POLITEKNIK MALAYSIA
KUCHING SARAWAK

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CHAPTER 1: INTRODUCTION OF FLUID MECHANICS & FLUID PROPERTIES

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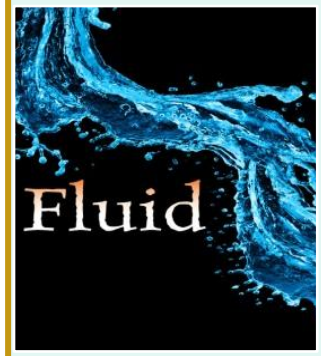
CONTENT



BASIC CONCEPT OF FLUID MECHANICS

A) Definition of Fluid
B) Classification of fluid flow
C) Characteristics of Fluid

TYPES OF PRESSURE

A) Atmospheric pressure
B) Gauge pressure
C) Absolute pressure
D) Vacuum pressure

PRESSURE IN FLUID

A) Relationship between pressure and depth
B) Basic equation of pressure related to depth
C) Pressure at different depth

PRESSURE MEASUREMENT EQUIPMENT

A) Piezometer
B) Barometer
C) Bourdon gauge
D) Manometer

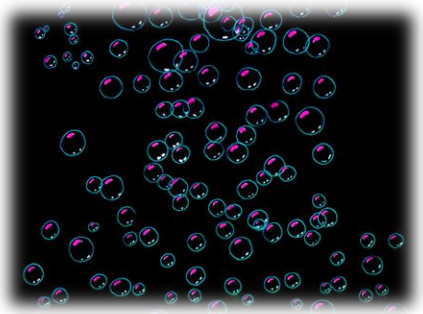
DEFINITION OF FLUID

What is Fluid Mechanics?

- **Fluid Mechanic** can be defined as a branch of Engineering - Science which deals with the behaviour of fluid under the conditions of rest and motion.
- Fluid → A) Fluid static
  → B) Fluid dynamic

What is Fluid

- ***A* Fluid** is defined as a substance which is capable of flowing, has no fixed shape,& offers little resistance to an external stress.
- OR, a fluid is a substance that deforms continuously when subjected to external shearing force.



CLASSIFICATION OF FLUID FLOW

CLASSIFICATION OF FLUID FLOW

BASED ON FLOW REGIME

i) STEADY FLOW

ii) UNSTEADY FLOW

BASED ON FLOW BEHAVIOUR

i) UNIFORM FLOW

ii) NON-UNIFORM FLOW

BASED ON VELOCITY & FLOW PATTERNS

i) LAMINAR FLOW

ii) TURBULENT FLOW

iii) TRANSITIONAL FLOW

CLASSIFICATION OF FLUID FLOW

BASED ON FLOW REGIME

(i) Steady Flow

- Fluid properties (velocity, pressure, etc.) at a point do not change with time.

(ii) Unsteady Flow

- Fluid properties vary with time at a given point.

BASED ON FLOW BEHAVIOUR

(i) Uniform Flow

- Fluid properties remain constant across any cross-section perpendicular to the flow direction.

(ii) Non-uniform Flow

- Fluid properties vary across the cross-section

BASED ON VELOCITY & FLOW PATTERNS

(i) Laminar Flow

- Smooth and orderly flow, with fluid particles moving in parallel layers.
- Common for low velocities
- Reynolds number (Re) < 2000.

(ii) Turbulent Flow

- Irregular and chaotic flow with mixing and eddies.
- Occurs at high velocities
- Re > 4000.

(iii) Transitional Flow

- Flow that transitions between laminar and turbulent states
- 2000 < Re < 4000.

CHARACTERISTICS OF FLUID

A liquid is a type of matter with specific properties that make it less rigid than a solid but more rigid than a gas. A liquid can flow and does not have a specific shape like a solid. Instead, a liquid conforms to the shape of the container in which it is held.

FLUID

- Liquids
  - Incompressible fluid
- Gases
  - Compressible fluid

a substance or matter in a state in which it will expand freely to fill the whole of a container, having no fixed shape (unlike a solid) and no fixed volume (unlike a liquid).

