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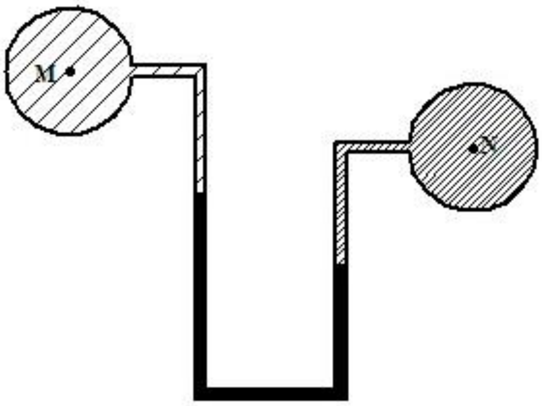
Internal Assessment Test 1 – Mar. 2019

Sub:	Fluid Mechanics					Sub Code:	17ME44	Branch:	Mechanical
Date:	06/03/2019	Duration:	90 min's	Max Marks:	50	Sem / Sec:	IV Sem/ A & B Section		OBE

Part –A: Answer any TWO FULL Questions

		MARKS	CO	RBT
1	Define the following terms: a) Mass Density b) Specific Gravity c) Absolute viscosity d) Kinematic Viscosity	[10]	CO3	L4
2	State Pascal's law and prove the same	[10]	CO3	L4
3	With a neat diagram, explain Single column vertical manometer	[10]	CO1	L1
4	With a neat diagram, explain U-tube differential manometer	[10]	CO1	L2

Part –B: Answer any THREE FULL Questions

5	A piston 100mm in diameter, 125mm in length moves in a vertical cylinder of 100.4mm diameter. The annular space between the piston and cylinder is filled with lubricating oil of dynamic viscosity of 0.08Ns/m^2. If the weight of the piston is 30N, at what velocity the piston would slide.	[10]	CO4	L3
6	The dynamic viscosity of oil, used for lubrication between a shaft and sleeve is 6 poise. The shaft diameter 0.4m and rotates at 190rpm. Calculate the power lost in the bearing for a sleeve length of 90mm. The thickness of oil film is 1.5mm.	[10]	CO4	L3
7	As shown in figure below, pipe M contains carbon tetrachloride of specific gravity 1.594 under a pressure of 1.05bar and pipe N contains oil of specific gravity 0.8. If the pressure in the pipe N is 1.75bar and the manometric fluid is mercury, find the difference x between levels of mercury. 	[10]	CO4	L3
8	A U-tube differential manometer with mercury is used to measure the pressure difference between points M and N on horizontal pipeline carrying water under pressure. If the deflection shown in the manometer is 0.6m and the level of mercury in the limb connected to M being lower, find the pressure difference between M and N	[10]	CO4	L3

Scheme Of Evaluation
Internal Assessment Test 1 – Mar.2019

Sub:	Fluid Mechanics							**Code:**	17ME44
Date:	06/03/2019	Duration:	90mins	Max Marks:	50	**Sem:**	IV	**Branch:**	ME

Part A: Answer any 2 questions

Question #		**Description**	**Marks Distribution**		**Max Marks**
1	a)	**Define the following terms: a) Mass Density b) Specific Gravity c) Absolute viscosity d) Kinematic Viscosity** • Mass Density(Definition and Units) • Specific Gravity(Definition and Units) • Absolute viscosity(Definition and Units) • Kinematic Viscosity(Definition and Units)	• 2.5M • 2.5M • 2.5M • 2.5M	10 M	10 M
2	a)	**State Pascal's law and prove the same** • Statement • Proof	• 3M • 7M	10 M	10 M
3	a)	**With a neat diagram, explain Single column vertical manometer**. • Diagram • Derivation and expression	• 3M • 7M	10 M	10 M
4	a)	**With a neat diagram, explain U-tube differential manometer.** • Diagram • Derivation and expression	• 3M • 7M	10 M	10 M
Part A: Answer any 3 questions					
5	a)	**A piston 100mm in diameter, 125mm in length moves in a vertical cylinder of 100.4mm diameter. The annular space between the piston and cylinder is filled with lubricating oil of dynamic viscosity of 0.08Ns/m2. If the weight of the piston is 30N, at what velocity the piston would slide** • Data • Steps • Answer	• 2M • 6M • 2M	10 M	10 M

<table>
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• Data
• Steps
• Answer</td><td>• 2M
• 6M
• 2M</td><td>10 M</td><td>10 M</td></tr>
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</table>

Internal Assesment Test - 1.
March 2019
Fluid Mechanics [17ME44]
Solutions

1) a) Mass Density

It is the ratio of mass of a fluid to the volume occupied by the same fluid. It is denoted by 'ρ'. The SI unit is Kg/m^3.

$$\rho = \frac{Mass}{Volume}$$

b) Specific Gravity

It is the ratio of mass density of fluid to the mass density of standard fluid.

