Solution - Internal Assessment Test 1 – September 2019

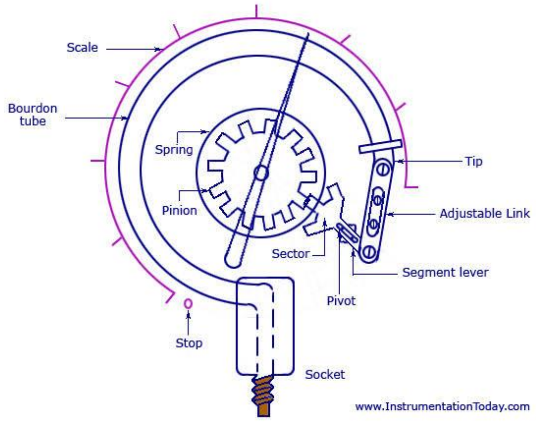
18CV33 Fluids Mechanics

Part A is **compulsory** and Answer any **TWO questions from Part B** — MARKS

Assume any missing data suitably. Provide neat sketches wherever necessary

PART A

1 (a) With the help of a neat sketch and explain working of Bourdan's pressure gauge. [06]



Bourdon Tube Pressure Gauge

- This is a mechanical pressure gauge used to measure medium to high pressures.
- Most common type invented by E Bourdon

Working:

- The pressure responsive element is a tube of steel/ bronze which is elliptical in cross section and is curves into a circular arc.
- Tube is closed at its outer end and this end is free to move.
- The outer end through which the fluid enters, is fixed to the frame
- When the gauge is connected to the gauge point, the fluid enters the tube.
- Due to increase in pressure, elliptical tube tends to be circular.
- Outward movement of the tube is transmitted by a link, quadrant and pinion to a pointer.
- Dial is so calibrated that when the pressure inside the tube becomes equal to atmospheric pressure, it reads zero.
- The pointer moves clockwise on the graduated scale and indicates the pressure intensity of the fluid.
- When a vaccum gauge is connected the tube tends to close and the pointer moves in anticlockwise direction.
- Pressure is read in N/m^2 or kgf/cm^2.

(b) State and prove Pascal's law. [06]

* Pascal's law.

It states that the intensity of pressure at a point in a static fluid is equal in all directions.

Consider a wedge shaped fluid element as shown in Fig (ii). The forces acting on it are shown

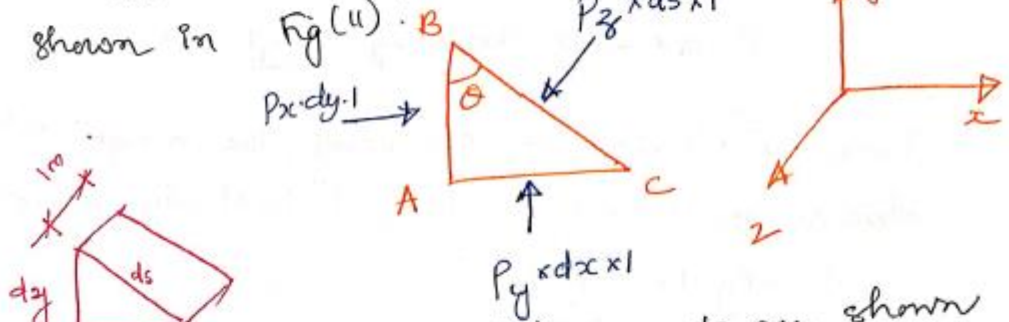
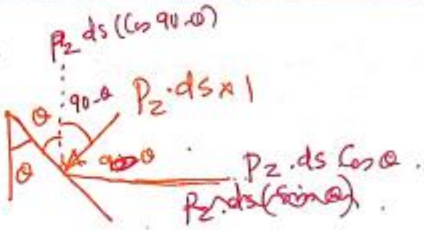


Fig (ii)



The weight of the fluid wedge $= \rho g \cdot \left(\frac{1}{2} \times dx \times dy\right)$.
(acting vertically downwards.

