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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

February / March 2023 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 19CH5DCTRP **Max Marks: 100**
Course: Transport Phenomena **Date: 21.02.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1 a) State and derive the Newton's law of viscosity. **06**

b) With the help of neat diagram, discuss the classification of the fluid. **08**

c) The lower plate is being pulled at a relative velocity of 0.5 m/s greater than top plate. The thermal oil fluid between the plates is at 24°C and viscosity 0.5×10^{-2} N s/m^2. **06**

(i) How far apart should the two plates be placed so that the shear stress, $\tau_{yx} = 0.3$ N/m^2? (ii) What is τ_{yx} and shear rate, if oil viscosity is 6×10^{-2} N s/m^2?

UNIT - II

2 a) Consider a Bingham fluid of constant density and constant viscosity is flowing in a circular tube of radius R and length L. Develop the expression for volumetric flow rate (Buckingham – Reiner's) relation. **12**

b) Oil is flowing in laminar region in a 1.27×10^{-2} m diameter tube at the rate of 22.72 lit/min. The oil viscosity and density 300 cP and 960.6 kg/m^3, respectively. Calculate the following. **08**

i. Pressure drop per meter of pipe length
ii. The wall stress/m^2
iii. The velocity at the centre of the tube

Radial position at which velocity is equal to average velocity

OR

3 a) Describe the approach to solve the viscous flow problem and list the most commonly used boundary conditions, for flow through an annulus and between parallel plates. Show the profiles of velocity and shear stress. **12**

b) A viscous fluid is in laminar flow in a slit formed between two parallel walls at a distance 2B apart. Make a differential momentum balance and obtain expression for distribution of momentum flux and velocity. What is the expression for average to maximum velocity in slit? Obtain the expression for volumetric flow rate. **08**

UNIT - III

4 a) Consider a cylindrical shell of radius 'r', thickness 'Δr' and length 'L'. The surface temperature of the wire be 'T_0' through this wire, an electric current having current density 'I' is flowing and wire material has electric conductivity K_e. Some of the electrical energy will be converted to heat. This rate of heat production per unit volume is given as, $S_e = \frac{I^2}{k_e}$ Develop the expression for temperature rise; maximum temperature rise and average temperature rise. **12**

b) Heat is being generated uniformly by a chemical reaction in a long cylinder of radius 91.4 mm. The heat generation rate is constant at 46.6 W/m^3. The outer wall of the cylinder is cooled so that the outside wall temperature is held constant at 311.0 K. The thermal conductivity is 0.865 W/m K. Calculate the centre-line temperature. **08**

OR

5 a) Consider a nuclear fuel rod of radius R_f, and having cladding diameter Rc. Inside the fuel rod, nuclear fission takes place and smaller fragments are produced. These fragments collide with atoms of the fissionable material. It will provide a source of thermal energy. **16**

The thermal energy production per unit volume is, $S_n = S_{n0}\left[1 + b\left(\frac{r}{Rf}\right)^2\right]$

Develop the expression for

i. Heat flow distribution for fuel rod and cladding

ii. Temperature distribution for fuel rod and cladding

b) An electric current of 200 A is passing through a stainless-steel wire having a diameter of 2.52 mm. The wire is 91 cm long and has a resistance of 0.126 Ohm. The outer surface is held constant at 422.1 K. The thermal conductivity is k = 22.5 W/mK. Calculate the centre-line temperature. **04**

UNIT – IV

6 a) Consider a catalytic reactor in which a reaction 2A → B is carried out on the catalyst surface each catalyst particle is surrounded by a gas film through which A must diffuse to reach catalyst surface where reaction occurs simultaneously. For this condition obtain the expression for molar flux. **12**

b) A well located in the desert is 10 m deep to the water level and 1.0 meter in diameter. The stagnant air and water in the well are 30°C and normal atmospheric pressure. A slight breeze of dry air is blowing across the top of the well. Calculate the rate of steady state diffusion of water vapor in the well, assume that the partial pressure of water vapor in the air = vapor pressure of water at 30°C. The diffusivity of water vapor in the air at 30°C is 2.6×10^{-5} m^2/s and the vapor pressure of water at 30°C = 4.112 kN/m^2. **08**

UNIT – V

7 a) Derive the Reynold's analogy between momentum, heat and mass transfer. State the assumptions made and the limitations of the same. **10**

b) Develop the expression for equation of continuity in Cartesian coordinate. **10**

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