For liquids, the standard fluid is water.

For gases, the standard fluid is air.

c) Absolute Viscosity

It is the resistance offered by one layer of fluid over to the adjacent fluid layer. It is denoted by μ. The S.I unit is $N\text{-}s/m^2$.

d) Kinematic Viscosity

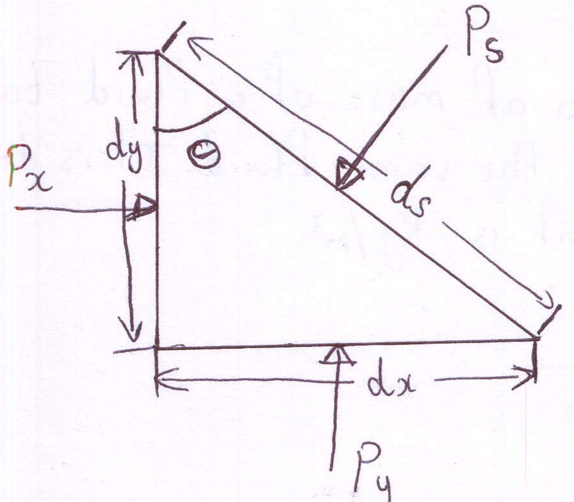
It is the ratio of absolute viscosity to mass density of a fluid. It is denoted by ν. The SI unit is m^2/s.

$$\nu = \frac{\mu}{\rho}.$$

2. Pascal's Law

It states that the pressure at a point in a fluid is same irrespective of direction.

Proof



Consider an arbitary fluid element of wedge shape in a fluid mass at rest. Let the width of the element ⊥lar to paper be unity.

The forces acting on the fluid element are:

1) Pressure forces normal to the surface:
   a) $P_x \cdot dy \cdot 1$ in x-direction
   b) $P_y \cdot dx \cdot 1$ in y-direction
   c) $P_s \cdot ds \cdot 1$ ⊥ar to the inclined plane.

2) Weight of the fluid element.

~~W = mass x Volume x g~~ =

$W = mass \times g$

$= \rho \times Volume \times g = \rho \times \frac{dx \cdot dy}{2} \times g.$

Under equilibrium, resolving forces in x-direction.

$P_x \cdot dy \cdot 1 - P_s \cdot ds \cdot 1 \cos\theta = 0$

From figure, $ds \cdot \cos\theta = dy.$

$\Rightarrow P_x \cdot dy = P_s \cdot dy$

$\Rightarrow \boxed{P_x = P_s}$

Resolving forces in y-direction,

$$P_y \cdot dx \cdot 1 - P_s \cdot ds \cdot 1 \cos(90-\theta) - \rho \cdot \frac{dx \cdot dy}{2} \cdot g = 0$$

The term $\frac{dx \cdot dy}{2}$ is a ~~sma~~ very small value, which can be neglected.

$\Rightarrow P_y \cdot dx \cdot 1 - P_s \cdot ds \cdot 1 \cdot \sin\theta = 0$

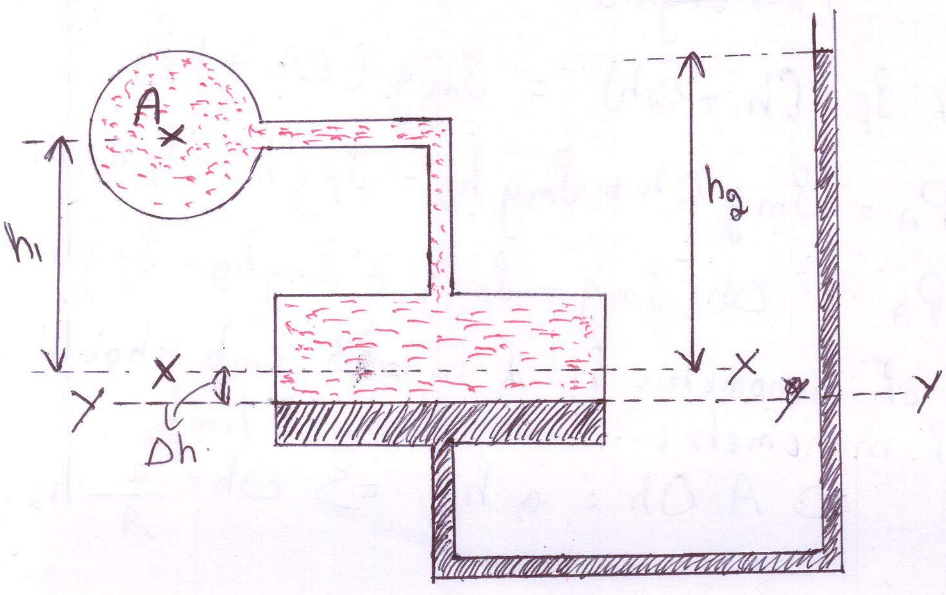
From figure, $ds \cdot \sin\theta = dx$.