CHARACTERISTICS OF FLUID

CHARACTERISTICS OF FLUID

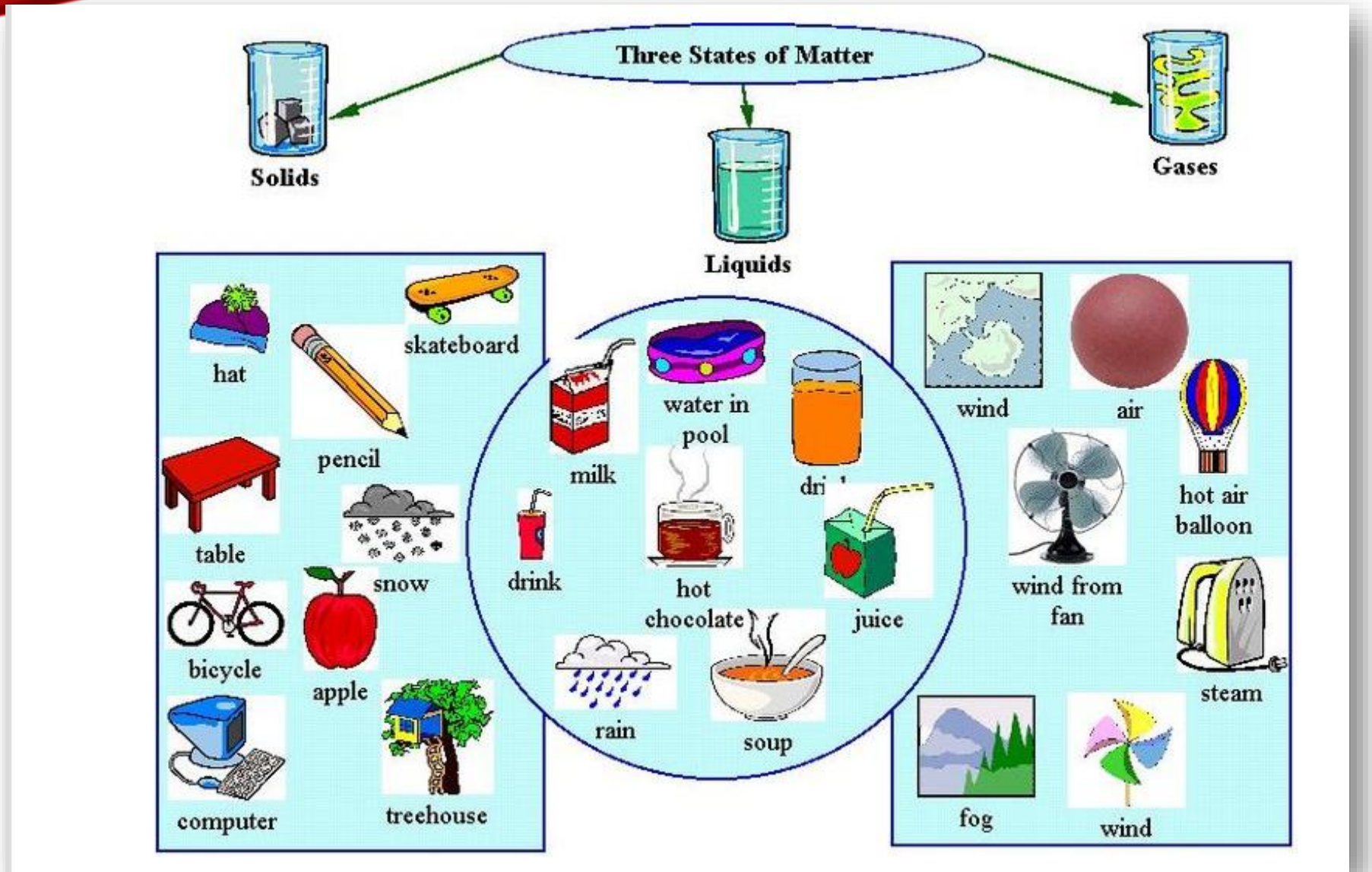
- It has no definite shape of its own.
- Conforms to the shape of containing vessel.

- Even a small amount of shear force exerted on a fluid will cause it to undergo a deformation which continues if the force continues to be applied.

