GOVERNMENT Polytechnic For Girls, Ahmedabad

- Civil Engineering Department

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UNIT:1 - Introduction, Pressure and Pressure Management

- Chapter 1
- Introduction

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- Fluid
- Fluid Properties

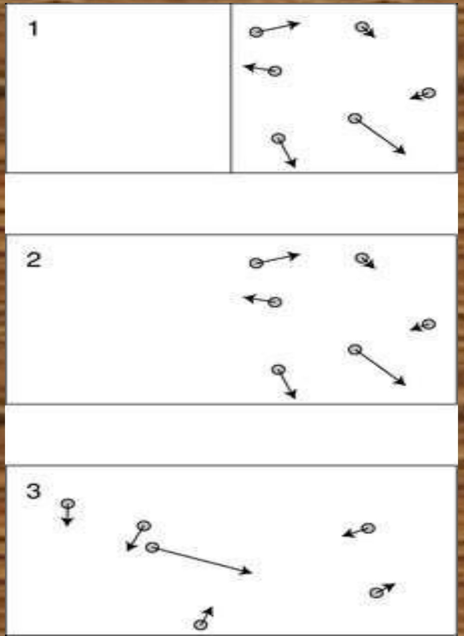
FLUID

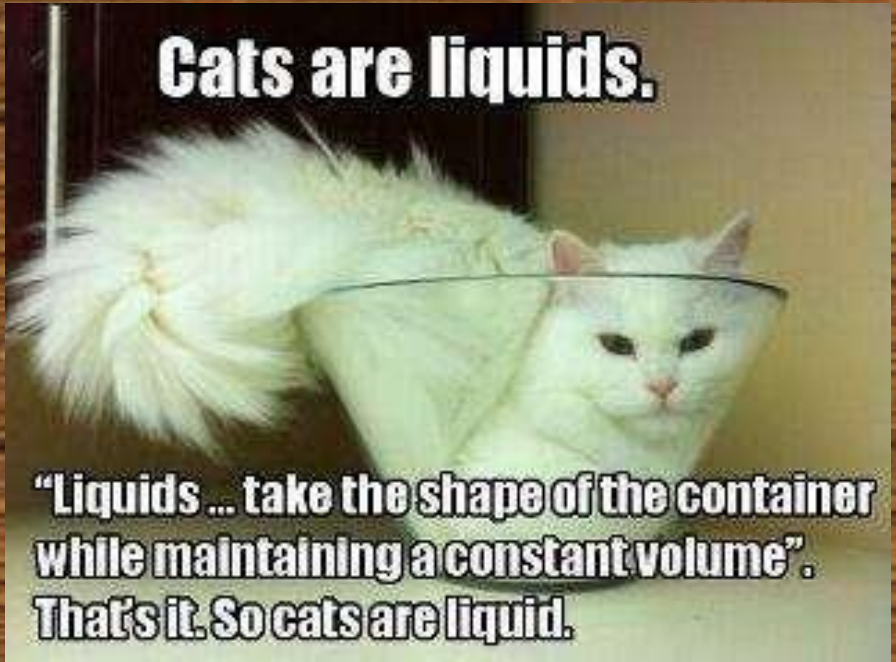
- FLUID: When a body or matter flows from one point to another point on application of shear force, it is called fluid.

- Matter exists in two states- the solid state and the fluid state. This classification of matter is based on the spacing between different molecules of matter as well as on the behavior of matter when subjected to stresses.
- Because molecules in solid state are spaced very closely, solids possess compactness and rigidity of form. The molecules in fluid can move more freely within the fluid mass and therefore the fluids do not possess any rigidity of form.
- Fluid exist in two form:- Liquid & Gas (difference)
- Further Classified as : Compressible fluid and Incompressible fluid

DIFFERENCE?

- Liquids flow and take the shape of their container but maintain a constant volume.
- Gases expand to fill the available volume.
- Liquids are incompressible while the gas are compressible.





INTRODUCTION

- Fluid mechanics is the science that deals with the action of forces on fluids at rest as well as in motion.

- HYDRAULICS : It is the branch of engineering dealing with the study of laws of pressure and practical utility of fluid flow with refrence to water.

