| Name:<br>Enrolment No: | UPES<br>UNIVERSITY WITH A PURPOSE |
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**UNIVERSITY OF PETROLEUM AND ENERGY STUDIES**
**End Semester Examination, January 2021 (Online)**

**Course: Advanced Transport Phenomena** **Semester: I**
**Program: M. Tech. Chemical Spl PDE** **Time 03 hrs.**
**Course Code: CHPD 7018** **Max. Marks: 100**

## SECTION A (6Q x 5 = 30 marks)

**Each Question will carry 5 Marks. Complete the statement / Fill in the blanks/ Type the answer in 20-100 words.**

| S.No. | Question | CO |
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| Q 1 | In the four parameter Carreau Equation the non-Newtonian Viscosity **$\eta$(Eta),** and the strain rate **$\dot{\gamma}$ (Gamma Dot)** are related by following equation:<br>$$\frac{\eta - \eta_\infty}{\eta_0 - \eta_\infty} = [1 + (\lambda\dot{\gamma})^2]^{(n-1)/2}$$<br>Fill in the appropriate blanks:<br>**$\eta_0$ (Greek Eta Zero)** = - - - - - - - - - - - - - - - - - - -<br>**$\eta_\infty$ (Greek Eta Infinity)** = - - - - - - - - - - - - - - - - - - -<br>**$\lambda$ (Greek Lambda)** = - - - - - - - - - - - - - - - - - - -<br>**n (English n)** = - - - - - - - - - - - - - - - - - - - | **CO3** |
| Q2 | It is clear that polymeric liquids **do not obey Newton's law of viscosity**. To study polymeric liquids, we need to study several controllable flows in which the **stress components** can be measured. Now describe in a few words how Newtonian fluids, differ in stress-strain behaviour, from non-Newtonian fluids or complex liquids. | **CO3** |
| Q3 | The Substantial Derivative, of a property is defined as<br>$$\frac{Dc}{Dt} = \frac{\partial c}{\partial t} + (\mathbf{v} \cdot \nabla \mathbf{c})$$<br>Where the **Term-I** is **Dc/Dt**, the **Term-II** is $\partial c / \partial$**t**, and the **Term-III** is **(v. $\nabla$c).** Can you explain **Term-I, II, and III** if possible, with an example. | **CO1** |

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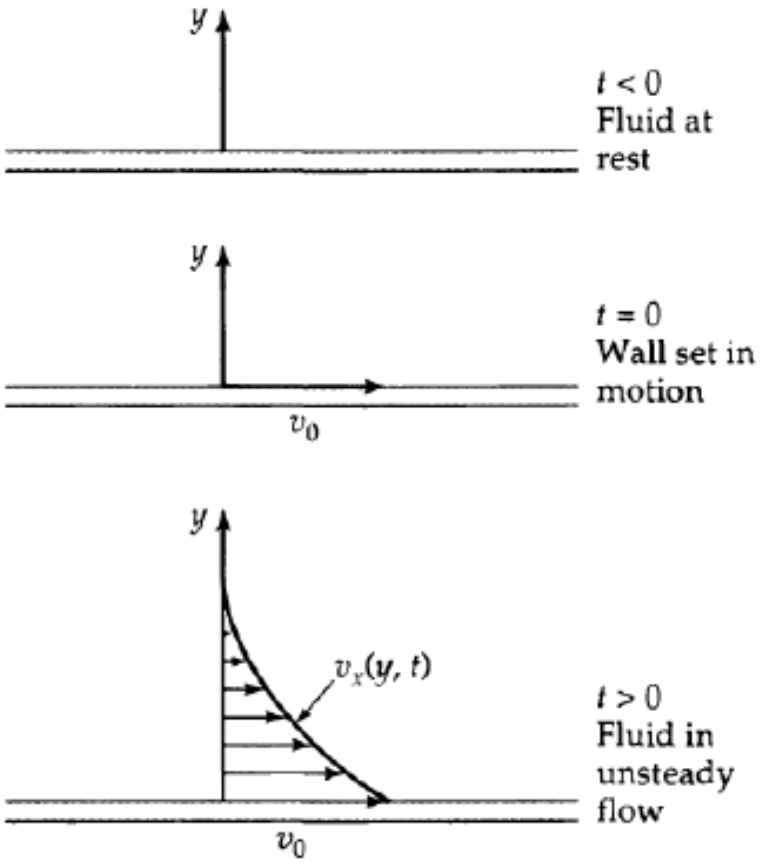
| **Q4** |  <br>Recall the problem of Velocity Distribution ith many variables. In this problem, what is discussed is essentially the unsteady state flow of liquid supported over a flat plate. The problem seeks a solution of the velocity distribution $\mathbf{V_x}$ $\boldsymbol{(y, t)}$, where $\mathbf{V_x}$ is velocity, y is distance in vertical direction and t is time.<br>Now we can write the contidions as follws:<br>I.C.: at $t \leq 0$, $v_x = 0$ for all $y$<br>B.C. 1: at $y = 0$, $v_x = v_0$ for all $t > 0$<br>B.C. 2: at $y = \infty$, $v_x = 0$ for all $t > 0$<br>In answer to Q4, please explain what is meant by intial condtion (IC) given, how it is going to affect the choice of method for solving this problem. In our notation, greek letters ν, μ, and ρ (Nu, Mu, and Rho) will refer to kinematic Viscosity, Dynamic viscosity and mass density. | **CO1** |

