Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII (NEW) EXAMINATION – WINTER 2021

Subject Code:3170511 Date:29/12/2021

Subject Name:Transport Phenomena

Time:10:30 AM TO 01:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1 **(a)** Differentiate between momentum, heat and mass transport phenomena. **03**

(b) With neat sketch derive the expression for Newton's law of viscosity. **04**

(c) A viscous fluid is in laminar flow in a slit formed by two parallel walls at a distance 2B apart. Make a differential momentum balance and obtain the expression for the distributions of momentum flux and velocity. **07**

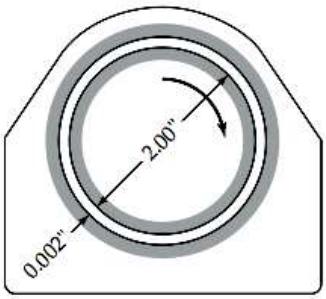
Q.2 **(a)** State the various types of boundary conditions used to solve the momentum transport problems. **03**

(b) Give the physical significance of the three kinds of time derivatives used in the equation of change for momentum transport. **04**

(c) With neat diagram and necessary assumptions derive the Navier-Stoke's equation in Cartesian coordinate. **07**

OR

(c) Calculate the required torque in kg/m^2s^2 and power consumption in horsepower to turn the shaft in the friction bearing as shown in the figure below. The length of the bearing surface on the shaft is 0.0508 m. The shaft is turning at 200 rpm. The viscosity of lubricant is 200 cp and the fluid density is 800.9 kg/m^3. **07**



Q.3 **(a)** State and explain the general shell energy balance equation. **03**

(b) Distinguish between free convection and forced convection heat transfer. **04**

(c) Derive the expression for the temperature distribution, maximum temperature rise and average temperature for an electrical heat source. **07**

OR

Q.3 **(a)** A plastic panel of area 929 cm^2 and thickness 0.640 cm was found to conduct heat at a rate of 0.717 cal/s steady state with temperatures $T_0 = 24^oC$ and $T_1 = 26^oC$ imposed on the two main surfaces. What is the thermal conductivity of the plastic in cal/cm.s. K at 25^oC? **03**

(b) Cite any four examples of conduction and convection heat transport which has been observed in chemical industry. **04**

(c) Develop a formula to determine the overall heat transfer coefficient for the heat transfer through composite cylindrical pipe wall. **07**

Q.4	**(a)**	Why fins are used in heat transfer?	**03**
	(b)	Differentiate between thermal conductivity and thermal diffusivity with necessary equations.	**04**
	(c)	Stating all relevant assumptions, derive the equation for temperature distribution across the rectangular cooling fin.	**07**

OR

Q.4	**(a)**	How is the binary diffusivity defined? Give typical orders of magnitude of diffusivities for gases, liquids, and solids.	**03**
	(b)	Compare Fick's law of diffusion with Newton's law of viscosity and Fourier's law of thermal conductivity.	**04**
	(c)	Calculate the evaporation rate in g/hr of CCl_3NO_2 (chloropicrin) into air at 25°C for the following given data. Make the customary assumption that air is a "pure substance." Total pressure – 770 mm Hg, Diffusivity (CCl_3NO_2-air) – 0.088 cm^2/s, Vapor pressure of CCl_3NO_2 – 23.81mm Hg, Distance from liquid level to top of tube – 11.14 cm, Density of CCl_3NO_2 – 1.65 g/cm^3, Surface area of liquid exposed for evaporation 2.29 cm^2	**07**
Q.5	**(a)**	Define Prandtl, Schmidt, and Lewis numbers.	**03**
	(b)	Compare and contrast the mass average velocity and the molar average velocity.	**04**
	(c)	With neat diagram derive an expression of molar flux for the diffusion with homogeneous chemical reaction as A + B → AB.	**07**

OR

Q.5	**(a)**	Write the general shell mass balance equation and necessary assumptions for solving the mass transport problems.	**03**
	(b)	Show that only one diffusivity is needed to describe the diffusional behavior of an isotropic binary mixture.	**04**
	(c)	With neat diagram derive an equation of molar flux for the diffusion with heterogeneous chemical reaction as 2A → A_2.	**07**

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII (NEW) EXAMINATION – SUMMER 2022

