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M.E. MECHANICAL ENGINEERING - FIRST YEAR - SECOND SEMESTER EXAMINATION, 2025

MASTER OF NUCLEAR ENGINEERING FIRST YEAR SECOND SEMESTER EXAM, 2025

TWO PHASE FLOW, BOILING AND CONDENSATION

Time: Three hours **Full Marks 100**

Each part carries 50 marks. Use separate answer script for each part.

All parts of the same question must be answered together. Assume any unfurnished data suitably
Use of Thermodynamic Tables and Charts permitted

Part: 1 (Full Marks 50)
Answer any two questions

1. (a) What are the types of flow patterns observed in vertical upward two-phase flow? 7

   (b) Determine the flow patterns for vertical of refrigerant R-12 inside a 12 mm internal diameter tube at 0°C (3.09 bar) for a flow rate of 0.05 kg/s and vapour quality of 20%. (Properties: liquid density = 1397 kg/m^3, vapour density = 18.1 kg/m^3, liquid viscosity = 0.267 kN s/m^2 and vapour viscosity = 0.01183 kN s/m^2). 18

2. (a) Explain the concept of two-phase multiplier in the context of pressure drop calculations in two phase flows? 7

   (b) What is Martinelli's parameter? Describe the procedure for calculating two-phase pressure drop in separated flow using Lockhart-Martinelli correlation? 18

3. (a) Liquid evaporated from an inlet condition at saturated temperature ($x = 0$) to a vapour liquid mixture having a mass quality x. For a linear change of x over length L ($dP/dx = constant$) derive an expression of the pressure drop over length L. 15

   (b) Derive the relationship between void fraction and quality in two-phase flow. 10

4. A mixture of steam and water flows inside a vertical pipe with a diameter of 3 mm and a length of 12 cm at 100 kPa. The mass flux of the mixture is 80 kg/m^{2}s, and the inlet quality is zero. A uniform heat flux of 25 kW/m^2 is applied to the pipe wall up to the

midpoint of the pipe length. The remaining length of the pipe is kept adiabatic. Find the total pressure drop considering separated flow model inside the pipe. Also, compare the frictional pressure drop between the first half and the second half of the pipe. 25

Part 2 (Full Marks 50)
Answer any two questions

1.a)	Derive the expression of critical radius of vapour nucleus as a function of liquid superheat.	13
b)	Explain the pool boiling curve and show different regimes.	12
2. a)	Show the surface temperature versus time curve and explain the bubble ebullition cycle during nucleate boiling. Clearly indicate the growth period and waiting period.	12
b)	Derive the Rayleigh equation of bubble dynamics.	13
3. a)	Derive the Rohsenow correlation of nucleate boiling for heat flux as a function of wall superheat and other thermophysical properties.	15
b)	A vertical cold plate is in contact with a saturated pure vapour undergoing film condensation. Write down the governing equations, boundary conditions and liquid-vapour interface conditions. State all the assumptions.	10