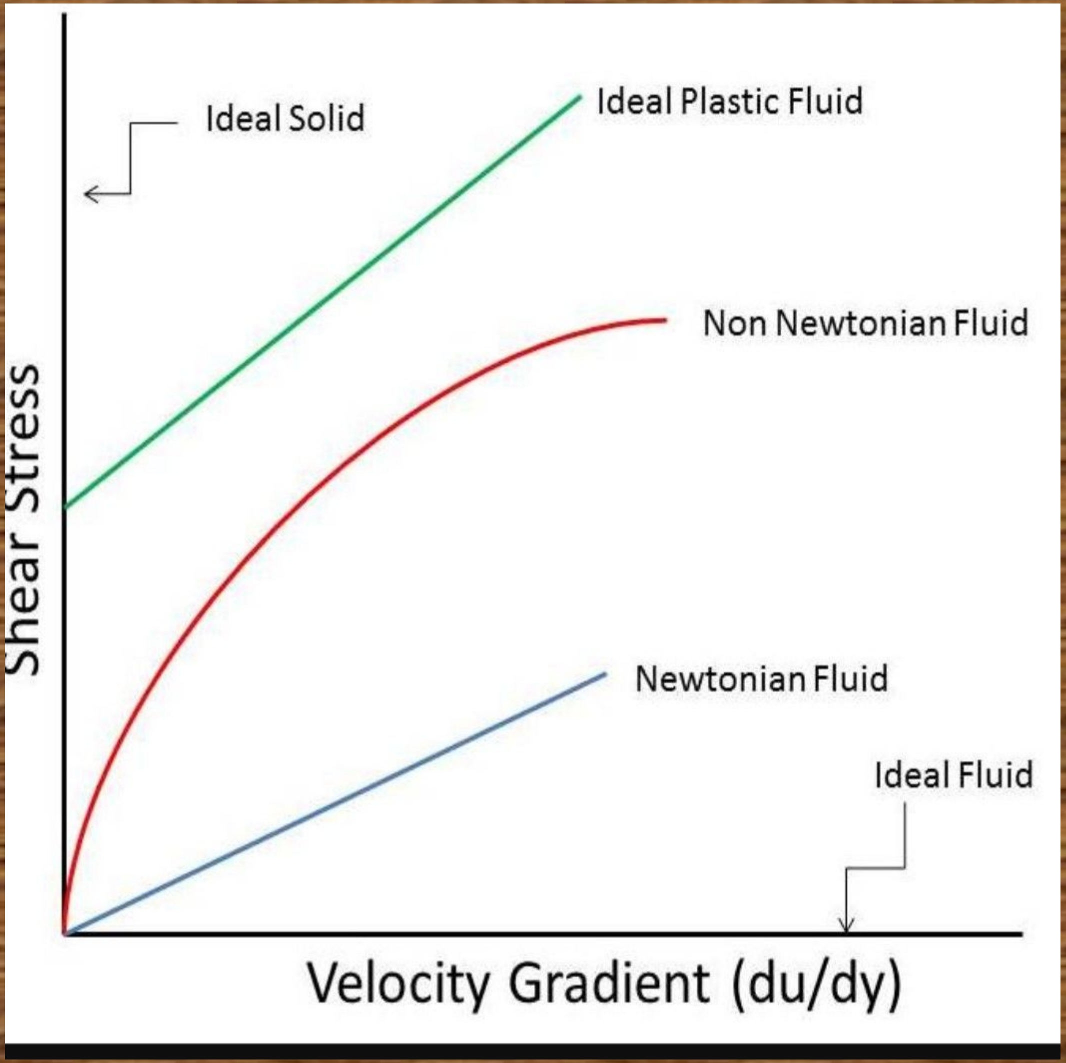
Hydrostatics	Hydrokinematics	Hydrodynamics
Examples		
• Gates of dam	velocity	Impact of jet
• Water tank	Acceleration	bend in pipe

TYPES OF FLUIDS

- Ideal Fluid
- Real Fluid
- Newtonian Fluid
- Non- Newtonian Fluid
- Ideal Plastic Fluid

