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

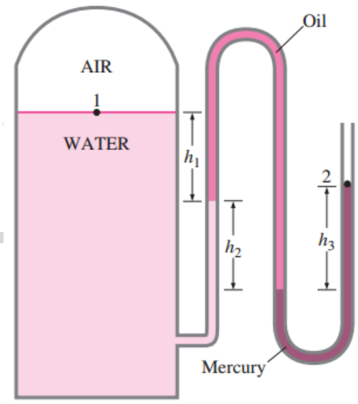
**Autonomous Institute Affiliated to VTU**

## June 2025 Semester End Main Examinations

**Programme: B.E.** | **Semester: IV**
**Branch: Mechanical Engineering** | **Duration: 3 hrs.**
**Course Code: 23ME4PCFME / 22ME4PCFME** | **Max Marks: 100**
**Course: Fluid Mechanics**

**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) | Derive an expression to determine the metacentric height? | *CO1* | *PO2* | **08** |
| | b) | The water in a tank is pressurized by air, and the pressure is measured by a multi-fluid manometer as shown in fig.1. 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 13,600 kg/m³ respectively.   Fig.1 | *CO1* | *PO2* | **08** |
| | c) | Find the kinematic viscosity of an oil having density 981 kg/m³. The shear stress at a point in oil is 0.24 N/m² and the velocity gradient is 0.2 per second. | *CO1* | *PO2* | **04** |
| | | **OR** | | | |
| 2 | a) | Derive the expression for Pascal's and hydrostatic law. | *CO2* | *PO2* | **10** |
| | b) | A wooden cylinder of specific gravity 0.6 and circular in cross-section is required to float in oil (specific gravity = 0.90). Find the L/D ratio for the cylinder to float with its longitudinal axis vertical in oil, where 'L' is the height of cylinder and 'D' is its diameter. | *CO2* | *PO2* | **10** |

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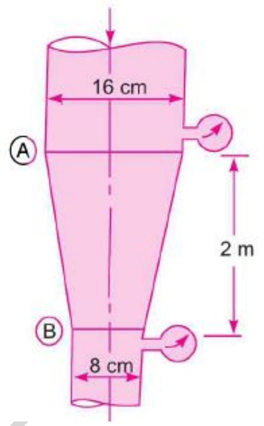
| | | | **UNIT - II** | | | |
| | 3 | a) | Define and explain, (i) Lagrangian method, (ii) Eulerian method (iii) stream lines, (iv) streak lines, and (v) time line. | *CO2* | *PO2* | **10** |
| | | b) | A fluid flow field is given by, $V = x^2yi + y^2zj - (2xyz + yz^2)k$ . Prove that, it is a case of possible steady incompressible fluid flow. Calculate the velocity and acceleration at a point (2,1,3). | *CO2* | *PO2* | **10** |
| | | | **OR** | | | |
| | 4 | a) | Derive Bernoulli's equation and state the assumptions made. | *CO2* | *PO2* | **10** |
| | | b) | In a vertical pipe conveying oil of specific gravity 0.8, two pressure gauges have been installed at A and B as shown in fig.2, where the diameters are 16 cm and 8 cm respectively. A is 2 meters above B. The pressure gauge readings have shown that the pressure at B is greater than at A by 0.98 N/cm². Neglecting all losses, calculate the flow rate. If the gauges at A and B are replaced by tubes filled with the same liquid and connected to a U-tube containing mercury, calculate the difference of level of mercury in the two limbs of the U-tube.<br><br><br>Fig. 2 | *CO2* | *PO1* | **10** |
| | | | **UNIT - III** | | | |
| | 5 | a) | Derive the general form of the Reynolds transport theorem. | *CO3* | *PO1* | **10** |
| | | b) | A spacecraft with a mass of 12,000 kg is dropping vertically toward a planet at a constant speed of 800 m/s. To slow down the spacecraft, a solid fuel rocket at the bottom of the spacecraft is fired and combustion gases leave the rocket at a constant rate of 80 kg/s and at a velocity of 3000 m/s relative to the spacecraft in the direction of motion of the spacecraft for a period of 5 sec. Disregarding the small changes in the mass of the spacecraft determine, (a) the deceleration of the spacecraft during the time the solid fuel rocket is being fired, (b) the change in velocity of the spacecraft, and (c) the thrust exerted on the spacecraft. | *CO3* | *PO2* | **10** |
| | | | **OR** | | | |

