SLOT: E1+TE1

VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF MECHANICAL ENGINEERING

CONTINUOUS ASSESSMENT TEST – I

WINTER SEMESTER 2023-2024

Programme Name & Branch: BMA, BME, BMM

Course Code: BMEE204L

Course Name: Fluid Mechanics and Machines

Faculty Name(s): Dr. Thundil Karuppa Raj R; Dr. Rajesh Kanna P ; Dr. Edison gundabattini; Dr. Mohamed Ibrahim M; Dr. Aruna Kumar Behura; Dr. Sreeja Sadasivam, Dr. Sreethul Das; Dr. Abinash Mohanta; Dr. Deepakkumar R

Emp.ID(s):

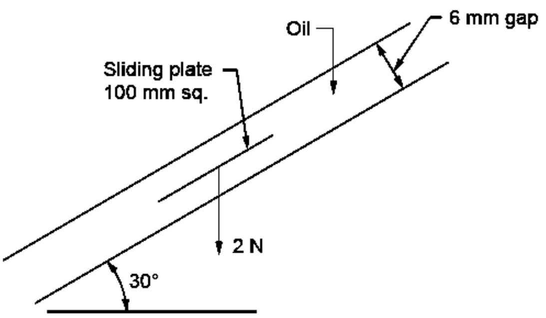
Contact Number(s):

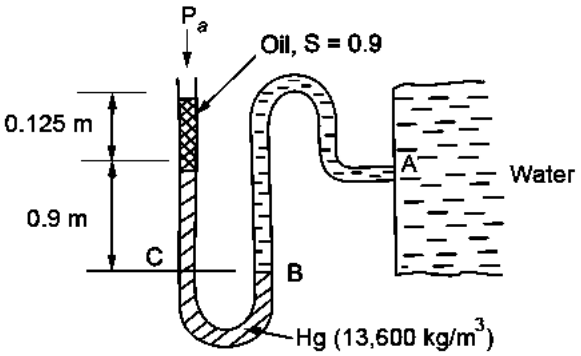
Email(s):

Class Number(s):

Exam Duration: 90 minutes **Maximum Marks: 50**

General instruction(s):

Q.No	Question
1.	The space between two large inclined parallel planes is 6mm and is filled with a fluid as shown in Fig.1. The planes are inclined at 30° to the horizontal. A small thin square plate of 100 mm side slides freely down parallel and midway between the inclined planes with a constant velocity of 3 m/s due to its weight of 2N. Determine the viscosity of the fluid.  **Fig. 1.** Sol: The vertical force of 2 N due to the weight of the plate can be resolved along and perpendicular to the inclined plane. The force along the inclined plane is equal to the drag force on both sides of the plane due to the viscosity of the oil.

	Force due to the weight of the sliding plane along the direction of motion = 2 sin 30 = 1N Viscous force, F = (A × 2) × μ × (du/dy) (both sides of plate). Substituting the values, 1 = μ × [(0.1 × 0.1 × 2)] × [(3 – 0)/6/ (2 × 1000)}] Solving for viscosity, μ = 0.05 Ns/m2 or 0.5 Poise.
2.	A manometer is fitted as shown in Fig. 2. Determine the pressure at point A.  **Fig. 2.** Sol: With respect to datum at B, pressure at left hand side = pressure at right hand side $P_C = P_B$ Consider the left limb $P_C = P_a + 0.125 \times 900 \times 9.81 + 0.9 \times 13600 \times 9.81$ $= P_a + 121178$ N/m^2 Consider the right limb P_A $= P_B - 0.9 \times 1000 \times 9.81$ $= P_a + 121178 - 0.9 \times 1000 \times 9.81$ $= P_a + 112349$ N/m^2 Expressed as gauge pressure $P_A = 112349$ N/m^2 = 112.35 kPa gauge
3.	A 100 kN pontoon of 4 m × 6 m × 0.8 m is to be used to transport a 200 kN cylindrical drum of 2 m in diameter through a river as shown in Fig.3. Check (1) whether the arrangement would be feasible (2) the stability.

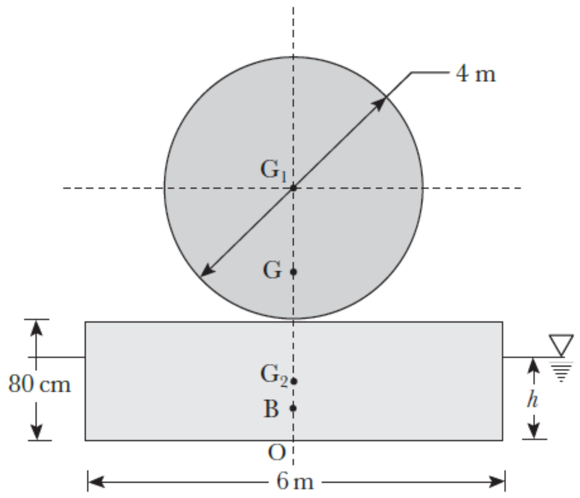


Fig. 3.