DIFFERENCES BETWEEN LIQUID,GAS & SOLID

	Properties	Solids	Liquids	Gases
1	Mass	Definite	Definite	Definite
2	Shape	Definite	Acquires the shape of the container	Acquires the shape of the container
3	Volume	Definite	Definite	Indefinite
4	Compressibility	Not possible	Almost Negligible	Highly Compressible
5	Fluidity	Not possible	Can flow	Can flow
6	Rigidity	Highly rigid	Less rigid	Not rigid
7	Diffusion	Slow	Fast	Very fast
8	Space between particles	Most closely packed 	Less closely packed 	Least closely packed 
9	Interparticle force	strongest	Slightly weaker than in solids	Negligible

EXAMPLE OF SOLID, LIQUID & GAS


Three States of Matter
Solids
Liquids
Gases
hat
skateboard
pencil
table
snow
bicycle
apple
computer
treehouse
milk
water in pool
dri
drink
hot chocolate
juice
rain
soup
wind
air
hot air balloon
wind from fan
steam
fog
wind

DEFINITION OF PRESSURE

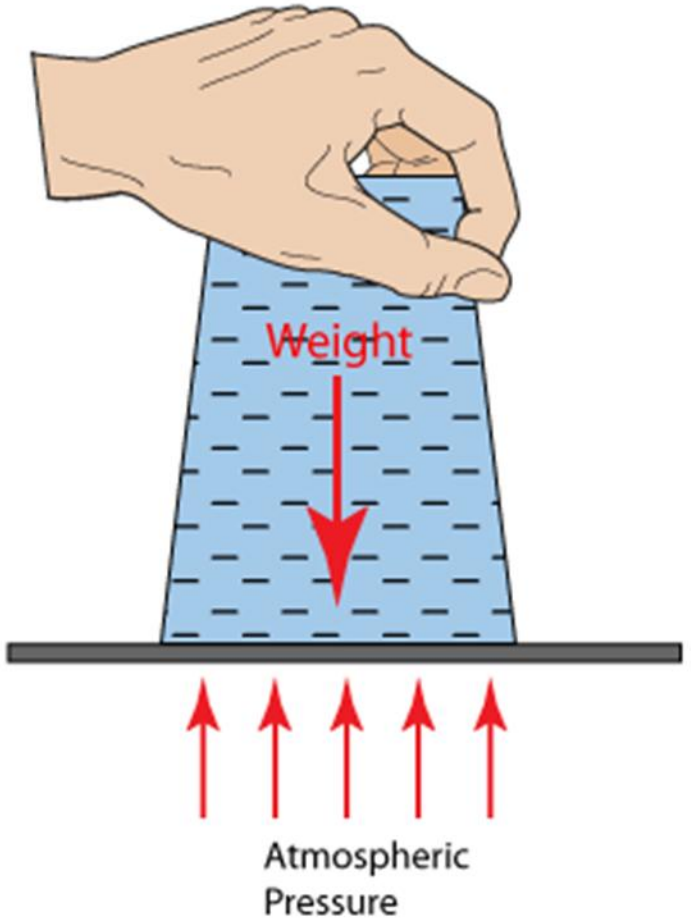
- Pressure is defined as a normal force (F) exerted by a fluid per unit area (A).
- We speak of pressure only when we deal with a gas or a liquid.
- The counterpart of pressure in solids is normal stress.
- Since pressure is defined as force per unit area, it has the unit of newtons per square meter (N/m^2), which is called a pascal (Pa).

TYPES OF PRESSURE

(A) Atmospheric Pressure, P_{atm}

- force per unit area exerted against a surface by the weight of air above that surface in the Earth's atmosphere.
- Atmospheric pressure at sea level is about 101.325 kN/m^2, which is equivalent to a head of 10.35 m of water or 760 mm of mercury approximately, and it decreases with altitude.
  - 101.325 kN/m^2 = 10.35 m of water = 760 mm of mercury

TYPES OF PRESSURE



TYPES OF PRESSURE

(B) Absolute Pressure, P_A

- Absolute pressure is measured relative to a perfect vacuum (absolute zero pressure)
- so, it is the pressure equal to the algebraic sum of the atmospheric pressure and gauge pressure.

