

Subject:-

Fluid Mechanics - I

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Question No-1

(1)

(a) Define Viscosity? Derive Newton equation of viscosity.

Ans VISCOSITY
Definition

"It is the property of a fluid which resists relative motion of its adjacent layers. It is due to cohesion and molecular momentum exchanged between fluid layers.

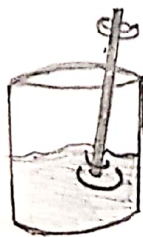
Unit:-

The unit of viscosity is "Poise"

Example:-

Syrup has a greater viscosity than water.

Lower
viscosity



water



Syrup

Greater
viscosity

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Newton's Equation of Viscosity

Statement:-

It states that "the shear stress in a flowing fluid is directly proportional to the rate of shear strain."

Mathematical Representation:-

$$\tau \propto \frac{du}{dy}$$

$\tau \rightarrow$ shear stress.

change the sign of proportionality.

$$\tau = \mu \frac{du}{dy}$$

Where

$\mu =$ viscosity (dynamic viscosity)

$\frac{du}{dy} =$ Rate of shear deformation.

The fluid which follows "Newton's law of viscosity" are called "Newtonian fluids."

(b) Define density, specific weight and specific volume. Show relation between Density and specific weight.

Ans Density:- (3)

Definition:-

Density of a fluid is derived as:
"The ratio of mass of a fluid to the volume of the volume of the fluid."
"OR"

"Mass per unit volume"

Mathematical Form:-

$$\rho = m/v = \text{kg/m}^3$$

where

$\rho \Rightarrow \text{Rho} \Rightarrow \text{density.}$

mass $\Rightarrow m$

$v = \text{volume.}$

Specific Weight:-

Definition:-

Specific weight of a fluid is defined as: "The ratio of the weight of a fluid to the volume of the fluid."

OR

"Weight of a fluid per unit volume"

Mathematical form:-

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$$W = mg/v = \rho g = N/m^3$$

Where $W \Rightarrow$ specific weight

$mg \Rightarrow$ weight of the fluid

$v \Rightarrow$ volume

Specific Volume:-

Specific volume is defined as:

"The ratio of the volume of a fluid to the mass of the fluid

"OR"

"Volume per unit mass of a fluid."

Mathematical form:-

$$\text{Specific Volume} = v/m = 1/\rho$$

Relation between Density and Specific Weight.

As we know that

and that $W = w/v$

$w \Rightarrow mg$

So,

$$W = mg/v \Rightarrow W = \boxed{\rho g} \therefore \rho = m/v \Rightarrow \rho = \text{density}$$

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c. If specific volume of gas is $0.72 \text{ m}^3/\text{kg}$.
What is the specific weight in N/m^3 ?

Ans

Given Data:-

Specific volume, $V = 0.72 \text{ m}^3/\text{kg}$

Required Data:-

Specific weight, $W = ?$

Solution:-

$$\text{As, } V = \frac{1}{\rho}$$

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

$$\rho = \frac{1}{0.72}$$

$$\rho = 1.38 \text{ kg}/\text{m}^3$$

As,

$$W \Rightarrow \rho g$$

$$g = 9.81 \text{ m}/\text{s}^2$$

$$\text{S. Weight} \Rightarrow W = 1.38 \text{ kg}/\text{m}^3 \times 9.81 \text{ m}/\text{s}^2$$

~~XXXXXXXXXX~~ $W \Rightarrow \boxed{13.54 \text{ N}/\text{m}^3}$

Question No. 2

(6)

(a) Define Pressure? What is absolute and gauge pressure

Ans Pressure :-

Definition:-

Pressure is defined as: "the force applied perpendicular by the surface of an object per unit area over which that force is distributed."

Unit:-

The S.I Unit of Pressure is Pascal (Pa)

Gauge Pressure:

Definition:-

"Gauge pressure is the pressure relative to atmosphere pressure. Gauge pressure is positive for pressure above atmospheric pressure and negative for pressure below it."

Mathematically:-

Total pressure or absolute pressure is thus the sum of gauge pressure and atmosphere pressure.

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

where

$P_{abs} \Rightarrow$ Absolute pressure

$P_g \Rightarrow$ Gauge Pressure

$P_{atm} \Rightarrow$ atmospheric pressure.

Absolute Pressure:-

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Definition

It is the total pressure at a point in a fluid equalling the sum of gauge pressure and the atmospheric pressure.

Mathematically:-

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

→ atmospheric pressure.

Absolute Pressure

Gauge Pressure

Example:-

For example, If your tire gauge reads 39 psi (pounds per square inch) then the absolute pressure is 39 psi plus 14.7 psi (P_{atm} in psi) or 53.7 psi (equivalent to 357 kPa)

$$P' = 38.94 \text{ kN/m}^2$$

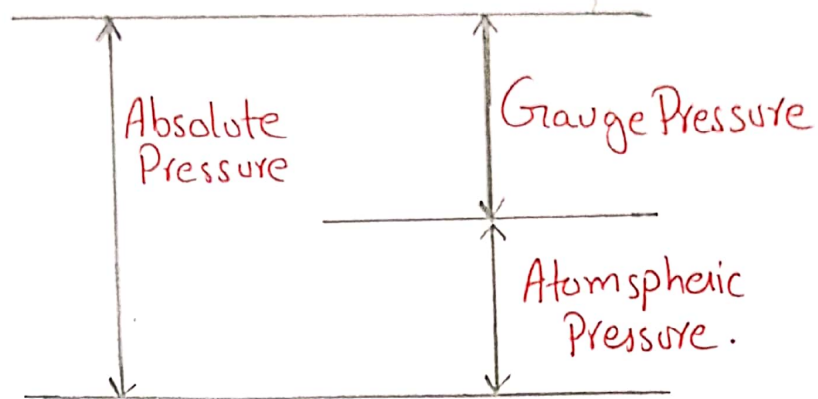
Centroid,

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

$$\bar{y}' = 1.323 \text{ m}$$

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DIAGRAM



(b) A water tank having dimensions of $1500\text{ mm} \times 1500\text{ mm}$. Depth of water tank is equal to your student ID number in mm. What is the net pressure on the wall of water tank? Find the location of force application?

If the water tank level drops to the half of the depth, what will be the force and point of application of force?

Given Data:-

$$\text{Length} = 1500\text{ mm} = 1.5\text{ m} = L$$

$$\text{Breadth} = 1500\text{ mm} = 1.5\text{ m} = b$$

Depth, $h \Rightarrow 7910 \text{ mm} = 7.910 \text{ m}$

Unit weight of water = 9.81 kN/m^3

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Required Data

→ a) net pressure, $P = ?$

→ b) Location of force

→ c) If water level drops half of depth find P and location of force.

Solution:-

a) Net Pressure:-

$$P = \gamma h$$

$$P = 9.81 \times 7.910$$

$$P \Rightarrow 77.5971 \text{ kN/m}^2$$

b) Force application (Centroid) :-

$$\bar{y} = h/3$$

$$\bar{y} = 7.910/3$$

$$\bar{y} = 2.6367 \text{ m}$$

c) Half Depth:-

Pressure at half depth, $P' = \gamma h/2$

$$P' = 9.81 \times 7.910/2$$

$$P' = 38.79855$$