Resolving the forces:-

x-direction

$$p_x \cdot dy \times 1 - p_z\, ds \cdot \cos\theta = 0.$$

$$p_x \cdot dy - p_z \cdot ds \times \frac{dy}{ds} = 0.$$

$$\text{or } \; p_x\, dy = p_z\, dy$$

$$\text{or } \; \boxed{p_x = p_z}.$$

y-direction:-

$$P_y \, dx - P_z \, ds \sin\theta - \rho g \frac{dx\,dy}{2} = 0$$

$$P_y \times dx - P_z \, ds \times \frac{dx}{ds} - \rho g \times \frac{dx\,dy}{2} = 0$$

$$P_y \, dx - P_z \, dx - \rho g \frac{dx\,dy}{2} = 0$$

Since the element is very small, the weight of the element is negligible. Hence $\left(\rho g \frac{dx\,dy}{2}\right)$ is negligible

$\therefore P_y \, dx = P_z \, dx$

or $P_y = P_z$

(c) An oil of viscosity 6 Poise is used for lubrication between shaft and sleeves. The diameter of the shaft is 0.6 m and it rotates at 200 rpm. Calculate the power lost in oil for a sleeve length of 150 mm and the thickness of the oil film is 1.2 mm. [08]

Power lost = F×velocity = F×rω

V=du= rω = 0.3×$r\omega = 0.3 \times \frac{2\pi N}{60} = 0.3 \times \frac{2\pi \times 200}{60} = 6.283\ m/s$

Shear force, F is given as $F = \pi \times 0.6 \times 0.15 \times 0.6 \times \frac{6.283}{1.2\times10^{-3}} = 888.24\ N$

Power lost = $888.24 \times 6{,}283 = 5580.8\ W$

PART B

2 (a) Prove that the relationship between surface tension and pressure inside a droplet of liquid in excess of outside pressure is given by p =4σ/d. [04]

★ Surface tension on Liquid Droplet

Consider a spherical droplet of radius 'r'.

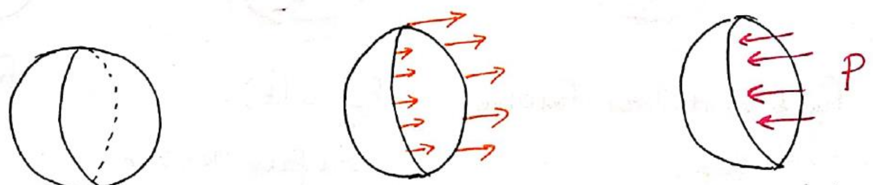


Fig 5(a) Droplet   Fig 5(b) Surface tension   Fig 5(c) Pressure forces.

(24)

Let σ is the surface tension of the fluid.

p is the pressure intensity inside the droplet

d - diameter of the droplet.

(i) Tensile force due to surface tension = σ × Circumference

$= \sigma \times \pi \times d$.

(ii) Pressure force $= p \times \frac{\pi}{4} \times d^2$.

Equating the two.

$$\sigma \times \pi \times d = p \times \frac{\pi}{4} \times d^2$$

$$\boxed{p = \frac{4\sigma}{d}}$$

(b) Define (i) Weight density (ii) Specific gravity (iii) Mass density. Specific gravity of oil is 0.85. Find the specific mass and mass density. [05]

<u>Density or Mass density (ρ)</u> :- It is the ratio of the mass of the fluid to its Volume.

$$\rho = \frac{\text{Mass of fluid}}{\text{Volume of fluid}}$$

Unit :- kg/m^3.

