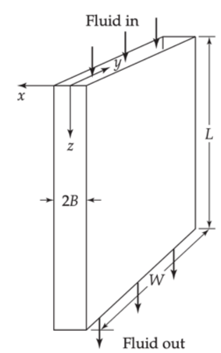
Tribhuvan University
Institute of Engineering
Examination Control Division
2082 Chaitra

Examination	Model Question		
Level	BE	Full Marks	60
Program	BCH	Pass Marks	24
Year/Part	III/I	Time	3 Hrs.

Subject:- Transport Phenomena (ENCH 303)

√*Candidates are required to give their answers in their own words as **far as practicable**.*
√*Attempt **all** questions*
√*The figures in the margin indicate **Full Marks.***
√*Necessary figure(s) are/is attached herewith.*
√*Assume suitable data if necessary*

QN	Description	Marks	Chapter No.
1	A Newtonian fluid is in laminar flow in a narrow slit formed by two parallel walls a distance 2B apart. It is understood that $B \ll W$ and $B \ll L$, so that "edge effects" are unimportant. Make a differential momentum balance, and obtain the following expressions for the momentum-flux and velocity distributions: $\tau_{xz} = \left(\frac{\wp_0 - \wp_L}{L}\right)x$ $v_z(x) = \left(\frac{(\wp_0 - \wp_L)B^2}{2\mu L}\right)\left[1 - \left(\frac{x}{B}\right)^2\right]$ In these expression $\wp = p + \rho g h = p - \rho g z$ 	6	1 and 2
2	Engineers often deal with the flow of fluids inside a circular conduit or pipe. Let us consider a horizontal section of pipe in which an incompressible Newtonian fluid is flowing in 1-D, steady state, laminar flow. The flow is fully developed; that is, it is not influenced by entrance effects and the velocity profile does not vary along the axis of flow in the x-direction. Obtain the equation for the velocity distribution using shell balance and draw velocity and momentum flux profiles. Also determine the average velocity for a cross section and express velocity in terms of average velocity.	6	1 and 2
3	Derive an equation using the equation of continuity giving the velocity distribution at steady state for laminar flow of a constant-density fluid with constant viscosity flowing between two flat and parallel plates. The velocity profile desired is at a point far from the inlet or outlet of the channel. The two plates will be considered to be fixed and of infinite width, with the flow driven by the pressure gradient in the x-direction.	9	3 and 4

	Assume that the channel is horizontal. Express your answer in terms of maximum velocity.		
4	Derive **q** = k∇T and mention all the assumptions. Explain Prandtl number in short.	5	3 and 4
5	Derive the temperature profile in an electrical wire with constant heat source using shell heat balance.	9	5
6	Define each expression in the following equation $\frac{\partial}{\partial t}\left(\frac{1}{2}\rho v^2 + \rho\hat{U}\right) = -\left(\nabla\cdot\left(\frac{1}{2}\rho v^2 + \rho\hat{U}\right)\boldsymbol{v}\right) - (\nabla\cdot\boldsymbol{q}) - (\nabla\cdot\boldsymbol{w}) + \rho(\boldsymbol{v}\cdot\boldsymbol{g})$	5	6
7	Derive the concentration or mole fraction profile for a liquid evaporating in a stagnant gas film using shell mass balance.	9	7 and 8
8	An open pan of diameter 0.2 m and height 80 mm (above water at 27 °C) is exposed to ambient air at 27 °C and 25 % relative humidity. Determine the evaporation rate, assuming that only mass diffusion occurs. Determine the evaporation rate considering bulk motion. Water vapor-air (T = 300 K and 1 atm), $D_{AB} = 0.26\times10^{-4}$ m²/s. Similarly, water vapor (T = 300 K and 1 atm), P_{sat} = 0.03531 bar and v_g = 39.13 m³/kg.	5	7 and 8
9	Derive Fick's second with suitable assumptions.	6	9 and 10

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Important Formula:

Cartesian coordinates (x,y,z):

$$\rho\left(\frac{\partial v_x}{\partial t} + v_x\frac{\partial v_x}{\partial x} + v_y\frac{\partial v_x}{\partial y} + v_z\frac{\partial v_x}{\partial z}\right) = -\frac{\partial p}{\partial x} + \mu\left[\frac{\partial^2 v_x}{\partial x^2} + \frac{\partial^2 v_x}{\partial y^2} + \frac{\partial^2 v_x}{\partial z^2}\right] + \rho g_x$$

$$\rho\left(\frac{\partial v_y}{\partial t} + v_x\frac{\partial v_y}{\partial x} + v_y\frac{\partial v_y}{\partial y} + v_z\frac{\partial v_y}{\partial z}\right) = -\frac{\partial p}{\partial y} + \mu\left[\frac{\partial^2 v_y}{\partial x^2} + \frac{\partial^2 v_y}{\partial y^2} + \frac{\partial^2 v_y}{\partial z^2}\right] + \rho g_y$$

$$\rho\left(\frac{\partial v_z}{\partial t} + v_x\frac{\partial v_z}{\partial x} + v_y\frac{\partial v_z}{\partial y} + v_z\frac{\partial v_z}{\partial z}\right) = -\frac{\partial p}{\partial z} + \mu\left[\frac{\partial^2 v_z}{\partial x^2} + \frac{\partial^2 v_z}{\partial y^2} + \frac{\partial^2 v_z}{\partial z^2}\right] + \rho g_z$$

Cylindrical coordinates (r,θ,z):

$$\rho\left(\frac{\partial v_r}{\partial t} + v_r\frac{\partial v_r}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_r}{\partial \theta} + v_z\frac{\partial v_r}{\partial z} - \frac{v_\theta^2}{r}\right) = -\frac{\partial p}{\partial r} + \mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(r v_r)\right) + \frac{1}{r^2}\frac{\partial^2 v_r}{\partial \theta^2} + \frac{\partial^2 v_r}{\partial z^2} - \frac{2}{r^2}\frac{\partial v_\theta}{\partial \theta}\right] + \rho g_r$$

$$\rho\left(\frac{\partial v_\theta}{\partial t} + v_r\frac{\partial v_\theta}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta} + v_z\frac{\partial v_\theta}{\partial z} + \frac{v_r v_\theta}{r}\right) = -\frac{1}{r}\frac{\partial p}{\partial \theta} + \mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(r v_\theta)\right) + \frac{1}{r^2}\frac{\partial^2 v_\theta}{\partial \theta^2} + \frac{\partial^2 v_\theta}{\partial z^2} + \frac{2}{r^2}\frac{\partial v_r}{\partial \theta}\right] + \rho g_\theta$$

$$\rho\left(\frac{\partial v_z}{\partial t} + v_r\frac{\partial v_z}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_z}{\partial \theta} + v_z\frac{\partial v_z}{\partial z}\right) = -\frac{\partial p}{\partial z} + \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_z}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 v_z}{\partial \theta^2} + \frac{\partial^2 v_z}{\partial z^2}\right] + \rho g_z$$

$$\tau_{xx} = -\mu\left[2\frac{\partial v_x}{\partial x}\right] + \left(\tfrac{2}{3}\mu - \kappa\right)(\nabla \cdot \mathbf{v})$$

$$\tau_{yy} = -\mu\left[2\frac{\partial v_y}{\partial y}\right] + \left(\tfrac{2}{3}\mu - \kappa\right)(\nabla \cdot \mathbf{v})$$

$$\tau_{zz} = -\mu\left[2\frac{\partial v_z}{\partial z}\right] + \left(\tfrac{2}{3}\mu - \kappa\right)(\nabla \cdot \mathbf{v})$$

$$\tau_{xy} = \tau_{yx} = -\mu\left[\frac{\partial v_y}{\partial x} + \frac{\partial v_x}{\partial y}\right]$$

$$\tau_{yz} = \tau_{zy} = -\mu\left[\frac{\partial v_z}{\partial y} + \frac{\partial v_y}{\partial z}\right]$$

$$\tau_{zx} = \tau_{xz} = -\mu\left[\frac{\partial v_x}{\partial z} + \frac{\partial v_z}{\partial x}\right]$$

Direction momentum is being transported	Component of momentum being transported		
	x component	*y* component	*z* component
x	$\phi_{xx} = \rho v_x v_x + p + \tau_{xx}$	$\phi_{xy} = \rho v_x v_y + \tau_{xy}$	$\phi_{xz} = \rho v_x v_z + \tau_{xz}$
y	$\phi_{yx} = \rho v_y v_x + \tau_{yx}$	$\phi_{yy} = \rho v_y v_y + p + \tau_{yy}$	$\phi_{yz} = \rho v_y v_z + \tau_{yz}$
z	$\phi_{zx} = \rho v_z v_x + \tau_{zx}$	$\phi_{zy} = \rho v_z v_y + \tau_{zy}$	$\phi_{zz} = \rho v_z v_z + p + \tau_{zz}$