TYPES OF FLUID

- **Ideal fluid:** A fluid which is incompressible having no viscosity, no surface tension is known as ideal fluid.
- **Real Fluid**: A fluid which is compressible having viscosity and surface tension is known as real fluid.
- **Newtonian fluid**: shear stress is proportional to shear strain
  - Slope of line is dynamic viscosity
- **Non-Newtonian fluid:** shear stress is not proportional to shear strain
- **Ideal Plastic Fluid:** *Shear stress is is more than yield value and shear stress is propotional to the rate of*



FLUID PROPERTIES

- Mass Density
- Specific Weight
- Specific Volume
- Specific Gravity
- Cohesion and Adhesion
- Viscosity
- Surface tension
- Vapour Pressure
- Capillarity
- compressibility
- Bulk modululus of elasticity

MASS DENSITY / DENSITY ρ

- The"mass per unit volume" is mass density. Hence it has units of kilograms per cubic meter.

- The mass density of water at 4ºC is 1000 kg/m^3 while it is 1.20 kg/m^3 for air at 20ºC at standard pressure.

$$\rho = \frac{m}{V}$$

Density: Example

A quantity of helium gas at 0°C with a volume of 4.00 m^3 has a mass of 0.712 kg at standard atmospheric pressure.

Determine the density of this sample of helium gas

$$V = 4.00\ m^3$$
$$m = 0.712 kg$$
$$\rho = ?$$

$$P = \frac{m}{V}$$

$$\rho = \frac{0.712\ kg}{4.00\ m^3} = 0.178 \frac{kg}{m^3}$$

$w = \frac{W}{V}$

SPECIFIC WEIGHT OR WEIGH DENSITY (W)

- It is the ratio between the weight if a fluid to its volume.
- It is also weight per unit volume of a fluid.
- Its unit is N/m^3.
- Water at 20 ºC has a specific weight of 9.79 kN/m^3

$$w = \frac{W}{V}$$

$$w = \frac{W}{V} = \frac{m.g}{V} = \rho.g$$

SPECIFIC VOLUME

- It is defined as the volume of a fluid occupied by a unit mass or volume per unit mass of a fluid is called specific volume.

- Specific Volume = Volume of the Fluid / Mass of the Fluid

  = 1/mass of the fluid/volume of the fluid

  = 1 / ρ

SPECIFIC GRAVITY S

- The ratio of specific weight of a given liquid to the specific weight of water at a standard reference temperature (4ºC)is defined as *specific gravity*, S.
- The specific weight of water at atmospheric pressure is 9810 N/m^3.
- The specific gravity of mercury at 20ºC is
- Sp. Gra. Of water is 1.

$$S_{Hg} = \frac{133\ \text{kN/m}^3}{9.81\ \text{kN/m}^3} = 13.6$$

$$\text{Specific gravity(S)} = \frac{\textit{weight density of liquid}}{\textit{weight density of water}}$$

Viscosity

- Different kinds of fluids flow more easily than others. Oil, for example, flows more easily than molasses. This is because molasses has a higher viscosity, which is a measure of resistance to fluid flow. Inside a pipe or tube a very thin layer of fluid right near the walls of the tube are motionless because they get caught up in the microscopic ridges of the tube. Layers closer to the center move faster and the fluid sheers. The middle layer moves the fastest.

- The more viscous a fluid is, the more the layers want to cling together, and the more it resists this shearing. The resistance is due the frictional forces between the layers as the slides past one another. Note, there is no friction occurring at the tube's surface since the fluid there is essentially still. The friction happens in the fluid and generates heat. The Bernoulli equation applies to fluids with negligible viscosity.

VISCOSITY

- It is defined as the property of a fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid.
- The viscosity of a fluid is a measure of its "resistance to deformation."