$$Absolute\ pressure = Gauge\ pressure + Atmospheric\ pressure$$

$$P_A = P_G + P_{atm}$$

TYPES OF PRESSURE

(C) Gauge Pressure, P_G

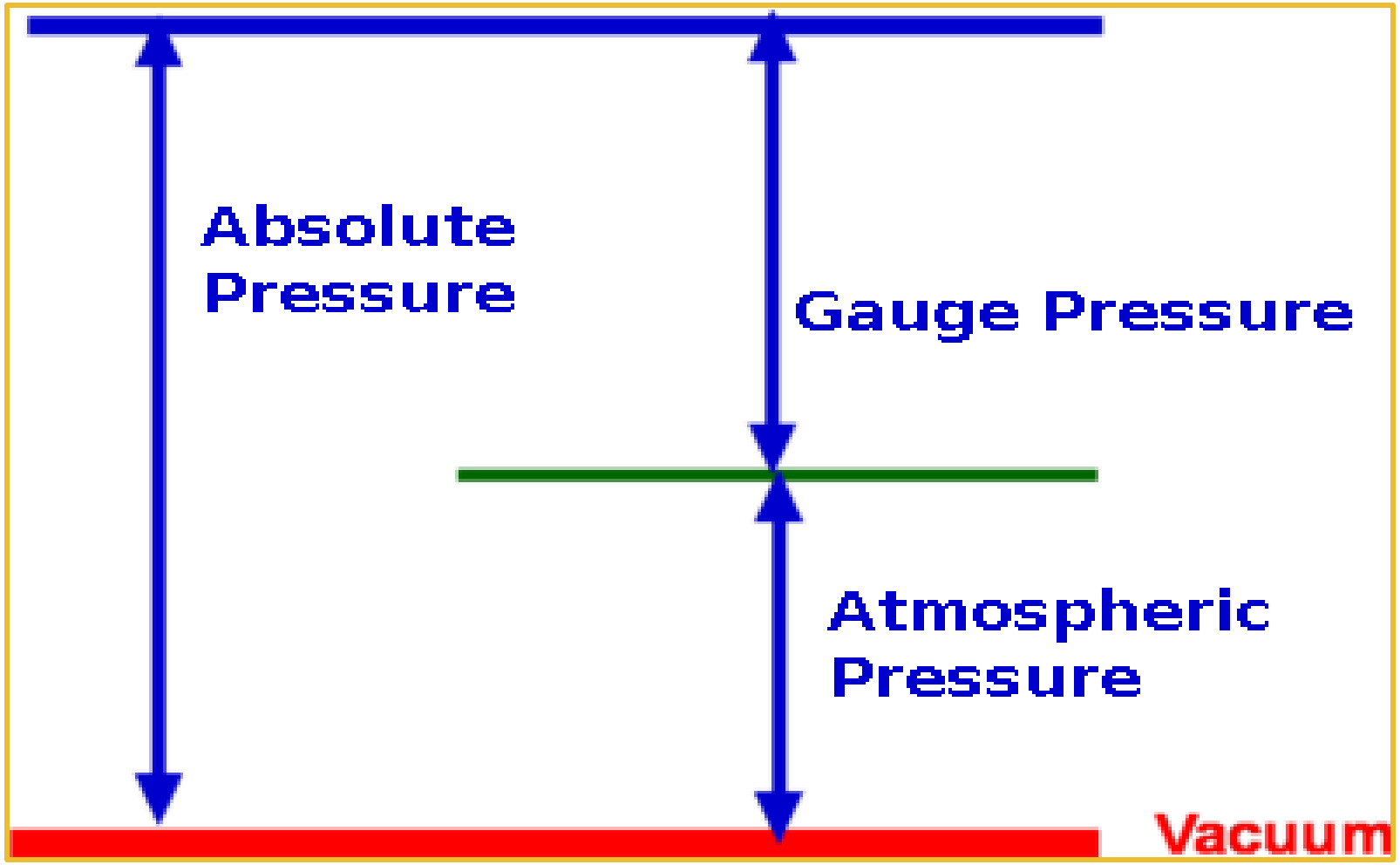
- It is a pressure measured with the help of a pressure measuring instrument.
- usually, the atmospheric pressure is taken as datum ($P_{atm} = 0$)

TYPES OF PRESSURE

(D) Vacuum Pressure, P_v

- refers to a pressure that is lower than the atmospheric pressure
- in a perfect vacuum which is completely empty space, the pressure is zero.
- Negative gauge pressure.

