of a liquid that allows it to resist an external force, due to the cohesive nature of its molecules

If you put a needle in a cup of water slowly It would just stay there on the surface
It is not floating because the needle is more dense
Than the water and if you push it a little bit below
The surface it would sinks Why is that?
Water molecules form hydrogen bonds
But a water molecule have a lot of other water
Molecules around it so it gets pulled from all sides
Making it stay at it's original position
But at the surface there is no water molecules above it
Making it form a tighter bonds than molecules inside
Of the water giving it the ability to handle a certain amount of weight
An example of that is insects that can stand still on the surface of water
T = F/L



- **If the density of ics is 920 kg/m3 , wha is the percentage of the floating part of an ice cube over water surface ?**

A- 8%
B- 29%
C- 92%
D- 38%
ANS:A

- **All fluids are:**

A. gases
B. liquids
C. gases or liquids
D. non-metallic E. transparent
Ans: C

- **Pa is:**

A. 1 N/m
B. 1 m/N
C. 1 kg/m · s
D. 1 kg/m · s2 E. 1 N/m · s
Ans: D

- Barometers and open-tube manometers are two instruments that are used to measure pressure.

A. Both measure gauge pressure
B. Both measure absolute pressure
C. Barometers measure gauge pressure and manometers measure absolute pressure
D. Barometers measure absolute pressure and manometers measure gauge pressure
E. Both measure an average of the absolute and gauge pressures
Ans: D

- To measure moderately low pressures oil with a density of 8.5×102 kg/m 3 is used in place of mercury in a barometer. A change in the height of the oil column of 1.0 mm indicates a change in pressure of about:

A. $1.2 \times 10-7$ Pa
B. $1.2 \times 10-5$ Pa
C. 0.85 Pa
D. 1.2 Pa
E. 8.3 Pa
Ans: E

- The pressure exerted on the ground by a man is greatest when:

A. he stands with both feet flat on the ground
B. he stands flat on one foot
C. he stands on the toes of one foot
D. he lies down on the ground
E. all of the above yield the same pressure
Ans: C

- In a stationary homogeneous liquid:

A. pressure is the same at all points
B. pressure depends on the direction
C. pressure is independent of any atmospheric pressure on the upper surface of the liquid
D. pressure is the same at all points at the same level
E. none of the above
Ans: D

- Which of the following five statements, concerning the upper surface pressure of a liquid, is FALSE?

A. It is independent of the surface area
B. It is the same for all points on that surface
C. It would not increase if the liquid depth were increased
D. It would increase if the liquid density were increased
E. It would increase if the atmospheric pressure increased
Ans: D

- An airtight box, having a lid of area 80 cm2, is partially evacuated. Atmospheric pressure is 1.01 × 105 Pa. A force of 600 N is required to pull the lid off the box. The pressure in the box was:

A. 2.60 × 104 Pa
B. 6.35 × 104 Pa
C. 7.50 × 104 Pa
D. 1.38 × 105 Pa
E. 1.76 × 105 Pa
Ans: A

- A closed hemispherical shell of radius R is filled with fluid at uniform pressure p. The net force of the fluid on the curved portion of the shell is given by:

A.2πR2p
B. πR2p
C. 4πR2p
D. (4/3)πR2p
E. (4/3)πR3p
Ans: B

- A uniform U-tube is partially filled with water. Oil, of density 0.75 g/cm 3 , is poured into the right arm until the water level in the left arm rises 3 cm. The length of the oil column is then:

A. 2.25 cm
B. 8 cm
C. 6 cm
D. 4 cm
E. need to know the cross-sectional area of the U-tube
Ans: B

THANKS

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