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Internal Assessment Test 1 – December 2021

Sub:	Fluid Mechanics					SubCode:	18CV33	Branch:	CV	
Date:	17.12.2021	Duration:	90 mins	Max Marks:	50	Sem/Sec:	III		OBE	

Answer all questions.
Provide neat sketches wherever necessary

		MARKS	CO	RBT
1	Define the following with formula and units: a) Specific gravity – It is the ratio of the density (mass of a unit volume) of a substance to the density of a given reference material. It has no units. $$Specific\ gravity = \frac{Density\ of\ fluid}{Density\ of\ water} = \frac{\rho_{fluid}}{\rho_{water}}$$ b) Surface tension – It is defined as the tensile force acting on. the free surface of liquid which is in contact with a gas or on the surface in. between two immiscible liquids such that the contact surface behaves like a. thin membrane under tension. The unit is N/m. $$\sigma = \frac{Force}{Unit\ length\ of\ free\ surface} = \frac{Surface\ Energy}{Surface\ Area}$$ c) Viscosity - It is defined as the property of a liquid which offers resistance to the movement of one layer of liquid over another adjacent layer of liquid. The viscosity of a liquid is due to cohesion and interaction between particles. The unit is Ns/m^2. $$\tau = \mu\frac{du}{dy}$$ d) Absolute pressure - It is the pressure of having no matter inside a space, or a perfect vacuum. Measurements taken in absolute pressure use this absolute zero as their reference point. The best example of an absolute referenced pressure is the measurement of barometric pressure. The unit is Pa, N/m^2. e) Capillarity – It is the tendency of a liquid in a capillary tube or absorbent material to rise or fall as a result of surface tension. Capillary action is the process of a liquid flowing in a narrow space without the assistance of, or even in opposition to, any external forces like gravity. The unit is m. $$h = \frac{4\sigma\cos\theta}{\rho g d}$$	[10]	CO1	L1
2	Define total pressure and centre of pressure. Derive the expression for total pressure and centre of pressure for inclined plane surface. Total Pressure - The total pressure is defined as the force exerted by a static fluid on a surface that is in contact with the fluid. The total pressure, the resultant hydrostatic force, always acts normal to the surface.	[10]	CO2	L3

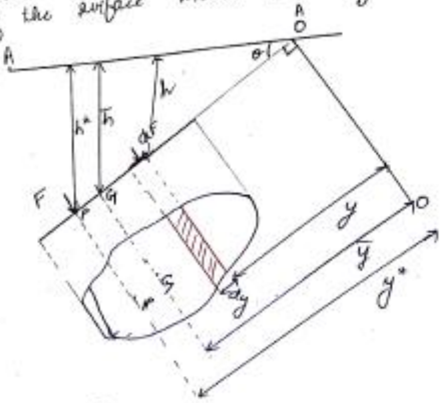
2) Centre of Pressure (C.P), h^*

It is calculated by 'Principle of Moments' which states that the ~~moment of~~ sum of moments of all the components about an axis is equal to the moment due to the resultant force about the same axis.

Inclined Surface Immersed in Liquid

Definition - 2

Consider a plane surface of arbitrary shape immersed in a liquid in such a way that the plane of the surface makes an angle θ with



the free surface (AA) of the liquid as shown in figure - 2.

Let

$A \rightarrow$ Total area of surface.

$\bar{h} \rightarrow$ depth of C.G (G) from free surface.

$h^* \rightarrow$ depth of centre of pressure from free surface

Let the plane of surface if produced meet the free liquid at O. Then O-O is the axis $\perp^r$ to the plane of surface.

$\bar{y}$ - distance of C.G from O-O-axis

$y^* \rightarrow$ distance of C.P from O-O axis.

From figure

$$\sin\theta = \frac{\bar{h}}{\bar{y}} = \frac{h^*}{y^*} = \frac{h}{y} \quad — (1)$$

1) Total Pressure, F

Consider a small strip of area dA at a distance of h from free surface and y from 0-0 axis

Pressure on the strip, $p = \rho g h$

Pressure force, dF on the strip

$$dF = \rho g h\, dA \quad \cancel{(2)} \quad [h \text{ and } dA \text{ are not } \perp^{r}]$$

sub $h = y \sin\theta$

$$dF = \rho g\, y\, dA \sin\theta \quad -(2)$$

$$F = \int dF = \rho g \sin\theta \int y\, dA \rightarrow 1^{st} \text{ Moment of area} = \int y\, dA = A\bar{y}$$

$$= \rho g \sin\theta\, A\bar{y}$$

$$= \rho g A\bar{h} \; (3) \; [\bar{y}\sin\theta = \bar{h}] \quad — 3$$

2) Centre of pressure, h^*

a) Sum of moments

Moment of force dF about 0-0 axis

$$dM = dF \times y$$

sub dF from (2)