NEWTON'S LAW OF VISCOSITY

- It states that the shear stress on a fluid element layer is directly proportional to the rate of shear strain.
- The constant of proportionality is called the coefficient of viscosity.
  - $\tau = \mu \ du/dy$
    - *Where* τ = shear stress
    - du/dy = Velocity Gradient
    - μ = coefficient of viscosity or Dynamic viscosity
    - S.I. unit is $N.S/m^2$ or Pa.s , 1 Pa= 1 N/m^2
    - Denoted by μ (mew)

KINEMATIC VISCOSITY

- It is defined as the ratio between the dynamic viscosity and density of the fluid. Unit is stoke. 1 stoke=1cm^2/s, denoted by new (υ)

$$\nu = \frac{\mu}{\rho} = \frac{N.s/m^2}{kg/m^3} = m^2/s$$

VARIATION OF VISCOSITY WITH TEMPERATURE

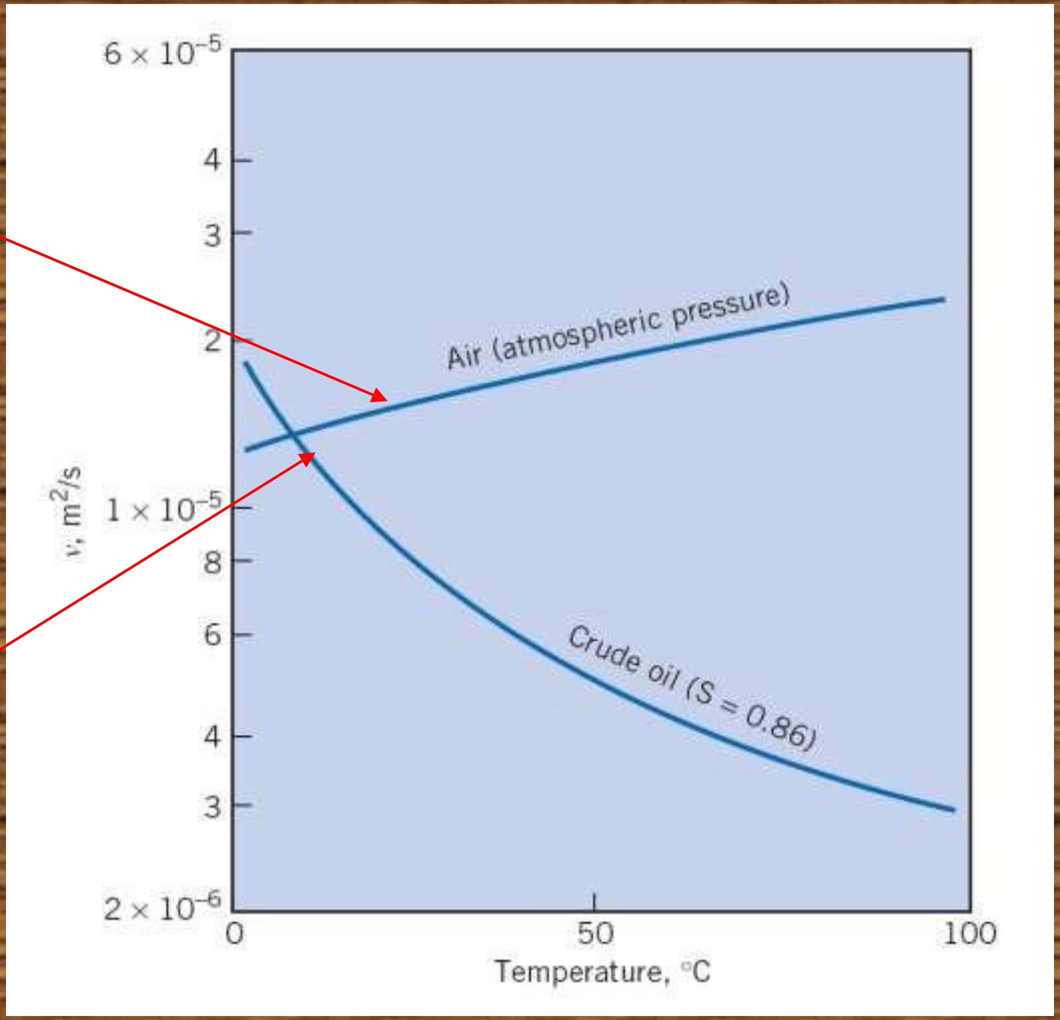
- Liquids - cohesion and momentum transfer
  - Viscosity decreases as temperature increases.
- Relatively independent of pressure (incompressible)

- Gases - transfer of molecular momentum
  - Viscosity increases as temperature increases.
  - Viscosity increases as pressure increases