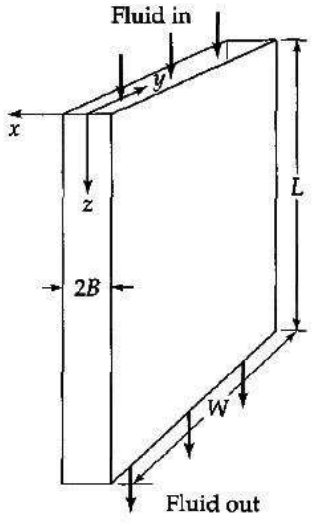
Subject Code:3170511 Date:10/06/2022

Subject Name:Transport Phenomena

Time:02:30 PM TO 05:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			Marks
Q.1	**(a)**	Discuss the significance of momentum, thermal and mass diffusivities.	**03**
	(b)	Find which of the following velocity fields **v**(x,y,z) are irrotational? a. $v_x = by$, $v_y = 0$, $v_z = 0$ b. $v_x = bx$, $v_y = 0$, $v_z = 0$ c. $v_x = by$, $v_y = bx$, $v_z = 0$ d. $v_x = -by$, $v_y = bx$, $v_z = 0$	**04**
	(c)	Compare Newton's Law of viscosity with Fourier's Law of heat conduction and Fick's of mass diffusion for their analogies.	**07**
Q.2	**(a)**	Define thermal diffusivity and Prandtl number.	**03**
	(b)	Discuss about temperature and pressure dependency of thermal conductivity.	**04**
	(c)	Derive equation of motion from momentum balance and modify it to the Navier-Stoke's equation.	**07**
		OR	
Q.2	**(c)**	Derive Continuity equation and prove that for incompressible fluids divergence of velocity vector is zero i.e. $\nabla . v = 0$	**07**
Q.3	**(a)**	What are commonly used boundary conditions of shell momentum balance?	**03**
	(b)	Explain the molecular momentum flux and write the components of the molecular momentum flux tensor.	**04**
	(c)	 A Newtonian fluid is flowing in laminar flow through a narrow slit formed by two parallel plates a distance 2B apart (as shown in fig.) where B << W so that end effects can be neglected. Obtain the shear stress and velocity profile for the flow.	**07**
		OR	
Q.3	**(a)**	Discuss the general trends of viscosity with temperature and pressure for ordinary fluids.	**03**
	(b)	Glycerine at 26.5 ^{0}C is flowing through a horizontal tube 1 ft long and with 0.1 in. inside diameter. For a pressure drop of 40 psi, the volume flow rate	**04**

is 0.00398 ft^3/min. The density of glycerine at 26.5°C is 1.261 g/cm^3. From the flow data, find the viscosity of glycerine in centipoises and in Pa.s.

(c) A liquid is slowly flowing down an inclined flat plate of length L and width W. Find Velocity distribution as a function of the fluid film thickness. Also find maximum and average velocity. Neglect end effects. **07**

Q.4 **(a)** Define the molecular and convective and total heat flux. **03**

(b) A copper wire has a radius of 2 mm and a length of 5 m. For what voltage drop would the temperature rise at the wire axis be 10°C, if the surface temperature of wire is 20°C? **04**

For copper, Lorentz No. $k/(k_e T_0)$ is 2.23×10^{-8} $volt^2/K^2$

(c) Consider an electric wire of circular cross section with radius *R* and electrical conductivity k_e ohm^{-1} cm^{-1}. Through this wire there is an electric current with current density I amp/cm^2. The transmission of an electric current is an irreversible process, and some electrical energy is converted into heat (thermal energy). The rate of heat production per unit volume is given by the expression $S_e = I^2/k_e$. The surface of the wire is maintained at temperature T_o. Find the radial temperature distribution within the wire. **07**

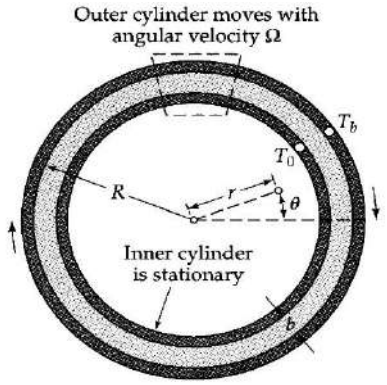
OR

Q.4 **(a)** State the fundamental law that governs the convictive heat transfer. **03**

(b) An oil is acting as a lubricant for a pair of concentric cylindrical surfaces. The outer cylinder rotates leading to the viscous heat dissipation given by equation **04**

$$\frac{T_x - T_o}{T_b - T_o} = \frac{\mu v_b^2}{2k}\frac{x}{b}\frac{1}{T_b - T_o}\left(1 - \frac{x}{b}\right) + \frac{x}{b}$$

What is the temperature at the center (x = b/2) in the annulus? Both wall temperatures are known to be 70 °C.



Data:
Angular velocity = 7908 rpm
Radius of The outer cylinder = 5.06 cm
Clearance between the cylinders = 0.027 cm.
Viscosity = 92.3 cp
Density = 1.22 g/cm3
Thermal conductivity = 2.303 W/m°C

(c) Consider the flow of an incompressible Newtonian fluid between two coaxial cylinders. The surfaces of the inner and outer cylinders are maintained at T_o and T_b, respectively. As the outer cylinder rotates, develop the temperature distribution due to viscous heat dissipation. **07**

Q.5 **(a)** Define Mass and Molar Concentrations, Mass Average and Molar Average Velocities, Molecular Mass and Molar Fluxes **03**

(b) Explain temperature and pressure dependency of diffusivity. **04**

(c) Show that for equimolar counter diffusion $D_{AB} = D_{BA}$ **07**

OR

Q.5	**(a)**	Define and explain binary Diffusivity.	**03**
	(b)	Shortly explain the theory of diffusion in gases at low density.	**04**
	(c)	Derive equation of molar flux for steady state diffusion of one gaseous component through stagnant non diffusing second component.	**07**

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