$$dM = \rho g y \, dA \sin\theta \cdot y$$

$$dM = \rho g y^2 \sin\theta \, dA$$

$$M_1 = \int dM = \rho g \sin\theta \int y^2 dA \qquad \left[2^{nd} \text{ Moment of area } \int y^2 dA = I_0 \right.$$

$$= \rho g \sin\theta \, I_0 \quad \text{— (4)}$$

where I_0 is the M.I about O-O axis

(b) Moment of Resultant Force

$$M_2 = F \times y^* \quad \text{— (5)}$$

Equating (4) & (5)

$$\rho g \sin\theta \, I_0 = F \times y^*$$

$$\cancel{\rho g} \sin\theta \, I_0 = \cancel{\rho g} A\bar{h} \times y^*$$

sub $y^* = \dfrac{h^*}{\sin\theta}$

$$\sin\theta \cdot I_0 = A\bar{h} \cdot \frac{h^*}{\sin\theta}$$

$$\frac{I_0 \sin^2\theta}{A\bar{h}} = h^* \qquad I_0 = I_G + Ay^2 = I_G + \frac{A\bar{h}^2}{\sin^2\theta}$$

$$h^* = \left[I_G + \frac{A\bar{h}^2}{\sin^2\theta} \right] \frac{\sin^2\theta}{A\bar{h}}$$

$$h^* = \frac{I_G \sin^2\theta}{A\bar{h}} + \bar{h} \quad \text{— 3.}$$

$$h^* = \bar{h} + \frac{I_G \sin^2\theta}{A\bar{h}}$$

3	One liter of crude oil weighs 9.6N. Calculate its density and specific gravity(2). b) Calculate the dynamic viscosity of oil which is used for lubrication between a square plate 0.8m x 0.8m size and inclined plane of angle 30° with a uniform velocity of 0.3m/s. The thickness of oil film is 1.5mm and the weight of block is 300N.(8).	[10]	CO1	L3

Volume = 1L = $10^{-3} m^3$

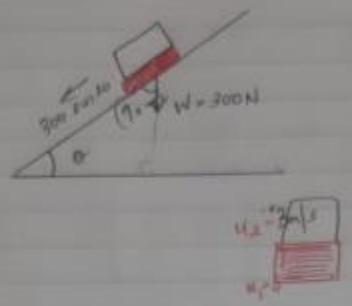
weight, W = 9.6 N

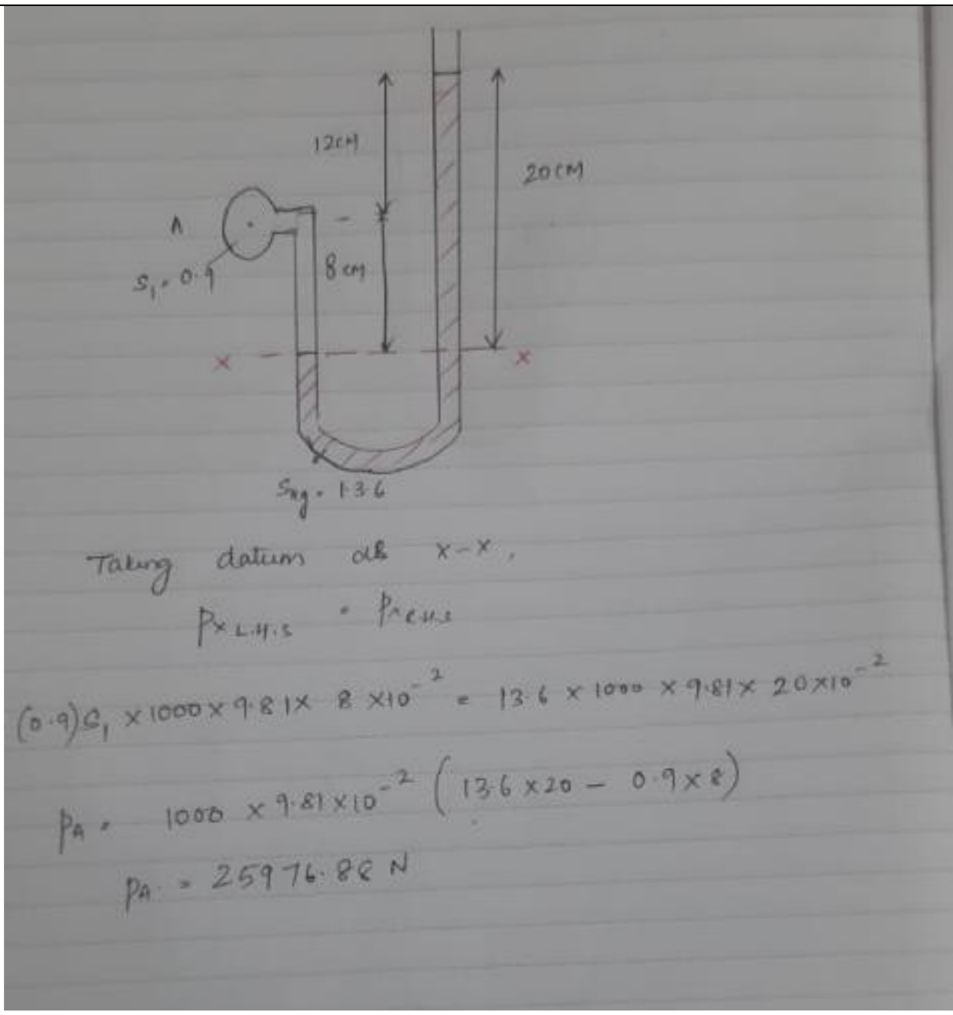
$$\text{Density}, \rho = \frac{\text{Mass}}{\text{Vol}} = \frac{9.6}{9.81 \times 10^{-3}} = 978.59 \text{ kg/m}^3$$

