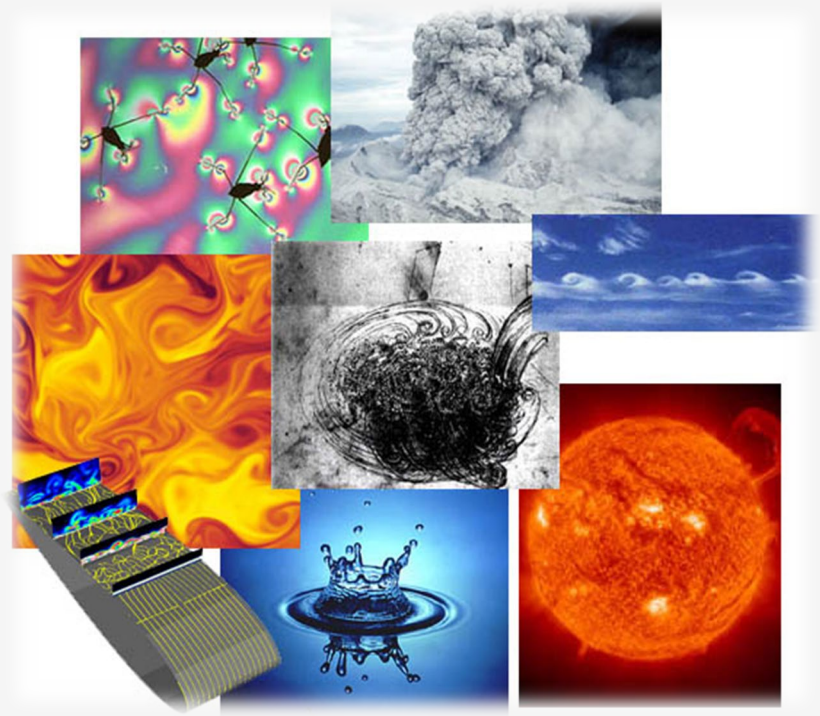
CHAPTER 1 : INTRODUCTION OF FLUID & FLUID PROPERTIES



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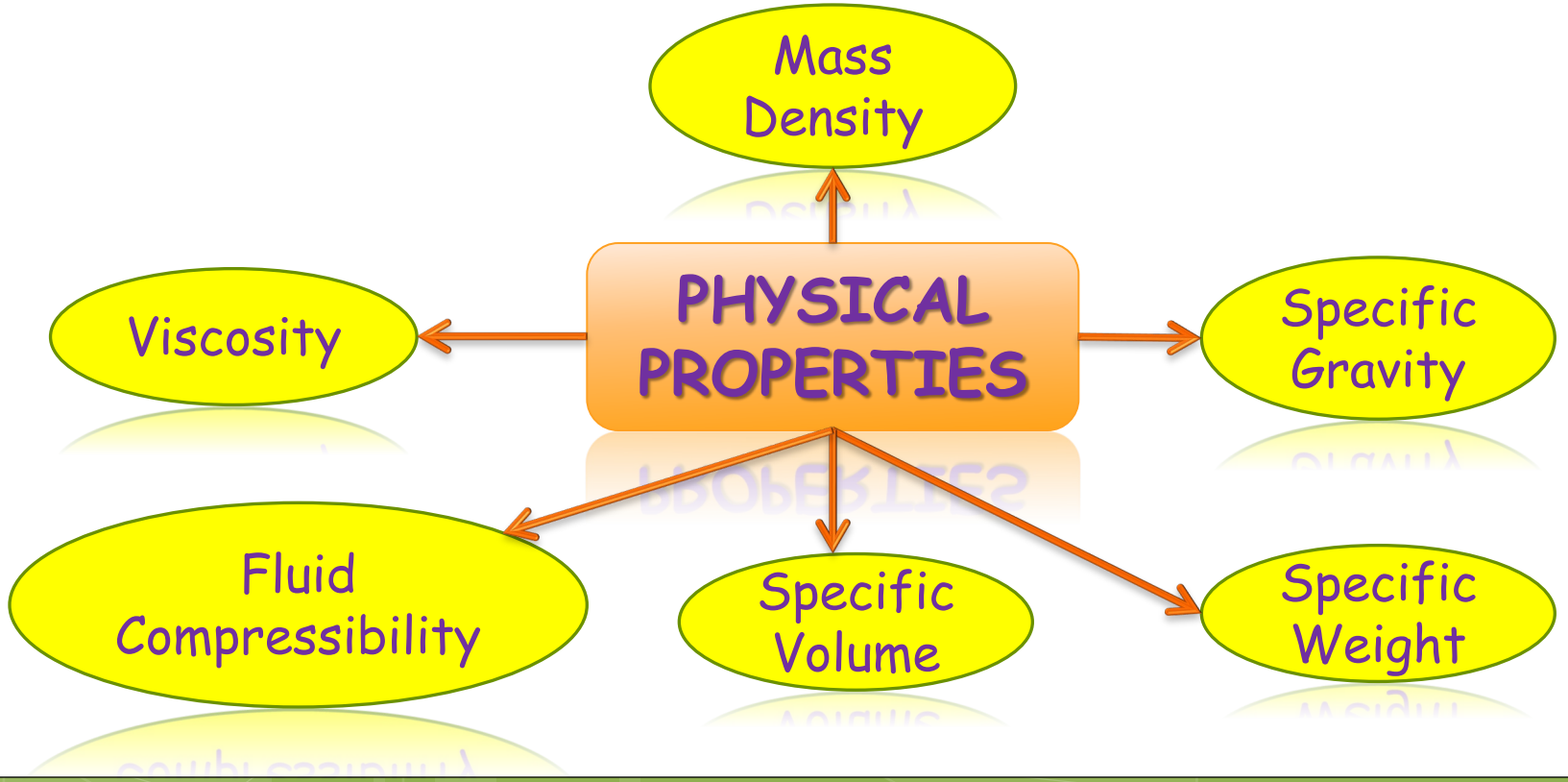
CONTENT