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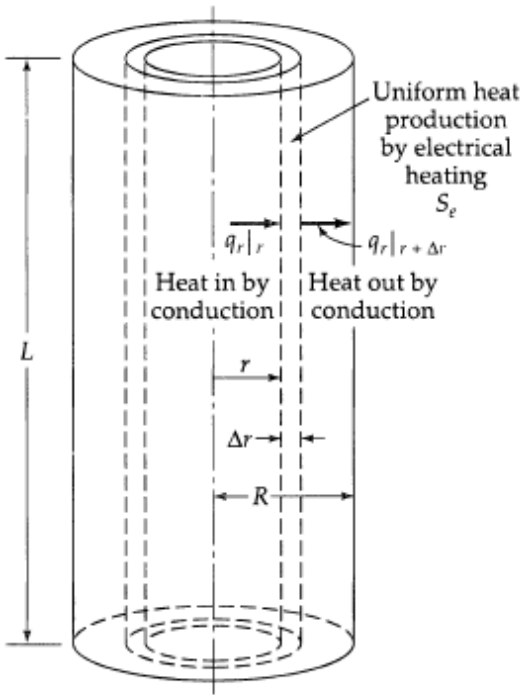
| **Q5** | In answer to Q5, please refer to the situaiton given in Q4, and please explain what is the physical interptretation of Boundary Conditons 1 and 2, BC 1, and BC 2, and how it is going to affect the choice of method for solving this problem. | **CO2** |
| **Q6** | Write a short note on importance of Fick's Law, and How it can help to calculate Mass Transfer Coefficients. | **CO3** |

## SECTION B (5Q x 10 = 50 marks, Attempt all 5)

**Each question will carry 10 marks. Instruction: Write full notes**

**Q 7** — **CO2**




Consider the problem of heat generation with an electrical heat source. The 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 $\mathbf{Se = I^2/ k_e}$. Describe the problem and the diagram, state the assumptions, and give method of solution, so as to obtain heat flux and Temp distribution.

