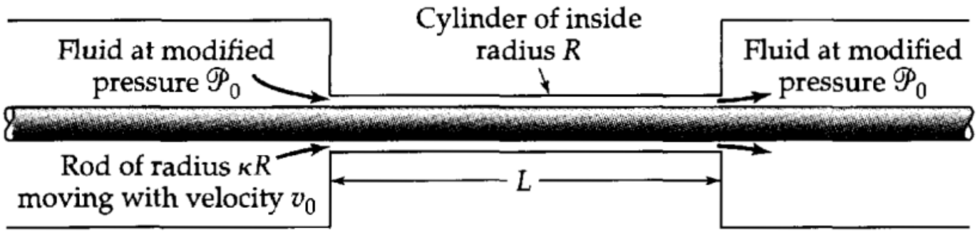
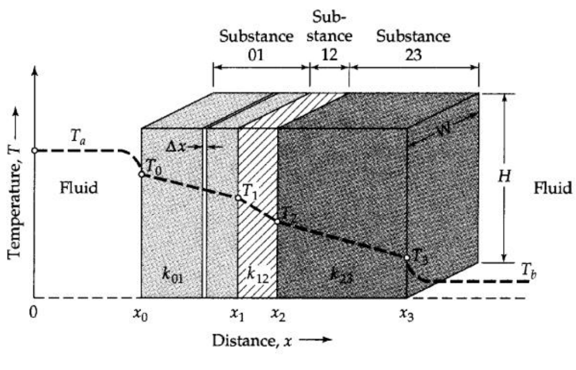
MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

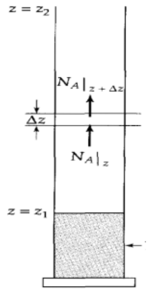
M.TECH. (INDUSTRIAL BIOTECHNOLOGY) FIRST SEMESTER EXAMINATIONS

NOVEMBER/DECEMBER 2023

SUBJECT: TRANSPORT PHENOMENA IN BIOPROCESS ENGINEERING [BIO5114]

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

1A.	A cylindrical rod of radius *kR* moves axially with velocity $V_z = V_o$ along the axis of a cylindrical cavity of radius R as seen in the figure. The pressure at both ends of the cavity is the same, so that the fluid moves through the annular region solely because of the rod motion.  • Find the velocity distribution in the narrow annular region. • Find the mass rate of flow through the annular region.	**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 per unit volume	**3**
2A.	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**
2B.	Saturated steam at 135° C is flowing inside a steel pipe having an ID of 21 mm and an OD of 27 mm. the pipe is insulated with 38 mm of insulation on the outside. The convective coefficient for the inside steam surface of the pipe is estimated as h_i = 5678 W/m^2 °C and convective coefficient on the outside of the lagging is estimated as h_o = 11.35 W/m^2 °C. The mean thermal conductivity of the metal is 45 W/m. °C and 0.064 W/m. °C for insulation. • Derive the expression used for the calculation • Calculate the heat loss for 1 meter of pipe using resistances if the surrounding air is at 27°C	**6**

	Calculate the overall heat transfer coefficient	
3A.	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 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. 	**5**
3B.	Gas **A** dissolves in liquid **B** in a beaker and diffuses isothermally into the liquid phase. As it diffuses, A also undergoes an irreversible first-order homogeneous reaction: A + B —> **AB.** An example of such a system is the absorption of CO_2, by a concentrated aqueous solution of NaOH. Treat this as a binary solution of **A** and B, ignoring the small amount of AB that is present. Give the concentration profile of gas A in Liquid B.	**5**
4A.	Using Buckingham Pi theorem show that Heat flux in a hot fluid flowing through pipe in dimensionless number and it is a function of other dimensionless numbers.	**5**
4B.	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 & R, respectively. The outer cylinder rotates at angular velocity Ω_0 and inner cylinder rotates at the angular velocity of Ω_i. Determine the velocity distribution in the fluid between the cylinders.	**5**
5A.	Water is pumped from a big underground storage tank to overhead tank which is 20 meter above the storage tank at the rate of 100 litre/second while consuming 25 KW of electric power. The top of the tank is open to the atmosphere. Disregard any frictional losses in the pipes and any changes in kinetic energy, Determine • The overall efficiency of the pump motor unit • Pressure difference between the inlet and exit of the pump. Assume density of water as 1000 kg/m^3	**5**
5B.	Water at 40^0 C with a mass flow rate of 0.5 kg/s enters a 2.5 cm internal diameter tube whose wall is maintained at 90^0 C. Calculate the tube length required for heating the water to 60^0 C. The density and viscosity of water at 50^0 C are 990 kg/m^3 and 5.623 x 10^{-4} kg/m.s respectively. Specific heat of water at 50^0 C is 4.019 KJ/kg. K. Viscosity of water at wall temperature is 3.183 x 10^{-4} kg/m.s and the thermal conductivity of the tube is 0.64 W/m. ^{0} C	**5**