PRESSURE CHART



Example 1

What is the pressure gauge of air in the cylinder if the atmospheric gauge is 101.3 kN/m^2 and absolute pressure is 460 kN/m^2.

Example 2

A bourdon gauge is attached to a boiler which is located at sea level with a reading pressure of 7 bar. If atmospheric pressure is 1.013 bar, calculate the absolute pressure in that boiler (in kN/m^2).

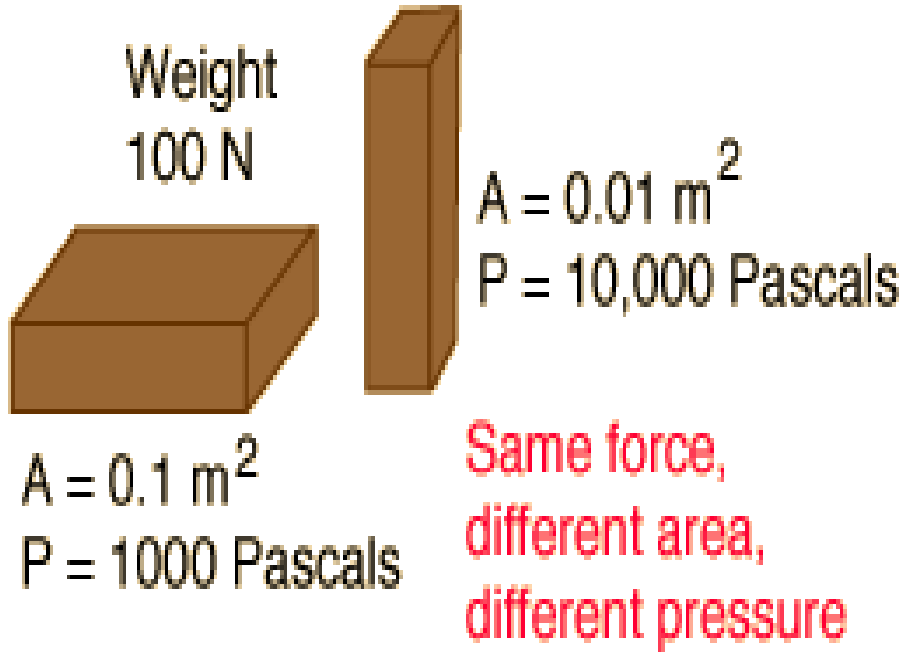
Example 3

Determine the absolute pressure of air in the compressor cylinder if the pressure gauge is 2500 N/m^2. (Assuming the atmospheric pressure is 101.3 kN/m^2)

DEFINITION OF PRESSURE

- ✓ defined as force per unit area.
- ✓ usually more convenient to use pressure rather than force to describe the influences upon fluid behavior.
- ✓ standard unit for pressure is Pascal (Pa), which is Newton per square meter (N/m^2).

$$Pressure = \frac{Force}{Area} = \frac{F}{A}$$



where:

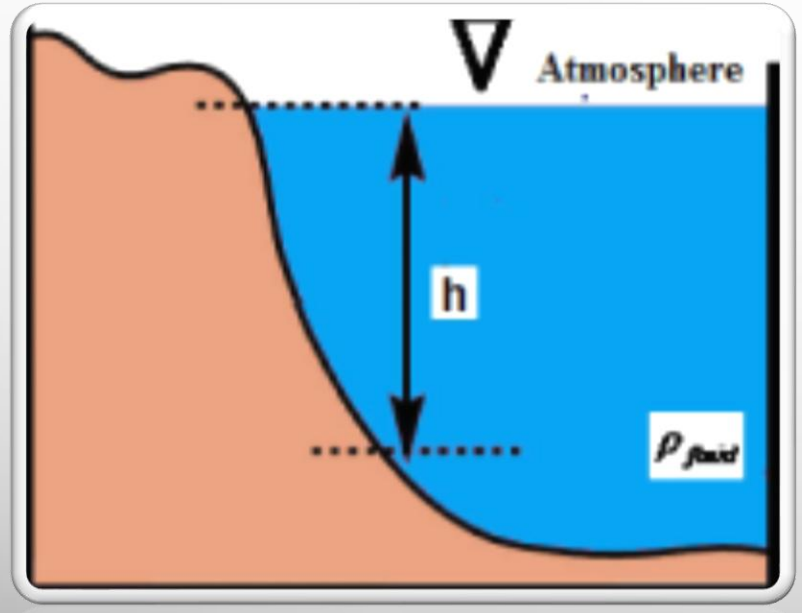
P is the pressure,
F is the normal force
A is the area.

