*Total number of printed pages:* **4** **UG / Fourth Semester / UFET403**

**2023**

# FLUID MECHANICS

*Full Marks: 100*

Time: Three hours

***The figures in the margin indicate full marks for the questions.***

*Answer **any five** questions.*



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| 1. | a) | Define viscosity and State Newton's Law of viscosity. | 3 |
| | b) | What are the different types of fluid based on viscosity? | 5 |
| | c) | If the velocity distribution over a plate is given by<br>$u = \frac{2}{3}y - y^2$<br>In which 'u' is the velocity in metre per second at a distance 'y' metre above the plate, determine the shear stress at y = 0 and y = 0.15 m. Take dynamic viscosity of fluid as 8.63 poises. | 6 |
| | d) | The space between two square flat parallel plates is filled with oil. Each side of the plate is 60 cm. The thickness of the oil film is 12.5 mm. The upper plate which moves at 2.5 metre per second requires a force of 98.1 N to maintain the speed. Determine:<br>(i) the dynamic viscosity of the oil in poise, and<br>(ii) the kinematic viscosity of the oil in stokes if the specific gravity of the oil is 0.95 | 6 |
| 2. | a) | Define surface tension? The surface tension of water in contact with air at 20°C is 0.0725 N/m. The pressure inside a droplet of water is to be 0.02 N/m² greater than the outside pressure. Calculate the diameter of the droplet of water. | 6 |
| | b) | State and prove Pascal's law | 8 |
| | c) | The pressure intensity at a point in a fluid is given 3.924 N/cm². Find the corresponding height of fluid when the fluid is : (a) water, and (b) oil of Sp. Gravity 0.9 . | 6 |

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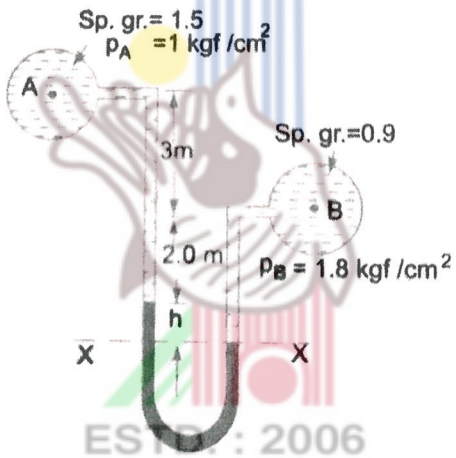
| 3. | a) | Define Gauge pressure, Vacuum pressure and Absolute pressure. | 5 |
| | b) | A U-Tube manometer is used to measure the pressure of water in a pipe line, which is in excess of atmospheric pressure. The right limb of the manometer contains mercury and is open to the atmosphere. The contact between water and mercury is in the left limb. Determine the pressure of water in the main line, if the difference in level of mercury in the limbs of U-Tube is 10 cm and the free surface of mercury is in level with the centre of the pipe. If the pressure of water in pipe line is reduced to 9810 N/m², calculate the new difference in the level of mercury. Sketch the arrangements in both cases. | 10 |
| | c) | A differential manometer is connected at the two points A and B as shown in the figure below. The pipe A contains a liquid of sp. gr. = 1.5 while pipe B contains a liquid of sp. gr. = 0.9. The pressures at A and B are 1 kgf/cm² and 1.8 kgf/cm² respectively. Find the difference in mercury level 'h' in the differential manometer.<br>  <br> | 5 |
| 4. | a) | Define Total pressure and Centre of Pressure. Determine the total pressure and centre of pressure of an isosceles triangular plate of base 4 m and altitude 4 m when it is immersed vertically in an oil of sp. gr. 0.9. The base of the plate coincides with the free surface of oil. | 2+8 = 10 |
| | b) | A rectangular plane surface is 2 m wide and 3 m deep. It lies in vertical plane in water. Determine the total pressure and position of centre of pressure on the plane surface when its upper edge is horizontal and (A) coincides with water surface, (B) 2.5 m below the free water surface. | 10 |
| 5. | a) | Define Centre of Buoyancy. A stone weighs 392.4 N in air and 196.2 N in water. Compute the volume of stone and its specific gravity | 2+4 = 6 |

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| | b) | State conditions of equilibrium of (i) a floating body and (ii) a submerged body. | 6 |
| | c) | A block of wood of specific gravity 0.7 floats in water. Determine the meta-centric height of the block if its size is 2m x 1m x 0.8m. State whether the equilibrium is stable or unstable. | 8 |
| 6. | a) | Derive Continuity Equation in three dimensions and show that $$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$$ | 10 |
| | b) | The velocity vector in a fluid flow is given as **$V= 4x^3i - 10x^2yj + 2tk$** Find the velocity and acceleration of a fluid particle at ( 2, 1, 3 ) at time t=1 | 10 |
| 7. | a) | Show that Equipotential Line and line of constant Stream Function are perpendicular at all points of intersection. | 6 |
| | b) | The velocity potential function (φ) is given by an expression $$\phi = -\frac{xy^3}{3} - x^2 + \frac{x^3y}{3} + y^2$$ (i) Find the velocity components in $x$ and $y$ direction (ii) Show that φ represents a possible case of flow | 6 |
| | c) | If for a two-dimensional flow, the velocity potential is given by **$\varphi = x(2y-1)$** Determine the velocity at the point **P (4 , 5)**. Determine also the value of stream function **ψ** at the point P. | 8 |
| 8. | a) | Derive Euler's Equation of Motion $$\frac{\partial p}{\rho} + gdz + vdv = 0$$ | 10 |
| | b) | State Bernoulli's Theorem. What are the necessary assumptions made in derivation of Bernoulli's Equation? Explain the mathematical expression. | 5 |
| | c) | Water is flowing through a pipe under a pressure of 29.43 N/cm² and with mean velocity of 2 m/s. Find the total head or total energy per unit weight of water at a cross-section, which is 5 m above the datum line. | 5 |

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| 9. | Write short notes on **any five** of the following. | | 5x4 = 20 |
| | a) | Capillarity Rise | |
| | b) | Single Column Manometer | |
| | c) | Hydrostatic Law | |
| | d) | Meta-Centre | |
| | e) | Laminar and Turbulent Flows | |
| | f) | Local Acceleration and Convective Acceleration | |
| | g) | Velocity potential Function and Stream Function | |



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