Vellore – 632014, Tamil Nadu, India

SCHOOL OF MECHANICAL ENGINEERING

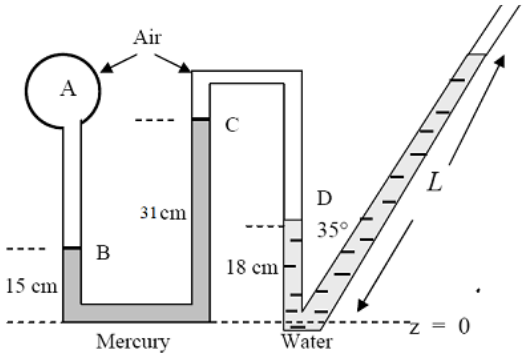
WINTER SEMESTER 2023-2024

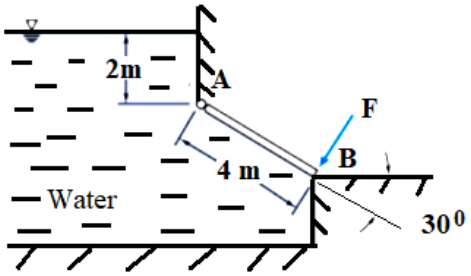
CONTINUOUS ASSESSMENT TEST – I

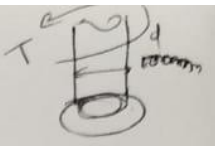
Programme Name & Branch : B.Tech- Automotive, Mechanical, Manufacturing Engineering
Course Code and Name : BMEE204L and Fluid Mechanics and Machines
Slot : E2+TE2
Class Number(s) : VL2023240504623, VL2023240504557, VL2023240504624, VL2023240504564
Faculty Members : Dr. Rajesh Kanna, Dr. Sreethul Das, Dr. Mohamed Ibrahim M, Dr. Sreeja Sadasivan
Date and Time of Exam : 15-02-2024, 2.00 PM-3.30 PM
Duration : 90 minutes Max. Marks: 5 x 10 M=50M

General instruction(s): **1.** ***Assume suitable data, if required,***

Answer ALL the Questions

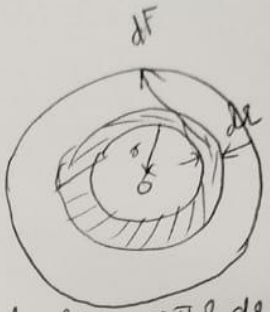
Q. No	Question	Marks	Course Outcome (CO)	Bloom's Taxonomy (BL)
1.	The shaft rests on a 2.5-mm-thin film of oil having a viscosity of 0.068 N s / m^2. If the shaft is rotating at a constant angular velocity of ω = 2.2 rad/s, determine the torque **T** that must be applied to the shaft to maintain the motion at i) r = 80 mm and *ii)* r = 40 mm. Assume the velocity profile within the oil is linear.	10	1	3
2.	The system in Fig. 1 is open to 1 atm on the right side. (a) If L = 118 cm, what is the air pressure in container A? (b) Conversely, if P = 128 kPa, what is the length L?  Fig.1	10	1	3
3.	When a hydrometer having a stem diameter of 7.62 mm is placed in water, the stem protrudes 80 mm above the water surface. If the water is replaced with a liquid having a specific gravity of 1.1, how much of the stem would protrude above the liquid surface? The hydrometer weighs 0.187 N.	10	1	4

4.	The gate AB shown is hinged at A. The gate is 4.2 m wide normal to the plane of the diagram. Calculate the force required at B to hold the gate closed.  Fig. 2	10	1	4
5.	A steady, incompressible, two-dimensional velocity field is given by the following components in the *xy*-plane: $u = 1.1 + 2.8x + 0.65y$; $v = 0.98-2.1x-2.8y$ Calculate the acceleration field (a_x and a_y) and calculate the acceleration at the point (x, y) = (-2, 3).	10	2	3