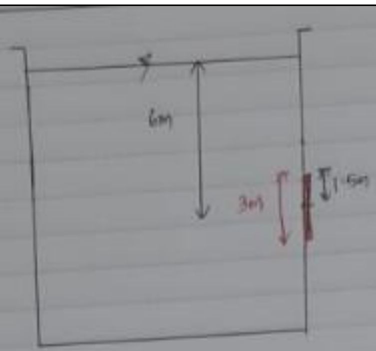
$$\left(\text{Mass} = \frac{Wt}{g} = \frac{Wt}{9.81} \right)$$

$$\text{Sp gravity} = \frac{\text{Density of crude oil}}{\text{Density of water}}$$

$$= \frac{978.59}{1000} = 0.978$$

	 $\tau = \mu \frac{du}{dy}$ $\theta = 30^\circ$ $\quad A = 0.8 \times 0.8 m^2$ $W = 200 N$ $\quad u_2 = 0.3 m/s$ $du = u_2 - u_1 = 0.3 - 0 = 0.3$ $t = dy = 1.5 mm = 1.5 \times 10^{-3} m$ $\tau = \frac{F}{A} = \frac{200 \times \sin 30}{0.8 \times 0.8} = \mu \times \frac{0.3}{1.5 \times 10^{-3}}$ $\mu = \frac{200 \times \sin 30}{0.8 \times 0.8} \times \frac{1.5 \times 10^{-3}}{0.3}$ $\mu = 1.1718 Ns/m^2$			
4	State Pascal's law and hydrostatic law. The right limb of a simple U tube manometer containing mercury is open to atmosphere while the left limb is connected to a pipe in which a fluid of specific gravity 0.9 is flowing. The centre of pipe is 12cm below the level of mercury in the right limb. Find the pressure of fluid in the pipe if the difference of mercury level in the two limbs is 20cm. Pascal's law – It is a principle in fluid mechanics that states that a pressure change at any point in a confined incompressible fluid is transmitted throughout the fluid such that the same change occurs everywhere. The pressure is same in all directions. Hydrostatic Law - It states that the rate of increase of pressure in a vertically downward direction must be equal to the specific weight of the fluid at that point.	[10]	CO2	L3

				
5	State Varignon's theorem. A circular opening 3m diameter in a vertical side of a tank is closed by a disc of 3m diameter which can rotate about a horizontal diameter. Calculate i) the force on the disc, ii) the torque required to maintain the disc in equilibrium in the vertical position when the head of water above the horizontal diameter is 6m. Varignon's Theorem: Moment of a force about any point is equal to the sum of the moments of the components of that force about the same point.	[10]	CO2	L4



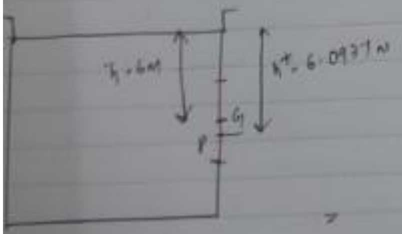
diameter, $d = 3m$

$$F = \rho g A\bar{h} = 1000 \times 9.81 \times 6 \times \frac{\pi}{4} \times 3^2$$

$$= 416224.28\,N$$

Centre of pressure, $h^* = \frac{I_G}{A\bar{h}} + \bar{h}$ $\qquad I_G = \frac{\pi}{64} d^4$

$$h^* = \frac{\frac{\pi d^4}{64}}{\frac{\pi}{4} \times d^2 \times \bar{h}} + \bar{h} = \frac{3 \times 3}{16 \times 6} + 6 = 6.0937m$$



Torque, $T = F \times (h^* - \bar{h})$

$$= 416224.28 \times (6.0937 - 6)$$

$$= 39021.02\,Nm$$