VARIATION OF VISCOSITY WITH TEMPERATURE

Increasing temp → increasing viscosity

Increasing temp → decreasing viscosity

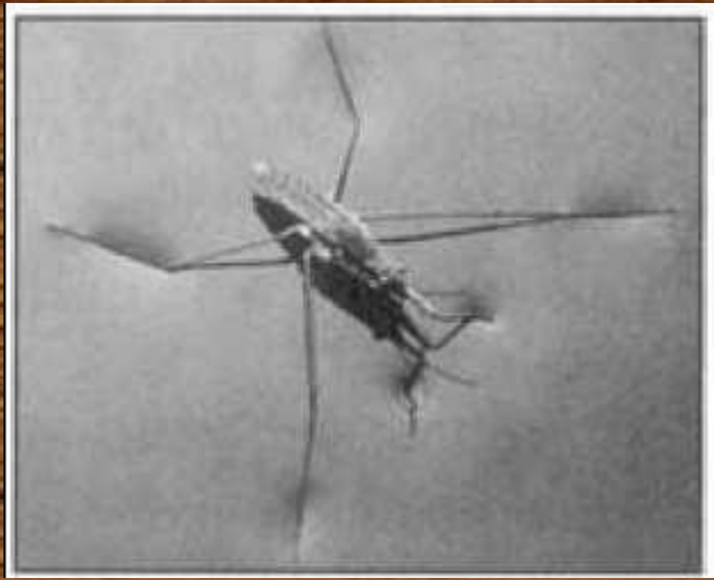


APPLICATION OF VISCOSITY :-

1. Transparent and storing facilities for fluids i.e., pipes, tanks
2. Bitumen used for road construction.
3. Designing of the sewer line or any other pipe flow viscosity play an important role in finding out its flow behaviour.
4. Drilling for oil and gas requires sensitive viscosity.
5. To maintain the performance of machine and automobiles by determining thickness of lubricating oil or motor oil.

SURFACE TENSION

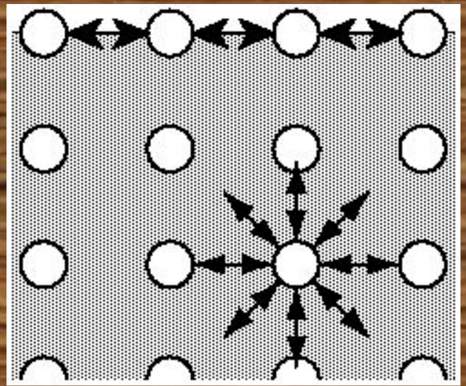
- Surface tension is a contractive tendency of the surface of a fluid that allows it to resist an external force. Surface tension is an important property that mark ably influences the ecosystems.



- What’s happening here?
  - – *Bug is walking on water*

SURFACE TENSION

- A molecules in the interior of a liquid is under attractive force in all direction.
- However, a molecule at the surface of a liquid is acted on by a net inward cohesive force that is perpendicular to the surface.
- Hence it requires work to move molecules to the surface against this opposing force and surface molecules have more energy than interior ones
- Higher forces of attraction at surface
- Creates a "stretched membrane effect"



APPLICATION OF SURFACE

- A water strider can walk on water.
- Some tent are made impermeable of the rain but they are not really impermeable, but if water is placed on it then the water doesn’t pass through the fine small pores of the tent cover. But as you touch the cover while water is on it, you break surface tension and water passes through.