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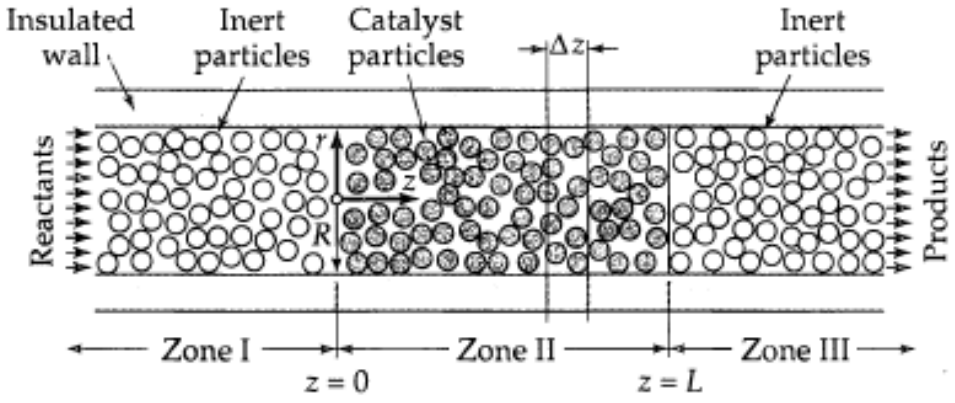
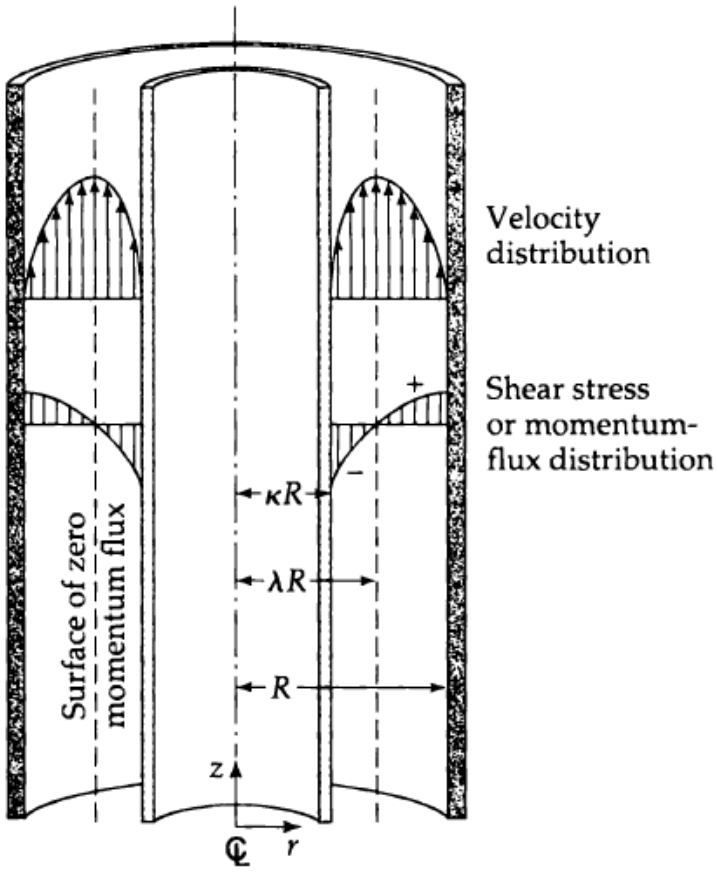
| | **OR**<br>Recall the problem for heat transfer in catalytic reaction. Write the shell balance, and give all Boundary conditions. What results do you expect?<br>  <br> | |
| Q 8 |  <br><br>Recall the problem of Flow through Annulus. The diagram is given: The momentum-flux distribution and velocity distribution for the | **CO1** |