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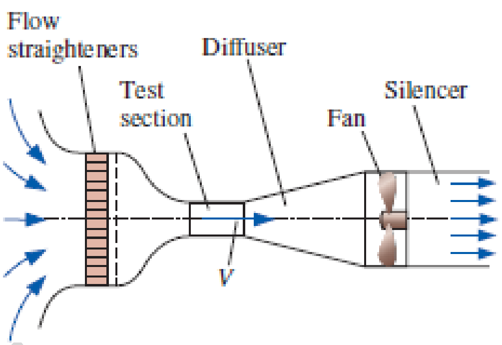
| | 6 | a) | Derive Hagen Poiseuille equation and state the assumptions. | CO2 | PO2 | **10** |
| | | b) | Determine, (i) the pressure gradient, (ii) the shear stress at the wall and (iii) the discharge per meter width for the laminar flow of oil. The maximum velocity is 2 m/s between two horizontal parallel fixed plates which are 100 mm apart.<br>Given viscosity $\mu$=2.45 Ns/m². | CO3 | PO2 | **10** |
| | | | **UNIT - IV** | | | |
| | 7 | a) | Explain Displacement Thickness and derive the expression for the same | CO4 | PO1 | **08** |
| | | b) | A small low-speed wind tunnel is being designed for calibration of hot wires as shown in fig. 3. The air is at 19°C. The test section of the wind tunnel is 30 cm in diameter and 30 cm in length. The flow through the test section must be as uniform as possible. The wind tunnel speed ranges from 1 to 8 m/s, and the design is to be optimized for an air speed of V = 4 m/s through the test section. (a) For the case of nearly uniform flow at 4.0 m/s at the test section inlet, by how much will the centerline air speed accelerate by the end of the test section? Kinematic viscosity of air at 19°C is $\mu$= $1.507 \times 10^{-5}$ m²/s.<br><br><br>Fig. 3 | CO4 | PO2 | **08** |
| | | c) | Explain the concept of 'Boundary layer separation' for the flow past a circular cylinder in a finite medium. | CO4 | PO2 | **04** |
| | | | **OR** | | | |
| | 8 | a) | By order of magnitude analysis derive the Prandtl's boundary layer equations for flow over a flat plate. | CO4 | PO2 | **10** |
| | | b) | When two things about the turbulent boundary layer over a flat plate, namely, the local skin friction coefficient,<br>$$C_{f,x} \cong \frac{0.027}{(Re_x)^{1/7}}$$<br>and the one- seventh power law approximation for the boundary layer profile shape,<br>$$\frac{u}{U} \cong \left(\frac{y}{\delta}\right)^{1/7} \text{ for } y \le \delta \qquad \frac{u}{U} \cong 1 \quad \text{for } y > \delta$$<br>Using the definition of displacement thickness and momentum thickness and employing the Karman integral equation, estimate $\delta$, $\delta^*$ and $\theta$ vary with x. | CO4 | PO1 | **10** |

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| | | | **UNIT - V** | | | |
| | 9 | a) | Define and explain non-dimensional numbers: (i) Reynolds number, (ii) Froude number, (iii)Euler's number, (iv)Weber's number, and (v) Mach number. | *CO5* | *PO2* | **10** |
| | | b) | The efficiency ($\eta$) of a fan depends upon density ($\rho$), dynamic viscosity ($\mu$) of the fluid, angular velocity ($\omega$), diameter of the rotator ($D$), and discharge ($Q$). Express ($\eta$) in terms of dimensionless groups. Take $D$, $\omega$ and $\rho$ as repeating variables | *CO5* | *PO2* | **10** |
| | | | **OR** | | | |
| | 10 | a) | At a sudden contraction in a pipe the diameter changes from $D_1$ to $D_2$. The pressure drop, $\Delta p$, 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, $\rho$, and viscosity, $\mu$. Use $D_1, V$ and $\mu$ as repeating variables to determine a suitable set of dimensionless parameters. | *CO5* | *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 $\omega$, speed of advance $V$, diameter $D$, dynamic viscosity $\mu$, mass density $\rho$, elasticity of fluid medium which can be denoted by the speed of sound in the medium $C$. Take $D$, $V$ and $\rho$ as repeating variables | *CO5* | *PO2* | **10** |

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