$\Rightarrow \boxed{P_y = P_s}$

$\therefore \boxed{P_x = P_y = P_s}$

The above equation proves Pascal's statement.

3. <u>Single Column Vertical Manometer</u>



Let X−X be the datum line when the pipe is not connected to pipe line.

When fluid flows through the pipeline, it exerts pressure on the reservoir in the left limb and hence the manometric fluid reduces its level from X−X to Y−Y in the left limb. Also, the manometric fluid rises its level in the right limb by a higher value as shown in figure.

Let, Δh = fall of manometric fluid in reservoir.

h_1 = height of centre of pipe above X−X.

h_2 = height of manometric fluid in right limb above X−X

A = C/s area of reservoir.

a = c/s area of right limb.

ρ_f = density of fluid flowing in pipe.

ρ_m = density of manometric fluid.

According to Pascal's law,

~~$P_{X-X(\text{left})} = P_{X-X(\text{right})}$~~ $P_{Y-Y(\text{left})} = P_{Y-Y(\text{right})}$.

$$P_A + \rho_f g(h_1 + \Delta h) = \rho_m g(\Delta h + h_2).$$

$$\Rightarrow P_A = \rho_m g \Delta h + \rho_m g h_2 - \rho_f g h_1 - \rho_f g \Delta h$$

$$P_A = \Delta h[\rho_m g - \rho_f g] + \rho_m g h_2 - \rho_f g h_1 \quad \text{--- (1)}$$

Fall of manometric fluid in left limb should be equal to rise of manometric fluid in right limb.

$$\Rightarrow A\,\Delta h = a h_2 \Rightarrow \Delta h = \frac{a}{A} h_2.$$

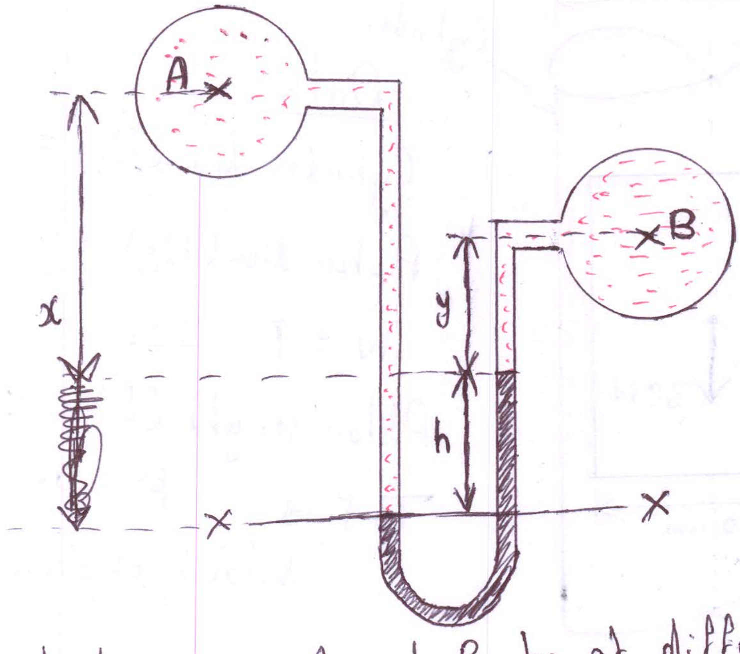
but $A >>> a$, ∴ $\frac{a}{A}$ is very close to zero and hence Δh is very close to zero.

∴ ~~the~~ Δh can be neglected.

∴ (1) ⇒ $P_A = \rho_m g h_2 - \rho_f g h_1$

From above equation, h_1 is a known value and hence by noting h_2, the pressure P_A can be calculated.

4. U-tube differential manometers



Let two pipes A and B be at different levels and contain different fluids.

h → Difference in manometric level in U-tube manometer.