PHYSICAL PROPERTIES OF FLUID

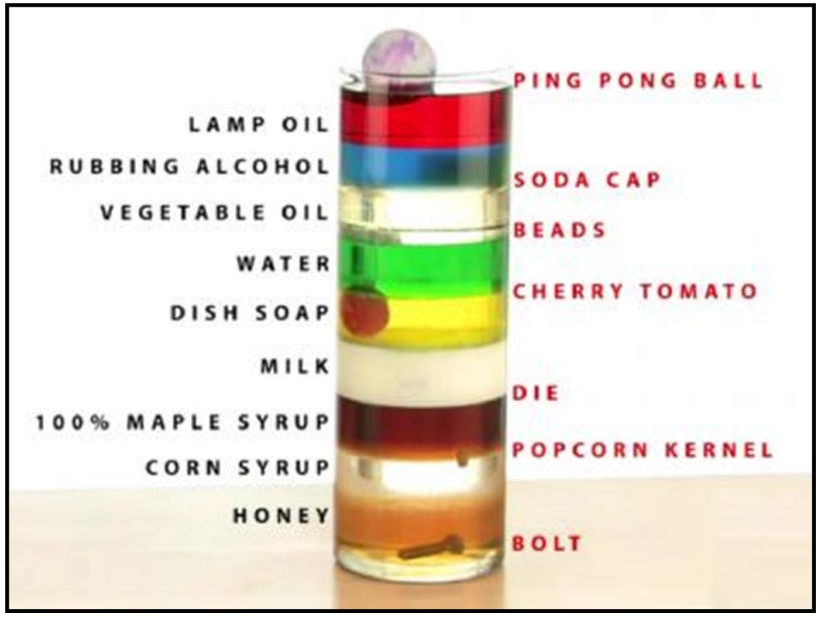
A) Mass Density
B) Relative Density (Specific Gravity)
C) Specific weight
D) Specific volume
E) Fluid Compressibility
F) Viscosity

PHYSICAL PROPERTIES OF FLUID

- Fluid properties are intimately related to fluid behavior.



PHYSICAL PROPERTIES OF FLUID



(A) Mass Density, ρ

- ✓ can be defined as mass per unit volume.
- ✓ symbol is ρ (rho) and the S.I unit is kg/m^3.

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

density = mass / volume

PHYSICAL PROPERTIES OF FLUID

(B) Relative Density, sp.gr (Specific Gravity)

- ✓ is the ratio of the specific weight of the liquid to the specific weight standard fluid (water).
- ✓ symbol is sp. gr.

$$\text{sp. gr.} = \frac{\text{Specific Weight of the substance}}{\text{Specific Weight of an equal volume of water}}$$

or,

$$\text{sp. gr.} = \frac{\text{Density of the substance}}{\text{Density of water}}$$

$$\zeta = \frac{\omega_{subs}}{\omega_{water}}$$

$$\zeta = \frac{\rho_{subs}}{\rho_{water}}$$

PHYSICAL PROPERTIES OF FLUID

(C) Specific Weight, ω

- ✓ can be defined as the weight per unit volume at the standard temperature and pressure.
- ✓ symbol is ω.
- ✓ S.I unit is N/m^3.

