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

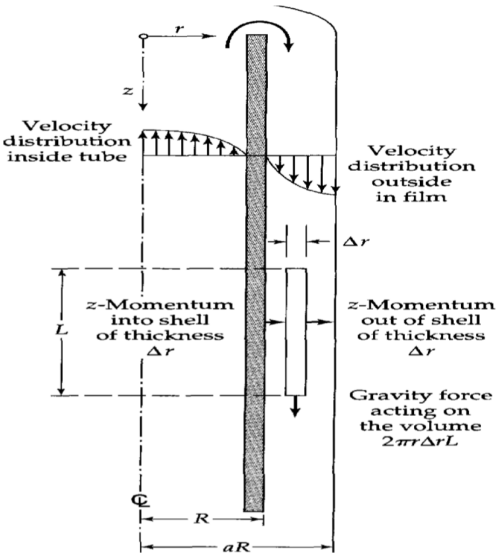
M.TECH END SEMESTER EXAMINATIONS FEBRUARY/MARCH 2021

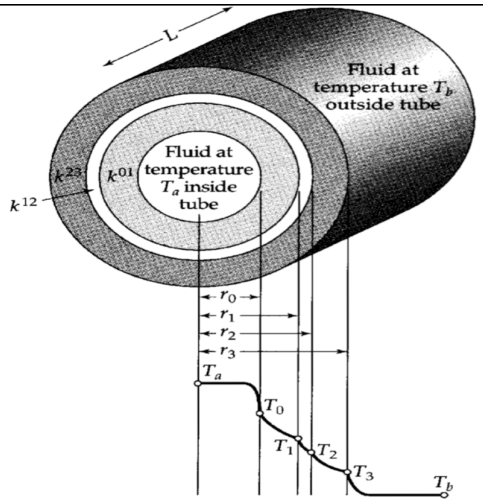
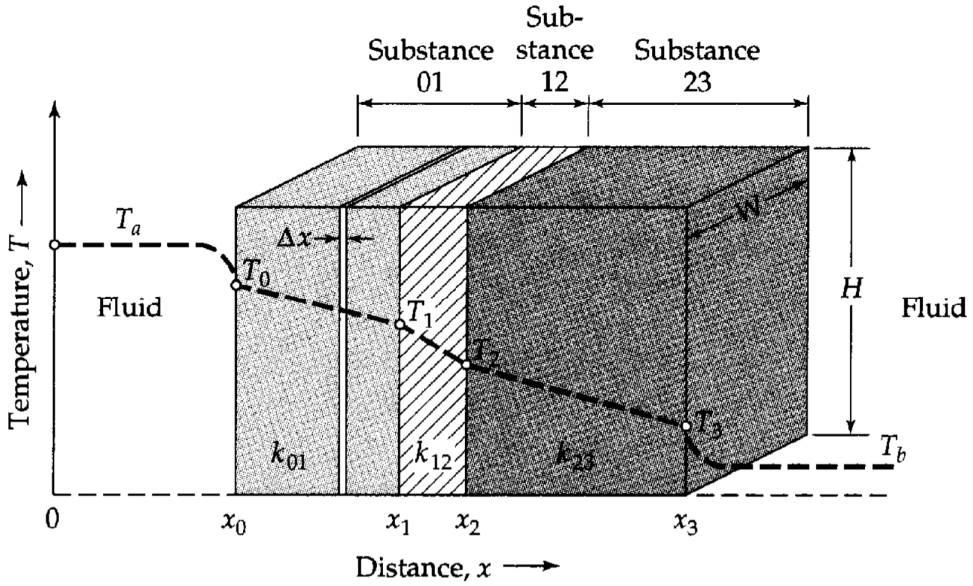
SUBJECT: TRANSPORT PHENOMENA IN BIOPROCESS ENGINEERING [BIO5154]