ρ_1 → Density of fluid in pipe A

ρ_2 → Density of fluid in pipe B.

ρ_m → Density of manometric fluid.

According to Pascal's law,

$$P_{x-x}(\text{left}) = P_{x-x}(\text{right}).$$

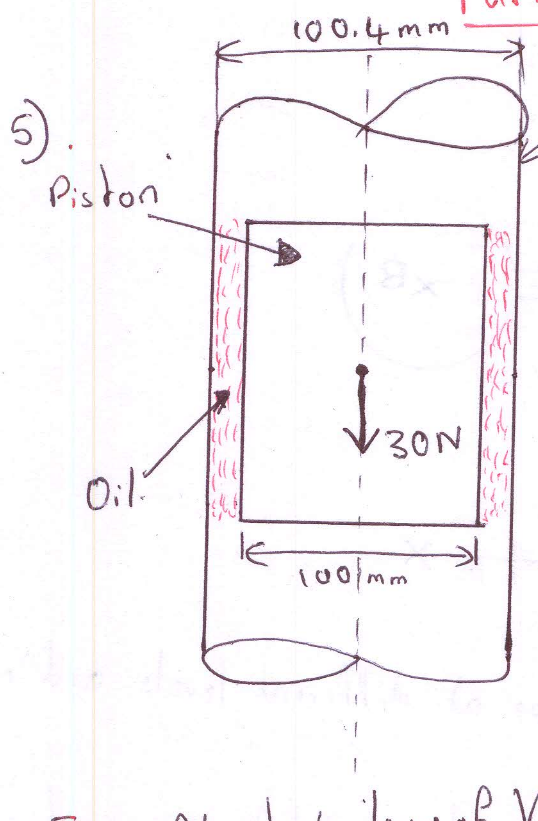
$$P_A + \rho_1 g(x+h) = P_B + \rho_2 g y + \rho_m g h$$

$$P_A - P_B = \rho_2 g y + \rho_m g h - \rho_1 g x - \rho_1 g h.$$

$$\boxed{P_A - P_B = h(\rho_m g - \rho_1 g) + \rho_2 g y - \rho_1 g x}$$

Part-B

5).



Data

Cylinder dia (D_1) = 100.4×10^{-3} m

Piston dia (D_2) = 100×10^{-3} m.

$W = F = 30N$

Piston length (L) = 125×10^{-3} m.

$\mu = 0.08\ N\text{-}s/m^2$.

To find,

Velocity of piston (u) = ?

From Newton's law of Viscosity,

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

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

$du = u - 0 = u.$

dy = thickness of oil film

$$= \frac{D_1 - D_2}{2} = \frac{(100.4 - 100) \times 10^{-3}}{2}$$

$$\boxed{dy = 2 \times 10^{-4}\ m}$$

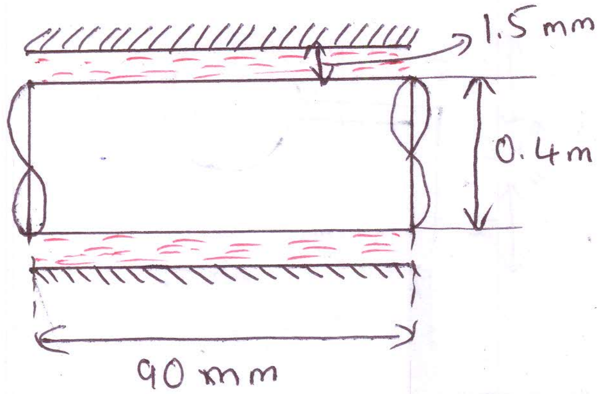
$$\tau = \frac{Force}{Area} = \frac{30}{\pi \times 100 \times 10^{-3} \times 0.125}$$

$$\tau = 763.94 \ N/m^2.$$

$$\therefore u = \frac{763.94 \times 2 \times 10^{-4}}{0.08}$$

$$\boxed{u = 1.909 \ m/s}$$

6.