$W = mg$

- m = mass, kg
- g = acceleration of gravity, m/s^2

Fomula: $\omega = \frac{weight, W}{volume, V}$, $\omega = \frac{mg}{V}$, $\omega = \rho g$

PHYSICAL PROPERTIES OF FLUID

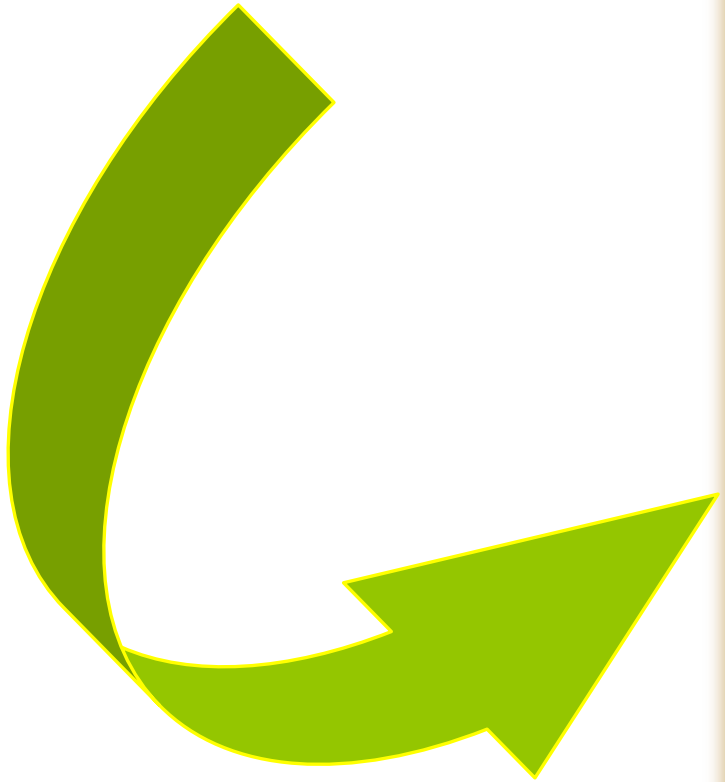
(D) Specific Volume, v

- ✓ can be defined as volume per unit of fluid.
- ✓ S.I unit is m^3/kg.

$$v = \frac{Volume, V}{mass, m}, \qquad v = \frac{1}{\rho}$$

PHYSICAL PROPERTIES OF FLUID

(E) Fluid Compressibility



COMPRESSIBLE AND INCOMPRESSIBLE FLUIDS

- The **compressibility** of a fluid is the reduction of the volume of the fluid due to an external pressure acting on it.
- A **compressible fluid** will reduce its volume in the presence of external pressure.
- In nature all the fluids are compressible. Gases are highly compressible but liquids are not highly compressible.
- **Incompressible fluid** is a fluid that does not change the volume of the fluid due to external pressure.
- Incompressible fluids are hypothetical type of fluids, introduced for the convenience of calculations.
- The approximation of incompressibility is acceptable for most of the liquids as their compressibility is very low. However, gases cannot be approximated as incompressible hence their compressibility is very high

PHYSICAL PROPERTIES OF FLUID

(F) Viscosity, μ

- ✓ Property of a fluid, due to cohesion & interaction between molecules, which resists sheer deformation.
- ✓ Different fluids deform at different rates under the same sheer stress.
- ✓ Example : viscous ➡ maple syrup (cold especially!)

  : not viscous ➡ water

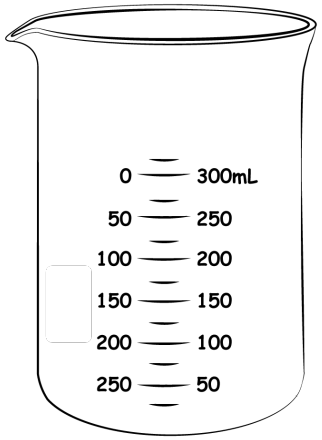
PHYSICAL PROPERTIES OF FLUID

Viscous

Not viscous

Example 1

What is the mass density ρ (in kg/m^3) and specific volume, v if mass is 450 g and the volume is 9 cm^3.



Solution

- ✓ Given mass, m = 450 g = 0.45 kg
- ✓ Volume, V = 9 cm^3 = 9 x 10^{-6} m^3

a) Mass density, $\rho = \frac{mass, m}{Volume, V} = \frac{0.45}{9 \times 10^{-6}}$

$= \underline{50 \times 10^3 \text{ kg/m}^3}$

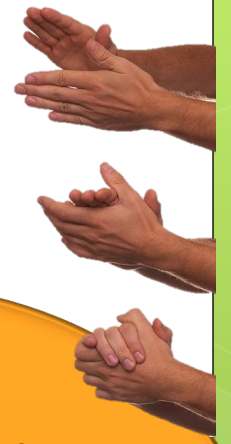
b) Specific volume, $v = \frac{Volume, V}{mass, m} = \frac{9 \times 10^{-6}}{0.45}$

$= \underline{2 \times 10^{-5} \text{ m}^3/\text{kg}}$

REMEMBER :
1 kg = 1000 grams
1 m = 100 cm
1m^3 = 1 x 10^6 cm^3

Example 2

What is the specific weight, ω of fluid (in kN/m³) and specific gravity if the weight of fluid is 10 N and the volume is 500 cm³.