Sol:

Solution: From Archimedes' principle, the weight of liquid displaced is equal to the total weight,

$$1000 \times 9.81 \times (4 \times 6 \times h) = 300 \times 10^3$$

$$\Rightarrow \quad h = 1.27 \text{ m}$$

The pontoon will be fully submerged. Hence, the given pontoon will not be feasible for transporting the given drum. To check further, the metacentric height is calculated to find out its stability.

The position of CG is determined in the following way:

$$W_{\text{total}} \times OG = W_{\text{pontoon}} \times OG_2 + W_{\text{drum}} \times OG_1$$

$$\Rightarrow \quad OG = \frac{100 \times 0.4 + 200 \times (0.8 + 1)}{300} = 1.33 \text{m}$$

The metacentric height can be determined as

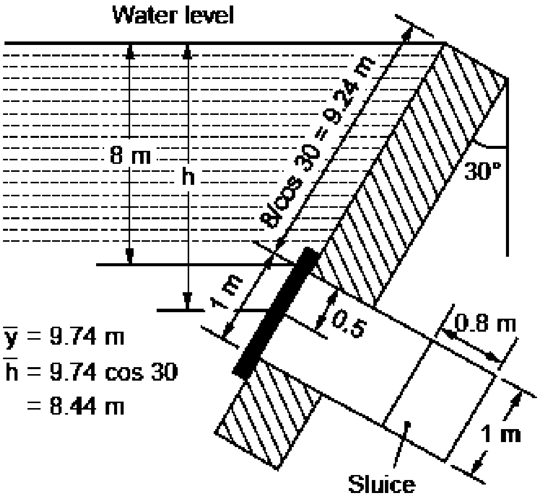
$$\text{MG} = \frac{I}{\forall} - BG \quad \Rightarrow \quad \text{MG} = \frac{6 \times 4^3}{6 \times 4 \times 0.637} - \left(1.33 - \frac{1.27}{2}\right)$$

$$\Rightarrow \quad \text{MG} = 24.42 \text{ m}$$

Since MG is positive, the arrangement is stable but not feasible as the river water reaches the drum.

4. The wall of a reservoir is inclined at 30° to the vertical. A sluice 1m long along the slope and 0.8 m wide is closed by a plate. The top of the opening is 8 m below the water level. Determine the location of the centre of pressure and the total force on the plate.

Sol:

	The angle with the horizontal is 60°. The depth of centre of gravity, $\bar{h}$ = 8 + (0.5 × sin 60) / 2 = 8.433 m **Total force** = $\gamma \bar{h} A$ = 1000 × 9.81 × 8.433 × 1 × 0.8 = **66182 N** $h_{cp} = (I_G \sin^2 \theta / \bar{h} A) + \bar{h}$, I_G = (1/12) bd^3 [(1/12) 0.8 × 1^3 × $\sin^2$ 60/8.433 × 0.8] + 8.433 = **8.44 m** Distance along the wall surface, 8.44/ cos 30 = 9.746 m 
5.	*Check whether the following velocity relations satisfy the requirements for steady irrotational flow.* (*i*) $u = x + y$, $v = x - y$ (*ii*) $u = xt^2 + 2y$, $v = x^2 - y\, t^2$ (*iii*) $u = xt^2$, $v = xyt + y^2$ Sol:

	To check for steady flow use continuity equation: (i) $\frac{\partial u}{\partial x} = 1, \frac{\partial v}{\partial y} = -1$ $\therefore$ $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$ So the flow is steady (ii) $\frac{\partial u}{\partial x} = t^2, \frac{\partial v}{\partial y} = -t^2$ $\therefore$ satisfies the continuity equation and flow is steady (iii) $\frac{\partial u}{\partial x} = t^2, \frac{\partial v}{\partial y} = xt + 2y$ This does not satisfy the requirements for steady flow To Check for irrotational flow: $\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x} = 0$ (i) $\frac{\partial u}{\partial y} = 1, \frac{\partial v}{\partial x} = 1$ $\therefore$ flow is irrotational (ii) $\frac{\partial u}{\partial y} = 2, \frac{\partial v}{\partial x} = 2x$ $\therefore$ flow is not irrotational (iii) $\frac{\partial u}{\partial y} = 0, \frac{\partial v}{\partial x} = yt$ $\therefore$ flow is not irrotational