Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

SECOND SEMESTER M.TECH. (ACFD)
END SEMESTER EXAMINATIONS, MAY 2024

MULTIPHASE FLOWS [AAE 5408]
REVISED CREDIT SYSTEM

Time: 3 Hours | **Date: 09 MAY 2023** | **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Part I questions need to be answered on the answer script and returned within 1.5 hours from the start of the exam.
- Part II question is to be solved /modelled using Ansys workbench.

QN		Part I	Marks	CO	BL
1		An upward adiabatic two-phase refrigerant flow occurs through a tube inclined with the vertical at an angle of 20°. The tube is 2m long and has an internal diameter of 1cm. The vapour quality is 0.05, and the mass flow rate is 0.02kg/s. The physical properties of the liquid and vapour phases are given below. Liquid density=1518 kg/m^3 Liquid dynamic viscosity =0.0005856 kg/ms Vapour density=2.6 kg/m^3 Vapour dynamic viscosity =0.0000126kg/ms		CO1	3
	(a)	Derive the void fraction relation based on vapour quality. Determine the average density based on void fraction and average viscosity based on vapour quality relations.	4		
	(b)	Determine the pressure drop using the homogenous flow model. Assume Blasius friction factor, f=0.079/Re$^{0.25}$	6		
2		Determine the two-phase pressure drop using the Lockhart-Martinelli method for an air-water mixture that flows through a horizontal tube having a diameter of 0.05m and a length of 10m. The air volume fraction is 0.45, and the mass flow rate is 10kg/s. Air and water with properties given below. Air density =1.21 kg/m^3. Water density= 100kg/m^3 Dynamic viscosity of air=1.7E-5 kg/ms; Dynamic viscosity of water=1E-3 kg/ms. For turbulent flow, assume Blasius friction factor, f=0.079/Re$^{0.25}$ and f=16/Re for laminar flow.	10	CO4	3

You can use the following relations if needed.

The pressure drop is then given by:

$$\left(\frac{dp}{dz}\right) = \phi_L^2\left(\frac{dp}{dz}\right)_L = \phi_G^2\left(\frac{dp}{dz}\right)_G$$

where the Lockhart-Martinelli parameter

$$X^2 = \frac{(dp/dz)_L}{(dp/dz)_G} \qquad \phi_L^2 = 1 + \frac{C}{X} + \frac{1}{X^2}$$

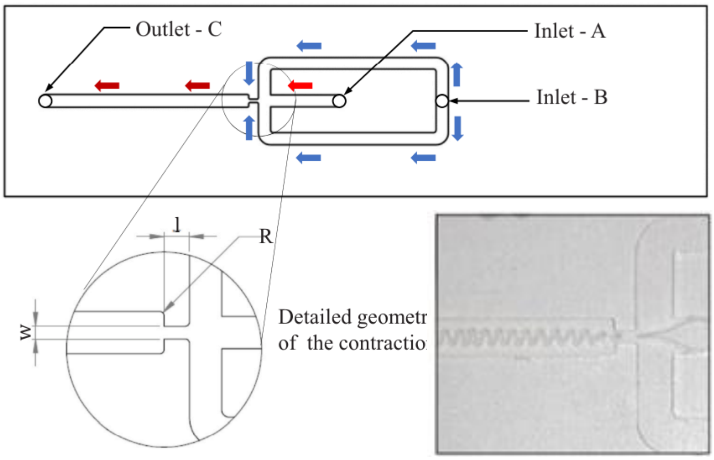
Liquid	Gas	C
Turbulent	Turbulent	20
Laminar	Turbulent	12
Turbulent	Laminar	10
Laminar	Laminar	5

Part II

3 A microfluidic droplet generator design from Hettiarachchi et al. (2021) is shown below. Computationally simulate the below two-phase flow. **CO5** **5**

The proposed design of the droplet generator shown in Fig. 2 is capable of injecting two fluids into the microfluidic channel. The inlet - A is for the dispersed phase fluid and the inlet - B is for the continuous phase fluid. The contraction (as detailed in Fig. 2) where the two fluids are touched, acts as the geometrical constraint that generates droplets. Then the generated droplets are channeled through the cavity that terminates at outlet - C, and is used for sensing and data acquisition.

The dominant parameters of the contraction geometry can be identified as contraction channel width (w), contraction channel length (l), and fillet radius (R) as shown in Fig. 2. In the proposed design, length of the contraction channel is 2.5 mm, fillet radius is 0.5 mm, channel depths are 1 mm, all the inlet channel widths are 4 mm, and the outlet channel width is 6 mm.



Experimental observation

Physical properties of the selected liquids.

Description	Liquid	Density (kg/m^3)	Dynamic Viscosity (cP)
Dispersed phase	Water	1000	1.01
Continuous phase	Coconut oil	900	55

		One centipoise (cP) is equal to 0.001 kilograms per meter-second.			
	(a)	Develop a numerical solution for the above two-phase flow using appropriate models to match the experimental observation. For simplicity, you can use a 2D simulation. Take w=1mm. Based on your judgment, decide on an appropriate computational geometrical domain.	**10**		
	(b)	Formulate a numerical scheme for Q_D=Q_C=65microlit/sec (Q_D-dispersed phase flow rate, Q_C-continuous phase flow rate). Take screenshots of model schemes and boundary conditions used.	**10**		
	(c)	Simulate the transient flow of droplets for Q_D/Q_C=1 (ratio of flow rate of dispersed to continuous phase)	**10**		
		Reporting method 1)Save the case and data file as MF24_YOURNAME.cas/.dat on the computer. 2)In a Word document, type the appropriate answer for the above questions along with screenshots and save them as MF24_PART2 _YOURNAME.docx.			