Solution :

✓ Given Weight , W = 10 N Volume, V = 500 cm³
= 500 x 10^{-6} m³

a) Specific weight, ω = $\frac{Weight\ ,W}{Volume,V}$

= $\frac{10\ N}{500\ x\ 10^{-6}}$

= 20,000 N/m³ = 20 x 10^3 N/m³

= <u>20 kN/m³</u>

Specific weight of water,
$\omega_{water} = \rho_{water}$ x g
= 1000 x 9.81
= 9810 N/m³

b) Specific gravity, sp.gr = $\frac{\omega_{substance}}{\omega_{water}}$

= $\frac{20\ x\ 10^3}{9810}$ = <u>2.0387</u> (No unit)

Exercise 1

1. Volume of lubricant oil in a tank is 5.5 m^3 and its weight is 50kN. Calculate the following;

   i. Mass density of oil
   ii. Specific weight of oil
   iii. Specific gravity of oil

Ans : i) 926.67 kg/m^3
ii) 9 kN/m^3
iii) 0.9267

Given Volume, V = 5.5 m^3 and W = 50 kN

So,

i) Mass density , $\rho = \frac{mass\ ,m}{Volume,V}$

$= \frac{5096.84}{5.5}$

$= \underline{926.7\ kg/m^3}$

Weight, W = mass x acceleration due to gravity

= mg

So, mass, $m = \frac{Weight,W}{acceleration\ gravity,g}$

$m = \frac{50\ x\ 10^3}{9.81}$

= 5096.84 kg

ii) Specific weight , $\omega = \frac{Weight,W}{Volume,V}$

$= \frac{50\ x\ 10^3}{5.5}$

= 9091 N/m^3 @ 9.091 kN/m^3

= $\underline{9\ kN/m^3}$

OR

ii) Specific weight, $\omega = \rho g$

= 926.7 x 9.81

= 9091 N/m^3 @ 9.091 kN/m^3

iii) Specific gravity, sp.gr. = $\frac{specific\ weight\ of\ substance}{specific\ weight\ of\ water}$

$= \frac{9091}{9810}$

$= \underline{0.9267}$

OR

iii) Sp. gr. = $\frac{mass\ density\ of\ substance}{mass\ density\ of\ water}$

$= \frac{\rho_{substance}}{\rho_{water}}$

$= \frac{926.7}{1000}$

= 0.9267

Exercise 1

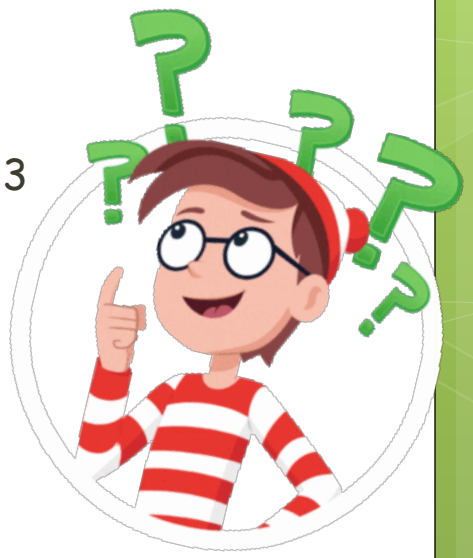
2. A beaker contains some fluid has a density of 0.8 g/cm^3 and volume of 500 ml. Determine the specific weight of fluid in unit N/m^3, weight of fluid in Newton and specific volume

ρ = 0.8 g/cm^3 $= \frac{0.8\ g}{cm^3} \times \frac{10^6\ cm^3}{1\ m^3} \times \frac{1\ kg}{1000\ g} = 800$ kg/m^3

V = 500 ml = 0.5 liter → m^3 = 0.5liter x $\frac{1m^3}{1000\ liter}$ = 5 x 10^{-4} m^3

1 m^3 = 1000liter * mass, m = 0.4 kg (calculated)

Solve it..!



Ans: 7848 N/m^3, 3.924 N, 1.25 x 10^{-3} m^3/kg

Any Question???

Thank you....

CHAPTER 2