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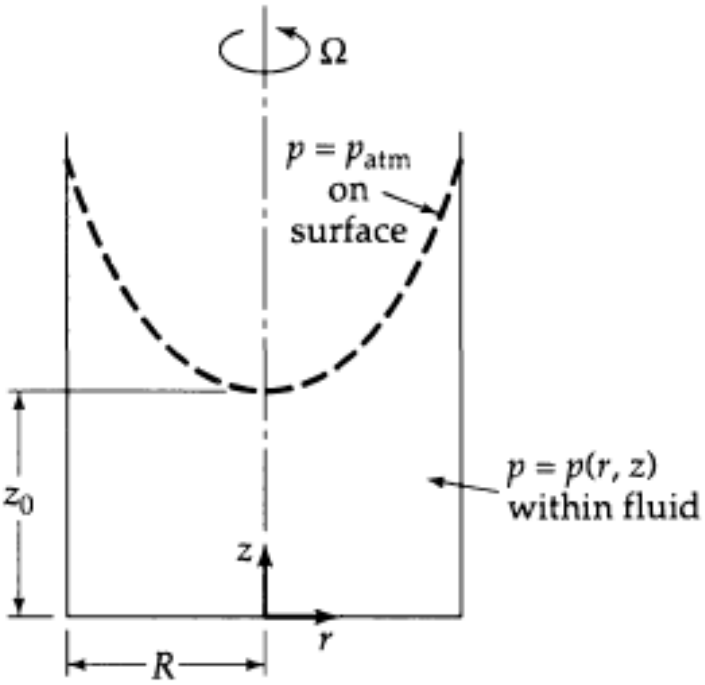
| | upward flow in a cylindrical annulus. Note that the momentum flux changes sign at the same value of r for which the velocity has a maximum. All the notation has its usual meaning. Derive an expression for velocity distribution, shear stress distribution, avg. velocity, maximum velocity and give full justifications.<br><br>**OR**<br><br>Recall the problem of Shape of the Surface of a Rotating Liquid. A liquid of constant density and viscosity is in a cylindrical container of radius R as shown in Fig. The container is caused to rotate about its own axis at an angular velocity $\boldsymbol{\Omega}$. The cylinder axis is vertical, so that $g_r = 0$, $g_\theta = 0$, and $g_z = -g$, in which g is the magnitude of the gravitational acceleration. Find the shape of the free surface of the liquid when steady state has been established.<br><br>  <br> | |
| Q 9 | Can you please write The general property balance equation for turbulent equation? Also describe instantaneous velocity in detail.<br><br>**OR**<br><br>What is meant by analogies in Transport Phenomena? What is the importance of Prandtl Mixing Length in detail. | **CO2** |

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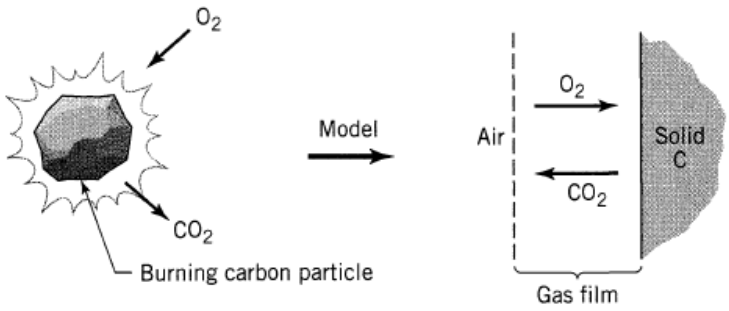
| Q 10 | Write in detail about Reynolds Stress Tensor. Can you also provide a diagram? What is the importance. | **CO3** |
| Q 11 | Write in deail about pressure and temperature dependence of Viscosity. Also please write how can we evaluate these proeprties? | **CO2** |

## Section C (1Q x 20 = 20 marks, Attempt one)

**Instruction: Write long answer.**

**Q12**




**Problem Statement**

Despite the fact that there are several renewable and alternate sources of clean energy, coal remains one of the popular fuels in India for industrial and domestic consumption. We are all familiar with the process of burning of coal in lumps. In fact, the burning of coal is a chemical reaction. Though it is just an assumption, we can presume that coal is carbon just for the sake of simplicity. In that case, burning of coal is, at least, a chemical reaction with $C + O_2 \rightarrow CO_2$. It is common observation that coal particles or lumps are of irregular shape and size. So we may model them as spherical particles, therefore to give a full model, we may require spherical coordinate system. But, we can simplify the situation further, and represent the whole process

**CO3, 20 marks**

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| | as to be happening in Cartesian System, as shown in the right hand figure. In that case, we have solid flat plate of pure carbon, and adjacent to it, is actually a gas film, of thickness, ***L.*** In that case, the situation becomes very simple to write the modeling of burning of coal. Given this situation, kindly answer the following:<br>**<u>Question</u>**<br>a. Draw an appropriate sketch of the problem, and label the coordinate system. (4)<br>b. Write the suitable assumptions, and give justification. Use meaningful notation, if possible. (4)<br>c. Can you please justify the assumptions or simplifications given in the problem statement? (4)<br>d. Derive an expression for production rate of CO2. (8) | |