<u>Specific Weight or Weight density (w)</u> : It is the ratio of weight of a fluid to its Volume.

$$w = \frac{\text{Weight of fluid}}{\text{Volume of fluid}} = \frac{\text{Mass of fluid} \times g}{\text{Volume of fluid}}$$

$\boxed{w = \rho g}$ Unit :- N/m^3

Specific gravity :-

Ratio of weight density of fluid to the weight density of a standard fluid.

liquids - Standard fluid is water

gases - Standard fluid is air.

$$S_{(liquids)} = \frac{\text{Weight density / Density of a fluid}}{\text{Weight density / Density of water}}$$

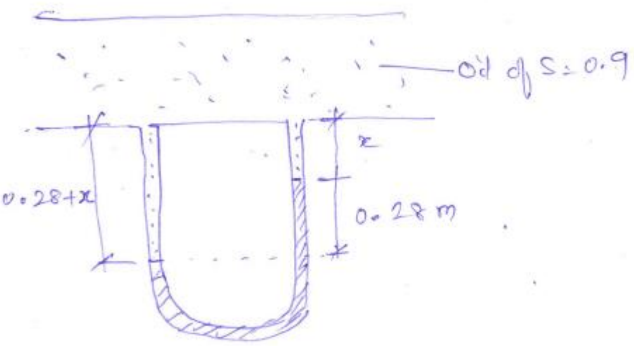
$$S_{(gases)} = \frac{\text{Weight density / Density of a fluid gas}}{\text{Weight density / Density of air}}$$

Density of a fluid = S × Density of water.

Density of a gas = S × Density of air.

Density of water = $1000\ kg/m^3$; Density of Hg = 13.6 or

(c) A differential manometer connected between two points A and B of a horizontal pipeline carrying an oil of relative density 0.9, shows a difference of mercury level as 0.28 m. Determine the difference in pressure between points A and B in terms of head of water in N/m^2. [06]



Considering XY as the reference and equating the pressure about the same

$$p_A + (0.28 + x) \times 0.9 \times 1000 = p_B + 0.28 \times 13.6 \times 1000 + x \times 0.9 \times 1000$$

$$p_A - p_B = (13.6 - 0.9) \times 0.28 \times 1000 = 3556\ N/m^2$$

3 (a) What are the desirable properties of a manometric fluid. [04]

Desirable properties of good manometric liquid should have;

- Low-freezing point.
- High boiling point.
- Non wetting characteristics.
- Low surface tension.
- Chemically inert.

- Clear visible interface.
- Ability to maintain density at various temperatures.

(b) State Newton's law of viscosity. The velocity distribution over a plate is given by $V = \frac{y}{4} - y^2$, in which 'V' is the velocity in m/s, at a distance 'y' m above the plate. Find the shear stress at y=0 and y = 0.15 m and μ = 0.835 N-s/m². [05]

$$\tau = \mu \times \frac{dV}{dy}$$

$$V = \frac{y}{4} - y^2$$

$$\frac{dV}{dy} = \frac{1}{4} - 2y$$

At y = 0;

$$\frac{dV}{dy} = \frac{1}{4}; \qquad \tau = \mu \times \frac{dV}{dy}; \ \tau = 0.835 \times \frac{1}{4} = 0.209\frac{N}{m^2}$$

At y = 0.15 m;

$$\frac{dV}{dy} = -0.05; \qquad \tau = \mu \times \frac{dV}{dy}; \ \tau = -0.835 \times 0.05 = -0.042\frac{N}{m^2}$$

(c) Derive the Bernoulli's energy equation from the Euler's motion equation, mentioning clearly the assumption made in the derivation. [06]

$$\frac{\partial p}{\rho} + g\,dz + v\,\partial V = 0$$

– Euler's Equn of motion

Assumptions:-

1. The fluid is ideal
2. The flow is steady
3. Flow is incompressible
4. Flow is irrotational.

	Integrating Euler's equation of motion $\frac{\partial p}{\rho} + g dz + v \partial v = 0.$ All terms can be present as full derivative because it involves at only variable, $\int \frac{dp}{\rho} + \int g dz + \int v dv = 0.$ $\frac{p}{\rho} + gz + \frac{v^2}{2} = a.const.$ Here $\frac{p}{\rho g}$ is called as pressure energy/unit wt of the fluid or pressure head. $\frac{v^2}{2g}$ - velocity head z - potential energy/unit weight or potential head	
4	(a) Differentiate between: (i) Absolute and gauge pressure (ii) Simple manometer and differential manometer	[04]
	(i) Absolute and gauge pressure (i) Absolute pressure:- Pressure measured with reference to absolute Vacuum pressure. (ii) Gauge pressure:- Pressure which is measured with the help of a pressure measuring instrument in which the atmospheric pressure is taken as datum. Atmospheric pressure is marked as zero. (ii) Simple and differential manometer A device that is used to measure pressure is called a manometer. Simple manometer and differential manometer are the two of them. Difference between Simple and Differential Manometer:	

