Notes by-

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Exercise : Properties of Fluids

1. The specific gravity of a liquid is 3.0, what are its specific weight, mass density and specific volume? $3.39 \times 10^{-5}\ m^3/N$
[$\gamma = 29.43\ kN/m^3$; $\rho = 3000\ kg/m^3$; $V = 3.33 \times 10^{-4}\ m^3/kg$.]

2. A certain liquid has a dynamic viscosity of 0.073 poise and sp. gravity of 0.87. Compute the kinematic viscosity of the liquid in stokes and also in m^2/s.
[$\nu = 0.0839$ stokes $= 0.0839 \times 10^{-4}\ m^2/s$]

3. If $5.27\ m^3$ of a certain oil weighs 44 kN, calculate the sp. weight, mass density and sp. gravity of the oil.
[$\gamma = 8349\ N/m^3$; $\rho = 851.08\ kg/m^3$; $S = 0.851$]

4. If a certain liquid has a viscosity of 0.048 poise and kinematic viscosity 3.50×10^{-2} stokes, what is the sp. gravity?
[$S = 1.371$]

5. If stream of glycerine in motion at a certain point the velocity gradient is $0.25\ s^{-1}$. If for fluid $\rho = 1268.4\ kg/m^3$ and $\nu = 6.30 \times 10^{-4}\ m^2/s$, calculate the shear stress at that point.
[$\tau = 0.1997\ N/m^2$]

6. If the equation of velocity distribution over a plate is given by $V = 2y - y^2$, in which $V \rightarrow$ velocity in m/s and y is measured in metres above the plate. What is the velocity gradient at the boundary and at 7.5 cm and 15 cm from it? Also determine shear stress at these points if absolute viscosity $\mu = 8.60$ poise.
[2 sec^{-1}; $1.85\ s^{-1}$; $1.70\ s^{-1}$; $1.72\ N/m^2$; $1.591\ N/m^2$; $1.462\ N/m^2$]

7. A body weighing 441.45 N with a flat surface area of $0.098\ m^2$ slides down lubricated inclined plane making a 30° angle with the horizontal. For viscosity of $0.1\ N \cdot s/m^2$ and body speed of 3 m/s, determine the lubricant film thickness.
[0.126 mm]

8. A piston 12 cm dia and 15 cm long moves down in a 12.04 cm dia. cylinder. The oil filling the annular space has a viscosity of $8.0 \times 10^{-2}\ N \cdot s/m^2$ and the weight of the piston is 9.81 N. Find the speed with which the piston slides down. [0.43 m/s]

(9) A very ~~large~~ 1.5m×1.5m thin plate is centred in a gap of width 6cm with different oils of unknown viscosities above and below, the viscosity of one being twice of the other. When the plate is pulled at a velocity of 30cm/sec, the resulting force on one square metre of plate due to viscous shear on both sides is 29.4 N. Assuming viscous flow and neglecting all end effects, calculate viscosities of the oils.

[$\mu_1 = 0.436$, $\mu_2 = 0.87$ Ns/m²]

10. Calculate the maximum capillary rise of water to be expected between two vertical, clean glass plates spaced 1mm apart. [h = 0.0326 m]

11. A soap bubble 5cm in diameter contains a pressure in excess of atmosphere of 20.07 N/m². Calculate the tension in the soap film. [σ = 0.125 N/m]

12. If the pressure inside a droplet of water is 196.2 N/m² in excess of the external pressure, what is the diameter of the droplet? $\sigma_{water/air} = 0.07358$ N/m (d = 1.5mm)

13. Calculate the capillary effect in mm in a glass tube of 4mm diameter when immersed in (1) water (2) mercury. The temperature of the liquids is 20°c and the value of surface tension of water and mercury at 20° in contact with air respectively 0.07357 N/m and 0.490 N/m. The contact angle for $\theta = 0°$ and for mercury $\theta = 130° 24'$

[$h_w = 7.5$mm, $h_{Hg} = -32.3$ mm]

Questions asked in examination

(a) Distinguish between ideal fluid and real fluid. Which of the following would you describe as Newtonian fluids - water, Bentonite slurry, kerosene, blood, tar, air

(b) Differentiate in Ideal fluid, Real fluid, Non-Newtonian fluid, Thixotropic fluid and Ideal Plastic. Show these in a diagram of shear stress τ, verses velocity distribution dv/dy.

(c) Would you imagine the viscous resistance to the flow of air to be greater or less than viscous resistance to the flow of water? Explain giving reasons in brief.

(d) Define fluid and classify fluid based on the property 'viscosity'. (1996 CE-III) Marks - 10

(e)

weight of the piston is 9.81 N. Find the speed with which the piston slides down. [ ]

① $S = 3.0$ $\quad S = \frac{\gamma}{\gamma_w} \Rightarrow \gamma = S\gamma_w = 3 \times 9.81 = 29.43\ kN/m^3$

$Vs = ?$

$\gamma = ?$

$\rho = ?$ $\quad \gamma = \rho \cdot g \Rightarrow \rho = \frac{\gamma}{g} = \frac{29.43 \times 10^3}{9.81} = 3000\ kg/m^3$

$Vs = \frac{1}{\gamma} = \frac{1}{29.43} = 0.03398\ m^3/kN$

$Vs = \frac{1}{\rho} = \frac{1}{3000} = 3.333 \times 10^{-4}\ m^3/kg$

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② $\mu = 0.073$ poise $= 0.0073\ N.s/m^2 = 0.0073 \times 9810\ kg.s/m^2$

$= 71.613\ kg.s/m^2$

$S = 0.87$

$\rho = ?$ (stokes)

$= ?$ (m^2/s)

~~$\mu = \frac{\rho}{\gamma}$~~ $\quad S = \frac{\rho}{\rho_w} \Rightarrow \rho = S \cdot \rho_w = 0.87 \times 1000 = 870\ kg/m^3$

~~$\gamma = \frac{\rho}{\mu} = \frac{870}{0.0073}$~~ $\quad \gamma = \frac{\mu}{\rho} = \frac{0.0073 \times 9.81}{870} = 8.39 \times 10^{-6} \times 9810 =$

Let $\gamma = \frac{\mu}{\rho}$ $\quad S = \frac{\rho}{\rho_w} \Rightarrow \rho = S \cdot \rho_w = 0.87 \times 1000 = 870\ kg/m^3$

$\gamma = \frac{71.613}{870} = 0.0823$ stokes.

$\gamma = 0.0823 \times 10^{-4}\ m^2/s$

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③ $V = 5.27\ m^3$ $\quad \gamma = \frac{W}{V} = \frac{44 \times 10^3}{5.27} = 8349\ N/m^3$

$W = 44\ kN$.

$\gamma = ?$ $\quad \rho = \frac{M}{V} = \frac{9.81 \times 44 \times 10^3}{5.27}$ $\quad \gamma = \rho \cdot g \Rightarrow \rho = \frac{\gamma}{g} = \frac{8349}{9.81}$

$\rho = ?$

$S = ?$ $\quad \therefore \rho = 851.08\ kg/m^3$

$S = \frac{\gamma}{\gamma_w} = \frac{8349}{9.81 \times 10^3} = 0.851$

$= \frac{\rho}{\rho_w} = \frac{851.08}{1000} = 0.851$

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④ $\mu = 0.048$ poise $= 0.0048\ N.s/m^2 = 0.0048 \times 9810 = 47.088\ kgs/m^2$

$\gamma =$