Data

$\mu = 0.6 \ \frac{N\text{-}s}{m^2}$

$D = 0.4m$

$N = 190 \ rpm$

$L = 90 \times 10^{-3} \ m$

$t = 1.5 \times 10^{-3} m$

$P_L = ?$

$$P_L = \frac{2\pi N T}{60}$$

$$T = Force \times \frac{D}{2}$$

$$Force \ (F) = \tau \times A.$$

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

$du = u - 0.$

$$u = \frac{\pi D N}{60} = 3.98 \ m/s.$$

$dy = t = 1.5 \times 10^{-3} m$

$$\tau = \frac{0.6 \times 3.98}{1.5 \times 10^{-3}}$$

$$\tau = 1592 \ N/m^2.$$

$F = \tau \times \pi \times D \times L$

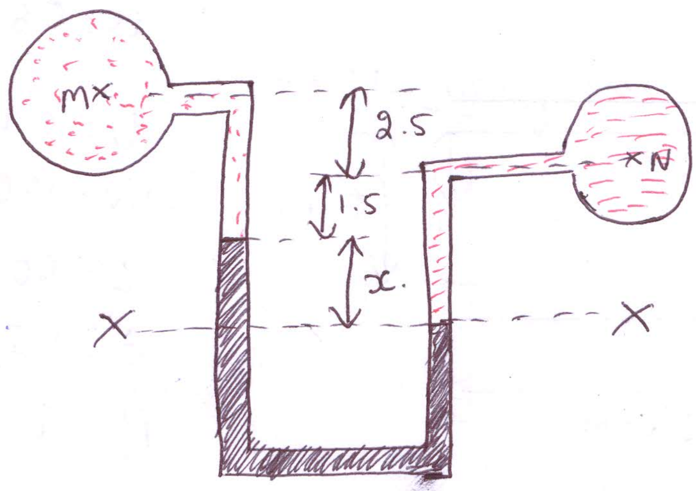
$= 1592 \times \pi \times 0.4 \times 90 \times 10^{-3}$

$F = 180.05\ N$

$T = F \times \frac{D}{2} = 180.05 \times \frac{0.4}{2} = 36.01\ N\text{-}m.$

$P_L = \frac{2\pi NT}{60} = \frac{2 \times \pi \times 190 \times 36.01}{60} = \boxed{716.48\ W}$

7)



Data

$\rho_m = 1.594 \times 1000 = 1594\ kg/m^3.$ $\rho_{Hg} = 13600\ kg/m^3.$

$\rho_N = 0.8 \times 1000 = 800\ kg/m^3.$ $x = ?$

$P_m = 1.05\ bar = 1.05 \times 10^5\ N/m^2.$

$P_N = 1.75\ bar = 1.75 \times 10^5\ N/m^2.$

According to Pascal's law,

$$P_{x-x(left)} = P_{x-x(right)}.$$

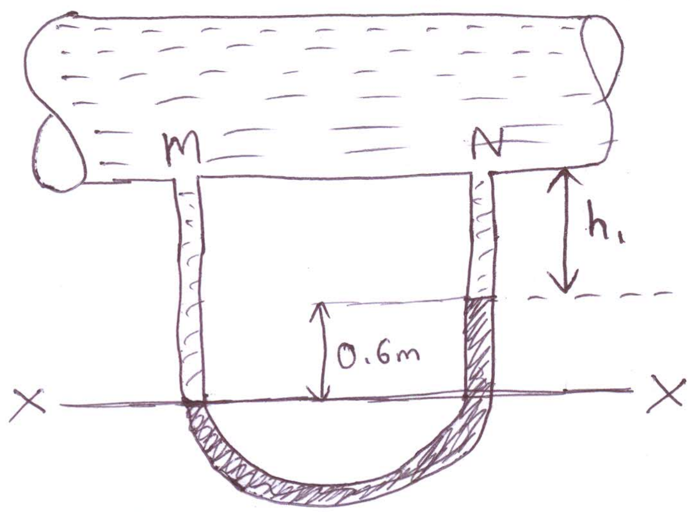
$$P_m + \rho_m g 4 + \rho_{Hg} g x = P_N + \rho_N g (1.5 + x).$$

$$(1.05 \times 10^5) + (1594 \times 9.81 \times 4) + (13600 \times 9.81 \times x)$$

$$= (1.75 \times 10^5) + 800 \times 9.81 \times (1.5 + x)$$

$$\boxed{x = 0.153\ m}$$

8)



$$P_{x-x(left)} = P_{x-x(right)}$$

$$P_m + \rho_w g (h_1 + 0.6) = P_N + \rho_w g (h_1) + \rho_{Hg} g (0.6).$$

$$P_m - P_N = \rho_w g h_1 + \rho_{Hg} g (0.6) - \rho_w g h_1 - \rho_w g 0.6$$

$$P_m - P_N = 13600 \times 9.81 \times 0.6 - 1000 \times 9.81 \times 0.6$$

$$\boxed{P_m - P_N = 74.16\ kN/m^2} = \boxed{74163.6\ N/m^2}$$