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

$u = \omega r$



The shear force that oil exerts on the differential area $2\pi r\, dr = dA$

$$dF = \tau \times dA = \mu \frac{du}{dy} \times 2\pi r\, dr$$

Since the velocity distribution is linear, velocity gradient is constant $\frac{du}{dy} = \frac{u}{t}$

$$\int dT = \mu \times \frac{u}{t} \times 2\pi \int r^2 dy$$

Put $u = r\omega$

$$T = \frac{\mu \omega}{t} 2\pi \int_0^R r^3 dy = \frac{2\pi \mu \omega R^4}{t\ 4}$$

$$T = \frac{\pi \mu \omega R^4}{2t}$$

at $r = 80mm$

$$T_1 = \frac{\pi \times 0.068 \times 2.2 \times (0.08)^4}{2 \times 2.5 \times 10^{-3}} = 3.85 \times 10^{-3}\ Nm$$

at $r = 40mm$

$$T_2 = 2.406 \times 10^{-4}\ Nm$$

2) $P_A + \rho_{Hg} g (0.31 - 0.15) - \rho_w g (L \sin 55 - 0.18) = P_{atm}$

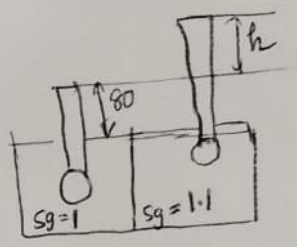
$P_A - 136 \times 9810 \times 0.16 - 9810 (L \sin 55 - 0.18) = 101325$

$P_A - 8035.8L = 120,90576$

If $L = 118$ cm $\quad P_A = 130.38$ kPa

If $P_A = 128$ kPa $\quad L = 0.882$ m

3) when hydrometer is placed in liquid of sg 1.1



$W = F_B$

$0.187 N = (\rho g)_{liquid} \times \forall_1$

$0.187 = 1.1 \times 9810 \times \forall_1$

$\forall_1 = 1.7329 \times 10^{-5}$

when the hydrometer is placed water

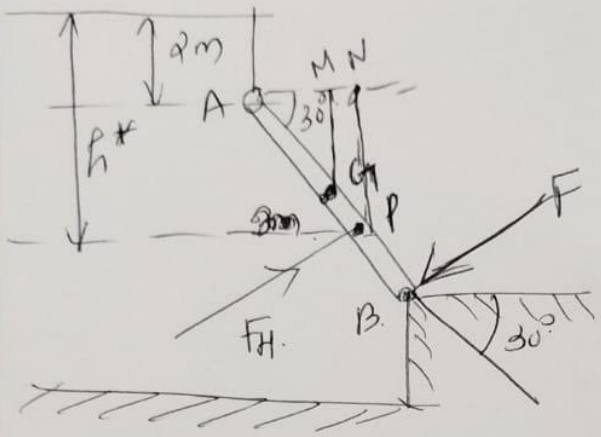
$0.187 = (\rho g)_{water} \left[\forall_1 + \frac{\pi}{4} d^2 h \right]$

$h = 38$ mm

The stem would protrude above $38 mm + 80 mm = 118 mm$ above the liquid surface.

5) $a_x = -9.233$ m/sec^2

$a_y = 14.371$ m/sec^2



$\Rightarrow F_h = \rho g A \bar{h}$

$F_h = 9810 \times (4 \times 4.2) \times 3$

$F_h = 494.424\ kN$

$\Rightarrow h^* = \bar{h} + \frac{I_{GG}}{A\bar{h}} \sin^2\theta$

$h^* = 3 + \frac{22.4}{(4 \times 4.2) \times 3} \sin^2 30$

$h^* = 3.11m$

$\Rightarrow \Sigma M_A = 0$

$F_h \times AP = F \times BA$

$494.24 \times 10^3 \times 2.22 = F \times 4$

$F = 274.303\ kN$

Δ AMG

$\sin 30 = \frac{MG}{AG}$

$AG = 2m$

$MG = 1m$

$h' = MG + 2m = 3m$

$I_{GG} = \frac{4.2 \times 4^3}{12} = 22.4m^4$

Δ APN

$NP = h^* - 2 = 1.11m$

$\sin 30 = \frac{NP}{AP} = \frac{1.11}{AP}$

$AP = 2.22m$