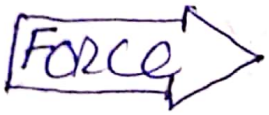
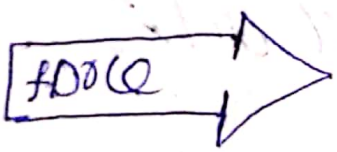
Fluid Mechanics - I

Define viscosity :-

It is the resistance of a fluid to flow. The molecules experience friction due to molecular interaction among them. Different fluid with different viscocity flow at different speed. The force required to induce moment.



less viscous fluids.



more viscous fluids.

It also determines the structure of molecules such as proteins in a solution.

→ Discovered by Jean-Louis-Marie Poiseuille in the year of 1829.

Newton's law of viscosity:-
It states, "The shear in a flowing fluid is directly proportional to the rate of shear strain."

Mathematically.

$\tau \propto \frac{du}{dy}$; rate of shear strain.

$\therefore \tau = \mu \frac{du}{dy}$ where μ = viscosity

→ Significance:- The fluids which follows 'Newton's law of viscosity are called "Newtonian fluids".

OR.

It states that the shear stress between adjacent fluid layers is proportional to the velocity gradient b/w two layers. The ratio of shear stress to shear rate is a constant for a given temperature and pressure and as defined the viscosity or co-efficient of viscosity.

(b) Define density:-

It is defined as the ratio of mass of fluid to the volume of fluid.

→ It is denoted by 'ρ' (rho).

→ Mathematically,

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

→ It's unit is kg/m^3.

→ For water:-

$$\rho = 1000\ kg/m^3$$

→ For mercury:-

$$\rho = 13600\ kg/m^3$$

→ In general sense, it is measure of mass of a fluid occupying one cubic meter of space.

→ Specific Volume:-

→ It is defined as the ratio of volume of fluid to the mass of fluid.

→ It is denoted by "V_s"

→ Mathematically,

$$V_s = \frac{V}{m} \Rightarrow \frac{1}{\rho}$$

→ It's unit is "m^3/kg"

→ For example
water
$$\rho = 1000\ kg/m^3$$

$$V_s = \frac{1}{\rho} \Rightarrow \frac{1}{1000}$$

$$V_s = 10^{-3}\ m^3/kg$$

→ It is reciprocal to our specific mass density.

Q: Specific weight:-

→ It is the measure that weight of a substance, which occupies one cubic meter of space.

→ Technically it is defined as the ratio of weight of fluid to its volume.

→ denote by "w".

→ mathematically

$$w = \frac{\text{weight of fluid}}{\text{volume of fluid}} = \frac{W}{V}.$$

we know that

$$w = mg$$

$$w = \frac{mW}{V} = \frac{mg}{V}.$$

→ unit

$$N/m^3.$$

Relation between density and specific weight :-

As

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

then

$$w = mg.$$

$$w = \frac{mg}{V}.$$

$$\boxed{w = \rho g} \qquad \boxed{\rho = \frac{m}{V}}$$

ρ density.

Part C.

Given

volume of gas $V = 0.72\ m^3/kg$

Required :-

specific weight in N/m^3 = ?

Sol :-

As we know that

$$v = \frac{1}{\rho}.$$

So

$$\rho = \frac{1}{v}$$

$$\rho = \frac{1}{0.72} \Rightarrow 1.389 \text{ kg/m}^3$$

Specific weight 'w' $= \rho \times g$

$= 1.389 \times 9.8$

$= 13.62 \text{ N/m}^3$

Q2 :-

Part a :-

What is Pressure?

Force acting on a unit area of a surface is called Pressure. The force applied on surface is perpendicular to the surface is known as thrust.

$$\text{Pressure} = \frac{F}{A}$$

S.I unit Pascal denoted by Pa

$$1 \text{ Pa} = \frac{\text{N}}{\text{m}^2}$$

Rel → It depends on two factors

wi → force more force is applied the pressure will be greater.

→ Greater the surface area lesser the pressure.

→ lesser the surface area more will be the pressure.

Example:-

- A sharp knife a axe very small surface are on its cutting edge. so high pressure can be exerted to cut the meat.

Absolute Pressure

The pressure which is measured with reference to absolute vacuum pressure or zero pressure.

OR

The total pressure at a point in a fluid equalling the sum of gauge pressure and absolute pressure.

Mathematically:-

$$P_{abs} = P_g + P_{atm}$$

P_g → gauge pressure, P_{atm} → atmospheric pressure.

E.g:-

If your tire gauge reads 39psi then the absolute pressure is 39psi plus 14.7 PSI or 53.7psi.

Gauge Pressure:-

→ The amount by which the pressure measured in a fluid exceeds that of the atmosphere.

OR

The Pressure relative to atmospheric Pressure. Gauge Pressure is positive for Pressure above atmospheric pressure, and negative for pressure below it.

Mathematically:-

Total pressure or absolute pressure is the sum of gauge pressure and atmospheric pressure.

$P_{abs} = P_g + P_{atm}$ — P_{abs}: absolute pressure; P_g: gauge pressure; P_{atm}: atmospheric pressure

Q NO 30:-

Part (b):-

Length = 1500mm = 1.5m

Breadth = 1500mm = 1.5m

Depth = 7.99.

unit wt of water = 9.81 KN/m^3

Required:

net pressure, P = ?

location of force = ?

If water level drop half of depth.

Find P and location of force.

Sol:-

(1) Net pressure.

$P = \gamma \times h$

$= 9.81 \times 7.929$

$P = 77.7839$

(2) force Application

$\bar{y} = h/3$

$\bar{y} = \frac{7.929}{3}$

$\bar{y} = 2.643$

③ Half depth :-

$$P = \rho \times \frac{h}{2}$$

$$P = 9.81 \times \frac{7.929}{2}$$

$$P = 9.81 \times 3.96$$

$$P = 38.84$$

centroid :-

$$\bar{y} = \frac{h}{2} \times \frac{1}{3}$$

$$\bar{y} = \frac{7.929}{2} \times \frac{1}{3}$$

$$y = 3.96 \times \frac{1}{3}$$

$$\bar{y} = 1.32$$