PRESSURE IN FLUID

Relationship between pressure & depth Pressure

- If a fluid is within a container, then the depth, h of an object placed in that fluid can be measured.
- The deeper the object is placed in the fluid, the more pressure it experiences.
- This is because of the weight of the fluid above it.
- The denser the fluid above it, the more pressure is exerted on the object that is submerged, due to the weight of the fluid.

PRESSURE IN FLUID



- If a container is open to the atmosphere above, the added pressure must be included if one is to find the total pressure on an object (Figure shown).
- Hence,

$$P_{total} = P_{atmosphere} + P_{fluid}$$

$$P_{total} = P_{atmosphere} + \rho gh$$

PRESSURE IN FLUID

Head/Depth/Height of equivalent Liquid Column

- The pressure exerted by a static fluid depends only upon the **depth of the fluid**, the **density of the fluid**, and the **acceleration of gravity.**
- The pressure in a static fluid arises from the weight of the fluid and is given by the expression

$$P = \rho g h$$

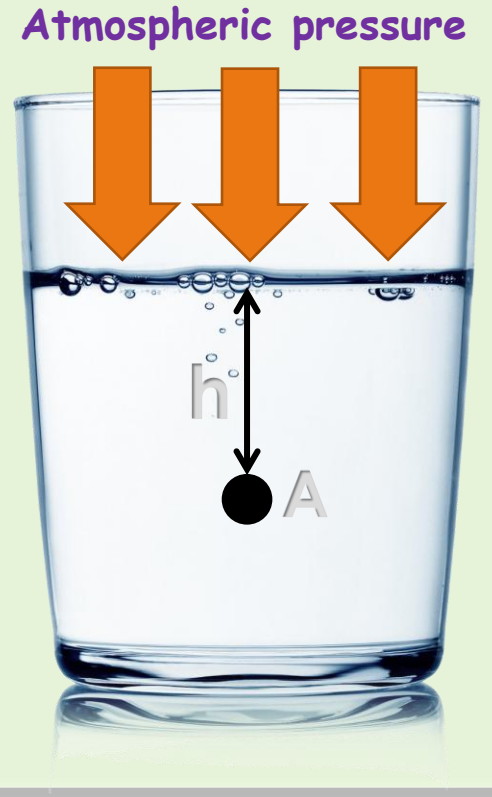
*Basic equation based on relationship pressure & depth

where ;

ρ = rho = fluid density, kg/m^3
g = acceleration of gravity, m/s^2
h = depth of fluid, m

PRESSURE IN FLUID

Head/Depth/Height of equivalent Liquid Column



- Referring to the Figure, consider a point A at a depth h (meter) in a liquid of density, ρ (kg/m^3),

$$P_A = \rho g h$$

$$P_{total} = P_{atmosphere} + P_A$$

$$P_{total} = P_{atmosphere} + (\rho g h)$$

PRESSURE IN FLUID

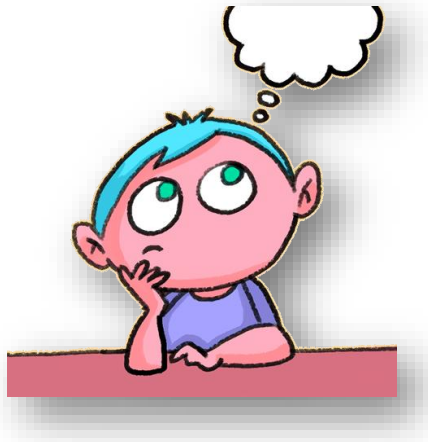
Pressure Head of a liquid

- A liquid is subjected to pressure due to its own weight
- This pressure increases as the depth of the liquid increases.

