Reg. No.										

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

I SEMESTER M.TECH. (CHEMICAL ENGINEERING)
END SEMESTER EXAMINATIONS, Dec 2023

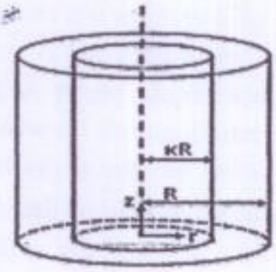
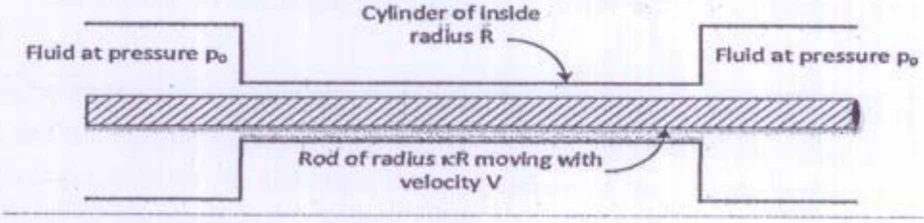
SUBJECT: ADVANCED TRANSPORT PHENOMENA

[CHE 5116]
REVISED CREDIT SYSTEM

Date : 07/12/2023 **Time: 9:30 AM – 12.30 PM** **MAX. MARKS: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Use of Transport Phenomena Tables permitted.

1A.	Consider an incompressible fluid flowing in steady state in an annular region between the two coaxial cylinders of radius R and kR having thickness as Δr. Derive the velocity distribution by shell balance approach and determine average velocity. 	**(5 marks)**
1B.	Consider a system in which a cylindrical rod and cylinder are co-axial to each other. The rod moves with velocity V. Find the steady state velocity distribution and volumetric flow rate. 	**(5 marks)**

2A. Derive the heat loss through the composite sphere having three layers of materials 1, 2 and 3 with the inner radius r_1, r_2 and r_3 having thermal conductivities to be k_1, k_2 and k_3 respectively and outer radii of r_4. The temperature of inner and outer surface to be T_i and T_o respectively. The inside and outside heat transfer coefficient are h_i and h_o respectively. **(5 marks)**

2B. The pressure vessel of a nuclear reactor is approximated as a large plane wall of thickness L. The inside surface of the wall at $x = 0$ is insulated. The outside surface at $x = L$ is maintained at a temperature T_2. The gamma ray heating of the plate can be represented as a heat generation term of the form $\dot{q}(x) = \dot{q}_o e^{-\gamma x}$ where $\dot{q}_o$ and γ are positive constants and x is measured from the insulated surface. Develop expressions for the following: **(5 marks)**

a. Temperature distribution in the plate
b. Temperature at the insulated surface
c. Heat flux at the outer surface.

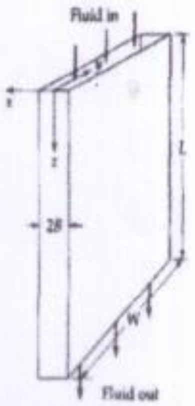
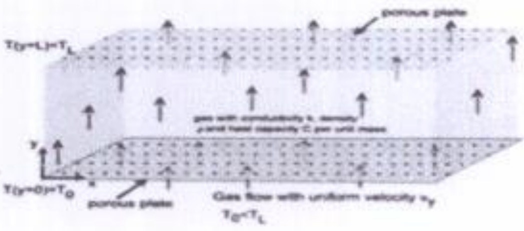
3A. Gas A dissolves in liquid B and diffuses into liquid phase A and as it diffuses, A also undergoes an irreversible first order chemical reaction.

$$A + B \longrightarrow AB$$

Derive an expression for concentration of A as a function of liquid depth and also obtain an expression for average concentration in liquid phase and the molar flux of A at gas liquid interphase. **(5 marks)**

3B. Derive an expression for diffusion through a spherical shell of radius r_1 and gas film radius as r_2 to get the concentration profile and molar flux when isothermal condition is maintained between spherical surface and gas film. **(5 marks)**

4A. An incompressible Newtonian fluid is flowing vertically through a narrow slit formed by parallel plates at a distance 2B apart. The right plate moves with velocity V and the left plate is stationary. Derive an expression for the velocity profile using Equation of motion and Equation of continuity. **(5 marks)**

		
4B.	Consider a forced convection mass transfer through which the viscous flow and diffusion occurs under such conditions that the velocity fields can be virtually unaffected by diffusion. Also consider absorption of gas A by the laminar flowing film of liquid B, where the material A is slightly soluble on B so that the viscosity of liquid is not changed appreciably. The diffusion takes place so slowly on the liquid film then the air will not penetrate very far into B so that the penetration distance is small on comparison with the film thickness, Derive the concentration profile for the above system.	**(5 marks)**
5A.	Two large flat porous horizontal plates are separated by a relatively small distance L. The upper plate at y=L is at temperature T_L, and the lower one at y=0 is to be maintained at a lower temperature T_0. To reduce the amount of heat that must be removed from the lower plate, an ideal gas at T_0 is blown upward through both plates at a steady rate. Develop an expression for the temperature distribution and the amount of heat $\dot{q}_0$ that must be removed from the cold plate per unit area as a function of the fluid properties and gas flow rate. 	**(5 marks)**
5B.	The inside surface of a brick wall (k = 1 W/m-K) of 10 cm thickness is at a temperature of 930°C and the outside surface is exposed to ambient air at 30°C providing a heat transfer coefficient of 20 W/m^2-K. Calculate the temperature of the outside surface. Calculate the thickness of insulation (k = 0.1 W/m-K) that is needed so that outside surface temperature exposed to air will not exceed 90°C.	**(5 marks)**