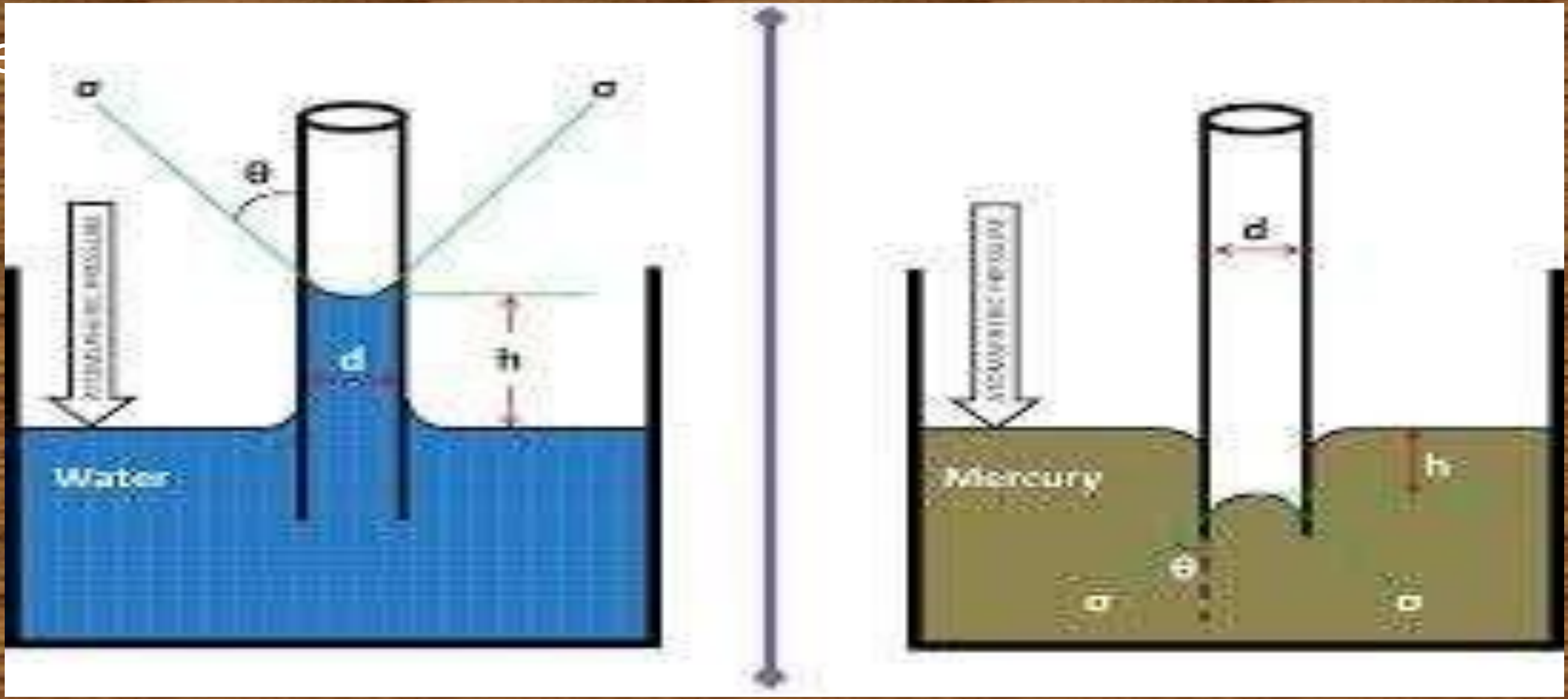
CAPILLARY ACTION

- How do trees pump water hundreds of feet from the ground to their highest leaves? Why do paper towels soak up spills? Why does liquid wax rise to the tip of a candle wick to be burned? Why must liquids on the space shuttle be kept covered to prevent them from crawling right out of their containers?! These are all examples of *capillary action*--the movement of a liquid up through a thin tube. It is due to adhesion and cohesion.
- Capillary action is a result of adhesion and cohesion. A liquid that adheres to the material that makes up a tube will be drawn inside. Cohesive forces between the molecules of the liquid will "connect" the molecules that aren't in direct contact with the inside of the tube. In this way liquids can crawl up a tube. In a pseudo-weightless environment like in the space shuttle, the "weightless" fluid could crawl right out of its container.

CAPILLARY ACTION :-

- Capillary action is the ability of a fluid to flow in narrow spaces without the assistance of, and in opposition to, external forces like gravity.OR

- A phenome
vertically.



