U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

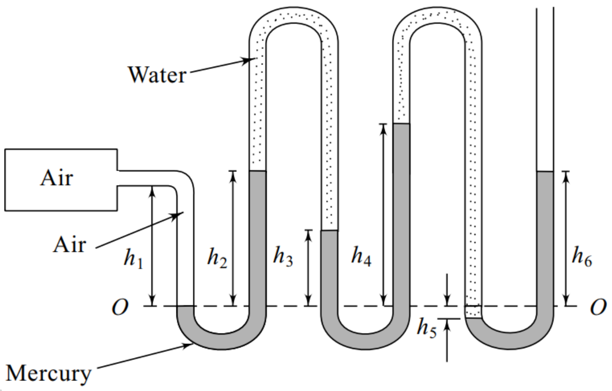
February 2025 Semester End Main Examinations

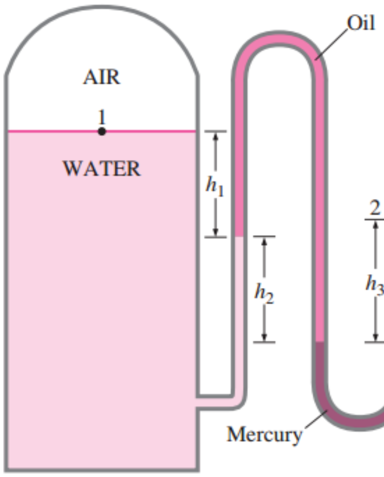
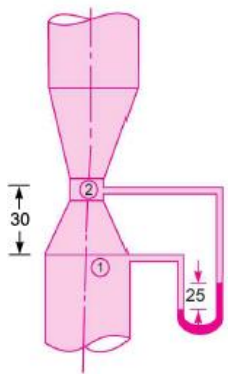
Programme: B.E.
Branch: Mechanical Engineering
Course Code: 23ME4PCFME / 22ME4PCFME
Course: Fluid Mechanics

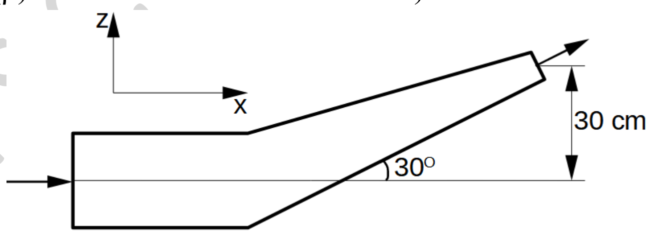
Semester: IV
Duration: 3 hrs.
Max Marks: 100

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	***CO***	***PO***	**Marks**
1	a)	State and prove hydrostatic law.	*CO1*	*PO 1*	**06**
	b)	A multitube manometer using water and mercury is used to measure the pressure of air in a vessel, as shown in **Fig. Q1b**. For the given values of heights, calculate the gauge pressure in the vessel. h1 = 0.4m, h2 = 0.5m, h3= 0.3m, h4 = 0.7m, h5 = 0.1m and h6 = 0.5m.  **Fig.Q1b**	*CO1*	*PO2*	**06**
	c)	A thin plate of area A is placed midway in a gap of height ***h*** filled with a liquid of dynamic viscosity μ_1. The plate requires a force ***F*** to move with a constant uniform velocity ***V***. The same gap is subsequently filled with another liquid of viscosity μ_2. And the same plate is positioned at a distance ***h/4*** from one wall. Experiments indicated that for the velocity **V**, the drag force required was same. Find μ_1 in terms of μ_2.	*CO1*	*PO2*	**08**
		OR			
2	a)	Derive an expression to determine the metacentric height?	*CO1*	*PO2*	**10**

	b)	The water in a tank is pressurized by air, and the pressure is measured by a multi-fluid manometer as shown in **Fig.Q2b** the tank is located on a mountain at an altitude of 1400 m where the atmospheric pressure is 85.6 kpa. Determine the air pressure in the tank if h_1= 0.1 m, h_2 = 0.2 m, and h_3 =0.35 m. take the densities of water, oil, and mercury to be 1000 kg/m³, 850 kg/m³, and 13,600kg/m³ respectively.  **Fig.Q2b**			**10**
		UNIT - II			
3	a)	Derive an expression of conservation of mass in cartesian coordinates for a steady, incompressible three-dimensional fluid flow and state the assumption made in it.	*CO2*	*PO1*	**10**
	b)	For a two-dimensional flow, the velocity function is given by the expression $\boldsymbol{\varphi = x^2 - y^2}$. (i) find the velocity components in **x** and **y** direction, (ii) show that $\boldsymbol{\varphi}$ represents possible case of flow and (iii) find stream function and flow rate at (2, 0) and (2,2),	*CO2*	*PO2*	**06**
	c)	Define stream function and velocity potential with appropriate realtion.	*CO2*	*PO1*	**04**
		OR			
4	a)	Derive an expression for discharge through Orifice Meter	*CO2*	*PO1*	**10**
	b)	A 30 cm × 15 cm venturimenter is provided in a vertical pipe line carrying oil of specific gravity 0.9, the flow being upwards. The difference in elevation of the throat section and entrance section of the venturimeter is 30 cm. The difference U-tube mercury manometer shows a gauge deflection of 25 cm. Calculate the discharge of oil.  **Fig.Q4b**	*CO2*	*PO1*	**06**
	c)	Define the following (i) stream lines (ii) streak lines (iii) path lines(iv) time line	*CO2*	*PO2*	**04**