1. Simple manometer has only one liquid. It never gives the negative pressure reading. Whereas, Differential manometer has two or more liquids.

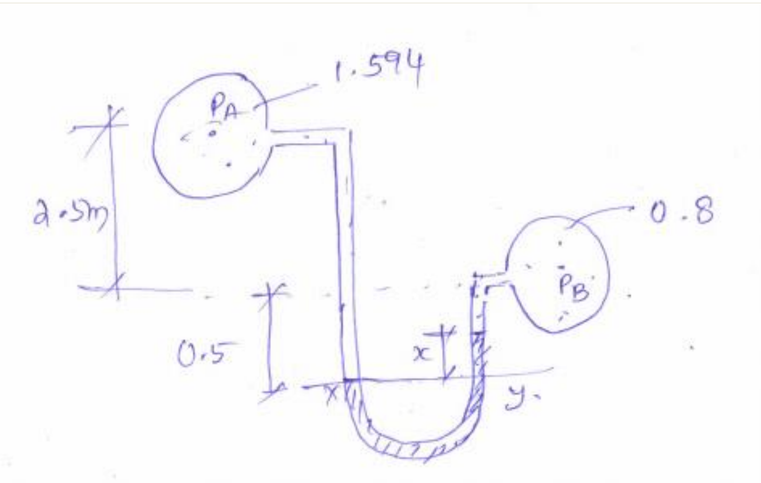
2. Simple manometer gives the direct measurement of pressure. But, Differential manometer differentiates between the pressure of two place and give the results as the measurement.

Fluids of low vapour pressure and high density (i.e mercury) requires a short tube, whether [illegible] ıld require a very long tube to measure the pressure head. So in laboratory or practical purpose in engineering, differential manometer is used in general.

(b) Water flowing through a pipe having diameter 40 cm and 20 cm at the bottom and upper end respectively. The intensity of pressure at the bottom end is 32.5 N/cm^2 and pressure at the upper end is 15.75 N/cm^2. Determine the difference in datum head if the rate of flow through the pipe is 50 l/s. [05]

	Section 1-1(bottom)	Section 2-2 (upper)
Pressure head		
Velocity	$= \dfrac{50 \times 10^{-3}}{\left(\frac{\pi}{4}\right) \times 0.4^2} = 0.397\ m/s$	$= \dfrac{50 \times 10^{-3}}{\left(\frac{\pi}{4}\right) \times 0.2^2} = 1.592\ m/s$
Velocity head, $\frac{v^2}{2g}$	8.033×10^{-3} m	0.129 m
Pressure head, $\frac{p}{\rho g}$	33.13 m	16.055 m
Difference in datum head , z2-z1	16.95 m	

(c) A U tube differential manometer connects two pipes A and B. Pipe A contains carbon tetrachloride having specific gravity 1.594 under a pressure of 117.72 kPa and pipe B contains oil of Specific gravity 0.8 under a pressure of 117.72 kPa. The pipe lies 2.5 m above pipe B. find the difference in pressure measured by mercury as fluid filling U-tube. Assume mercury in the right limb is 50 cm below the centre of pipe B. [06]



Pipe A carries a fluid of higher density. Hence, mercury in the limb connected to A, will be at a lower level than B.

$117.72 + 1.594\times1000\times9.81\times3\times10^{-3} =$

$117.72 + 0.8\times1000\times9.81\times10^{-3}\times(0.5-x) + 13.6\times10^{-3}\times1000\times9.81x$

X = 0.342 m