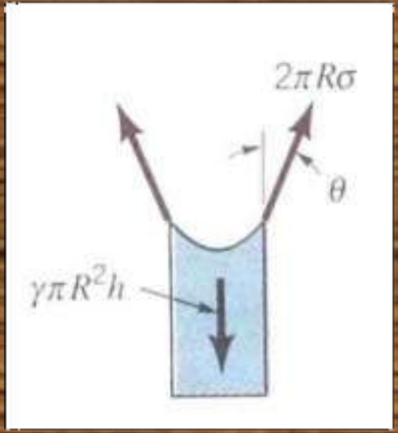
DIFFERENCES BETWEEN ADHESIVE& COHESIVE

- The force of or attraction between of unlike charges in the atoms molecules substances are responsible for cohesion and adhesion.
- *Cohesion* is the clinging together of molecules/atoms within a substance. Ever wonder why rain falls in drops rather than individual water molecules? It's because water molecules cling together to form drops.
- *Adhesion* is the clinging together of molecules/atoms of two different substances. Adhesive tape gets its name from the adhesion between the tape and other objects. Water molecules cling to many other materials besides clinging to themselves.

CAPILLARY EFFECT

- h=height of capillary rise (or depression)
- σ=surface tension
- θ=wetting angle
- G=specific weight
- R=radius of tube
- If the tube is clean, θ is 0 for water

$$F_{\sigma,z} - W = 0$$



$$2\pi R\sigma Cos\theta = \pi R^2 h\gamma$$

$$h = \frac{2\sigma Cos\theta}{\gamma r}$$

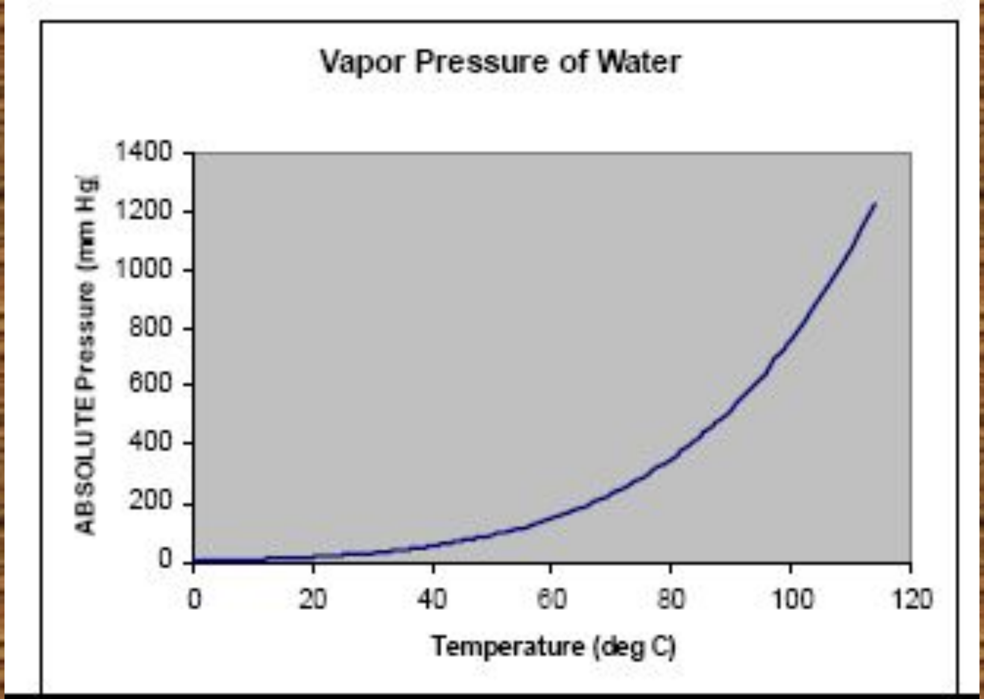
APPLICATION OF CAPILLARY ACTION :-

- Capillary action is found in thermometer where fluid used in it automatically rises when comes in contact with higher temperature or falls down with lower ones.

- Capillary action can be performed to transfer fluid from one vessel to another on its own.

VAPOR PRESSURE

- *Vapor pressure: the* pressure at which a liquid will transform in to vapour at given temp.
- Vapor pressure ↑ when temperature increases
- At atmospheric pressure, water at 100 °C will boil
- Water can boil at lower temperatures if the pressure is lower
  - When vapor pressure > the liquid's actual pressure
  - It will boil



- BULK MODULUS OF ELASTICITY

It is the ratio of change in pressure to the corresponding volumetric strain. Unit of K is N/m^2 or Pa.

$$K = -\frac{dp}{\frac{dv}{v}}$$

- Compressibility:

- The reciprocal of bulk modulus of elasticity is called compressibility. So it is 1/K