			UNIT - III			
	5	a)	Derive the Reynolds transport theorem for one-dimensional flow through a fixed control volume such as variable area duct section with one inlet and one outlet having uniform properties.	*CO2*	*PO1* *PO2*	**10**
		b)	A laminar flow of fluid (μ = 0.7 Ns/m^2, specific gravity = 0.65) is taking place in a pipe of diameter ***D***. The maximum velocity occurs at a distance of 120 mm from the pipe wall. Find (i) pressure gradient, if the maximum shear stress at the wall is 196.2 N/m^2, (ii) the mean velocity and the radius at which this occurs, (iii) the velocity at 12 cm from the wall of the pipe and (iv) Reynolds number of the flow.	*CO2*	*PO2*	**10**
			OR			
	6	a)	Derive an expression for velocity profile and shear stress distribution in a Couette flow.	*CO2*	*PO1* *PO2*	**10**
		b)	A reducing elbow (as shown **Fig. Q4b)** is used to deflect water flow at a rate of 14 kg/s in a horizontal pipe upward 30° while accelerating it. The elbow discharges water into the atmosphere. The cross-sectional area of the elbow is 113 cm^2 at the inlet and 7 cm^2 at the outlet. The elevation difference between the centers of the outlet and the inlet is 30 cm. The weight of the elbow and water in it is considered to be negligible. Determine (a) the gage pressure at the center of the inlet of the elbow and (b) the horizontal and vertical components of the force needed to hold the elbow in place. (Assume the pressure at the outlet is zero (gage pressure) as the water is discharge to atmosphere and take density of the water as 1000 kg/m^3, momentum flux correction factor (β) = 1.03 at both inlet and outlet).  **Fig.Q4b**	*CO2*	*PO2*	**10**
			UNIT - IV			
	7	a)	Draw the schematic showing development of the boundary layer for flow over a flat plate and the different flow regimes.	*CO3*	*PO1*	**04**
		b)	A small, axisymmetric, low-speed wind tunnel is built to calibrate hot wires. As the boundary layer grows along the wall of the wind tunnel test section, air in the region of irrotational flow in the central portion of the test section accelerates in order to satisfy conservation of mass. To eliminate this acceleration, the engineers can diverge the test section walls. Assume laminar	*CO3*	*PO2*	**06**

			flow, the wind tunnel diverges linearly, the diameter of the test section inlet is 15 cm, and its length is 25.4 cm. The air is at 21°C and enters the wind tunnel at a uniform air speed of 1.5 m/s at the test section inlet. What is the Reynolds number of the flow, displacement thickness and diameter at the test section outlet? (Take kinematic viscosity of air at 21 °C as 1.516×10^{-5} m^2/s).			
		c)	Write the boundary layer equations in non-dimensional form. Also, obtain simplified Navier-Stokes equation from the order of magnitude analysis.	*CO3*	*PO1* *PO2*	**10**
			OR			
	8	a)	With respect to flow over thin flat plate, define boundary layer and list its characteristics.	*CO3*	*PO1*	**04**
		b)	Water flows over a flat plate at a free stream velocity of 0.15 m/s. There is no pressure gradient and laminar boundary layer is 6 mm thick. Assume a sinusoidal velocity profile ($\mu = 1.02 \times 10^{-3}$ kg/ms, $\rho = 1000$ kg/m^3) $$\frac{u}{U_\infty} = \sin\frac{\pi}{2}\left(\frac{y}{\delta}\right)$$ For the flow conditions stated above, calculate the local wall shear stress and skin friction coefficient.	*CO3*	*PO2*	**06**
		c)	Obtain the momentum-integral equations for a boundary layer over a flat plate.	*CO3*	*PO1* *PO2*	**10**
			UNIT - V			
	9	a)	Define and give the physical significance of; (i) Reynolds number, (ii) Froude's number, (iii) Weber number, and (iv) Mach number.	*CO4*	*PO1*	**08**
		b)	State Buckingham's π theorem and explain the procedure for solving the problem by using this method and also Obtain an expression for torque, **T** using the above method. Where, Torque developed by a disc of diameter **D**, rotating at a speed **N,** is dependent on fluid viscosity **μ** and fluid density **ρ**. (use D, N and ρ as repeating variables**)**	*CO4*	*PO1* *PO2*	**12**
			OR			
	10	a)	At a sudden contraction in a pipe the diameter changes from D_1 to D_2. The pressure drop, Δp, which develops across the contraction is a function of D_1 and D_2, as well as the velocity, V, in the larger pipe, and the fluid density, ρ, and viscosity, μ. Use D_1, V and μ as repeating variables to determine a suitable set of dimensionless parameters.	*CO4*	*PO1*	**10**
		b)	Derive on the basis of dimensional analysis suitable parameters to present the thrust developed by a propeller. Assume that thrust P depends upon angular velocity ω, speed of advance V, diameter D, dynamic viscosity μ, mass density ρ, elasticity of fluid medium which can be denoted by the speed of sound in the medium C. Take D, V and ρ as repeating variables	*CO4*	*PO1*	**10**

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