- 1 bar = 1×10^5 N/m^2
- 1 bar = 1×10^2 kN/m^2
- 1N/m^2 = 1 Pascal
- 760 mmHg = 1.01325 bar
  = 101.325 kN/m^2

Example 4

Calculate the pressure at a point of 1 km depth in the sea bed in Pascal and bar units. Given the density of sea water is 1025 kg/m^3.



Ans : P = 100.553×10^5 Pascal
P = 100.553 bar

Example 5

Find the height of a water column which is equivalent to the pressure of 3.5 kN/m^2.

(Take into consideration ρ_{water} = 1000 kg/m^3)

Ans : h = 0.357 m

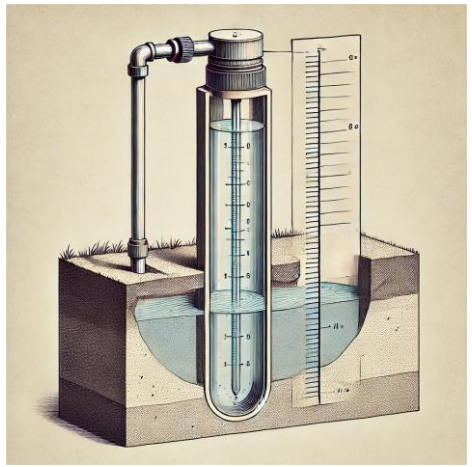
PRESSURE MEASUREMENT EQUIPMENT

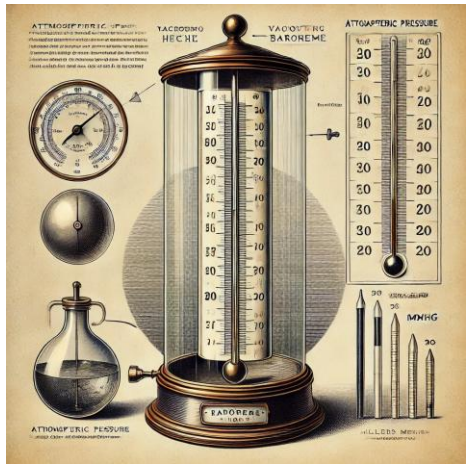
A) PIEZOMETER

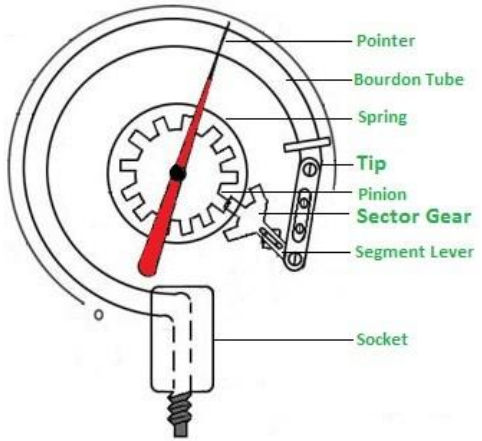
B) BAROMETER

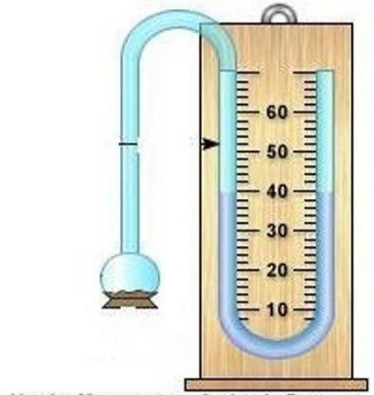
C) BOURDON GAUGE

D) MANOMETER









U-tube Manometer : A simple Pressure Gauge

STANDARD PREFIXES IN SI UNITS

TABLE 1–2

Standard prefixes in SI units

Multiple	Prefix
10^{12}	tera, T
10^{9}	giga, G
10^{6}	mega, M
10^{3}	kilo, k
10^{2}	hecto, h
10^{1}	deka, da
10^{-1}	deci, d
10^{-2}	centi, c
10^{-3}	milli, m
10^{-6}	micro, μ
10^{-9}	nano, n
10^{-12}	pico, p

Multiple and sub-multiple of the basic units are formed by means of prefixes, and the ones most commonly used are shown in the following table:

Any Question???
Thank you....