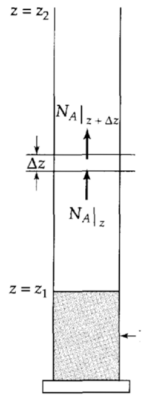
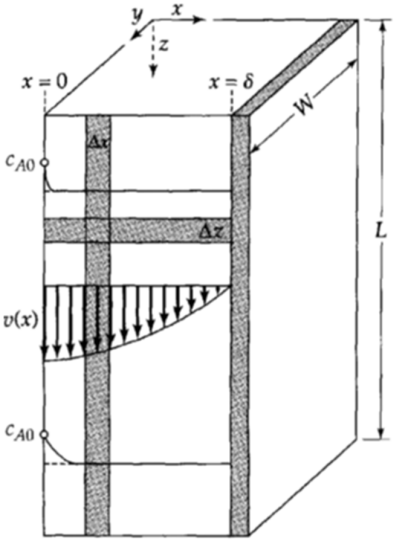
Time of Exam: 3 Hours Max. Marks: **50**

Instructions to Candidates:

- Answer ALL the questions & missing data may be suitably assumed

1A.	In a gas absorption experiment a viscous fluid flows upward through a small circular tube and then downward in laminar flow on the outside. Set up a momentum balance over a shell of thickness **Δr** in the film as shown in Fig. Note that the "momentum in" and "momentum out" arrows are always taken in the positive coordinate direction, even though in this problem the momentum is flowing through the cylindrical surfaces in the negative *r* direction. Show that the velocity distribution in the falling film (neglecting end effects) 	**7**
1B.	Write basic molecular transport equation for Momentum, heat and mass transport and modify the equation for all the three transports in the form flux = diffusivity x change in transport/volume	**3**
2A.	Develop a formula for the overall heat transfer coefficient for the composite cylindrical pipe wall shown in the figure.	**6**

		
2B.	Develop a over all heat tranfer coefficient for the heat conduction through a composite wall located between two fluid streams maintained at temperature T_a and T_b as shown in the figure below. 	**4**
3A.	Using Buckingham Pi theorem show that power required for an impeller of the reactor without baffles in dimensionless number and also show that it is a function of other dimensionless numbers.	**8**
3B.	Explain the significance of dimensionless numbers	**2**
4A.	The space between two coaxial cylinders is filled with an incompressible fluid at constant temperature. The radii of the inner and outer wetted surfaces are ***KR*** and R, respectively. The angular velocities of rotation of the inner and outer cylinders are Ω_i and Ω_o Determine the velocity distribution in the fluid	**6**
4B.	Liquid A evaporates in gas B. We assume that the liquid level is maintained at $Z = Z_1$ Right at the liquid-gas interface, the gas-phase concentration of ***A,*** expressed as mole fraction, is X_{A1}. **A** stream of gas mixture **A-B** of concentration $\mathbf{X_{A2}}$ flows slowly past the top of the tube, to maintain the mole fraction of **A** at $\mathbf{X_{A2}}$ for $\mathbf{Z = Z_2}$**.** The entire system is kept at constant temperature and pressure. Gases **A** and B are assumed to be ideal, write a basic mass transport equation for A passing through stagnant gas B with both	**4**

	molecular transport and convective transport terms and develop equation how mole fraction of A and B (X_A & X_B) varies with respect to distance Z.  	
5A.	Consider a catalytic heterogeneous chemical reaction in which a reaction A →2B is carried out and assume reaction occurs instantaneously at the catalytic surface. Imagine that the catalytic particle is surrounded by a stagnant gas film through which A has to diffuse to reach the catalytic surface. Neglect the curvature of the particle. Obtain the expression for concentration profile of A in stagnant gas film in terms of mole fraction of A	**4**
5B.	Consider the absorption of gas *A* by a laminar falling film of liquid B. The material *A* is only slightly soluble in B, so that the viscosity of the liquid is unaffected. We shall make the further restriction that the diffusion takes place so slowly in the liquid film that A will not "penetrate" very far into the film-that is, that the penetration distance will be small in comparison with the film thickness. Derive an expression to represent concentration profile of gas A in a falling liquid film.  	**6**