TRANSFER OPERATION - I
(BIOT 2202)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The fluid, in which the shearing stress within it is proportional to the velocity gradient across the sheared section, is called a _____ fluid.
(a) Newtonian (b) Non-newtonial
(c) Ideal (d) Viscous

(ii) When a fluid is called turbulent?
(a) High viscosity of fluid
(b) Reynolds number is greater than 2000
(c) Reynolds number is less than 2000
(d) The density of the fluid is low.

(iii) A liquid flows through pipes 1 and 2 with the same flow velocity. If the ratio of their pipe diameters $d_1 : d_2$ be 3:2, what will be the ratio of the frictional head loss in the two pipes?
(a) 3:2 (b) 9:4 (c) 2:3 (d) 4:9.

(iv) If viscosity of fluid is more, the thickness of boundary layer is
(a) more (b) less
(c) not affected by change in viscosity (d) unpredictable.

(v) The value of coefficient of discharge of venturimeter usually lies between
(a) 0.55-0.58 (b) 0.66-0.68
(c) 0.77- 0.88 (d)0.95-0.98.

(vi) Mechanism of size reduction in nutcracker is
(a) Cutting (b) Compression
(c) Impact (d) Attrition.

(vii) Prandtl Number is equal to
(a) $C_P\mu/k$ (b) $Dv\rho/\mu$
(c) h_iD/k (d) None of the above.

(viii) Counter flow heat exchanger is preferred for
(a) rapid initial cooling (b) uniform cooling
(c) gradual cooling (d) none of the above.

(ix) Unit of overall heat transfer coefficient is
(a) m^2.K/W (b) W/m.K
(c) W/m^2.K (d) M.K/W.

(x) Filtration at constant pressure is given by
(a) Fourier's law (b) Fick's law
(c) Ruth's equation (d) Reynold's equation.

Group – B

2. (a) Describe the phenomenon of boundary layer separation. *[(CO2)(Remember/LOCQ)]*
(b) State the flow behaviour of fluid flowing under laminar condition and turbulent condition. *[(CO1)(Understand/LOCQ)]*
(c) What is Reynolds number? State its significance in flow behaviour of fluid. *[(CO1)(Understand/LOCQ)]*

4 + 4 + (2 + 2) = 12

3. (a) Write and explain continuity equation in fluid mechanics. *[(CO1)(Remember/LOCQ)]*
(b) Describe the principle of operation of fluidised bed reactor. How does it differ from packed bed reactor? *[(CO2)(Analyse/IOCQ)]*
(c) State any two application of fluidised bed reactor in biotechnology. *[(CO2)(Apply/IOCQ)]*

4 + (3 + 3) + 2 = 12

Group – C

4. (a) A properly designed venturimeter has a throat diameter of 30 cm and inlet opening diameter of 60 cm. If it is inserted in a pipe line of 60 cm through which dry chlorine gas is flowing, the reading of the venturimeter connected to a U tube mercury manometer is 1.3 cm of Hg. Calculate the rate of flow of chlorine gas in Kg/hr. Assume the density of mercury to be 13.6 gm/cc and that of chlorine gas at the conditions involved as 0.009 gm/cc. The coefficient of discharge of venturimeter can be taken as 0.98. *[(CO4)(Compute/HOCQ)]*
(b) State the operating principle of Pitot tube. *[(CO3)(Explain/LOCQ)]*

7 + 5 = 12

5. (a) Determine the power required to overcome frictional energy loss for transportation of oil of sp. gravity 0.90 and viscosity 30 cP through a pipe of diameter 25 cm and through 50 km long line at a flow rate of 300,000 litre/hour. Given f = 0.046/$(Re)^{0.2}$. [*(CO3)(Critical/HOCQ)]*
(b) Describe the principle of operation of Rotameter. *[(CO3)(Understand/IOCQ)]*

8 + 4 = 12

Group – D

6. (a) Derive an expression for heat transfer through a composite wall of three different layers? *[(CO4)(Remember/LOCQ)]*

   (b) Oil is flowing through a 75 mm ID iron pipe at 1 m/s. It is being heated by steam outside the pipe and the steam film coefficient is 11,000 W/(m2.°C). At the particular point along the pipe, the oil is at 50°C, its density is 880 kg/m^3, viscosity is 2.1 cP, thermal conductivity, k, is 0.135 W/(m.°C), specific heat, Cp,=217J/(g°C). What is the value of Ui, based on the inside area of the pipe? Given: (h/(Cp.v.ρ)(Pr)2/3 =0.023(Re)-0.2. *[(CO4)(Calculate/IOCQ)]*

5 + 7 = 12

7. (a) What are Dimensionless Numbers? Give examples. What is the usefulness of Dimensionless numbers? *[(CO4)(Remember/LOCQ)]*

   (b) A furnace wall consists of 200 mm of refractory fireclay brick, 100 mm of kaolin brick, and 6 mm of steel plate. The fireside of the refractory is at 1150˚C, and the outside of the steel is at 30˚C. An accurate heat balance over the furnace shows the heat loss from the wall to be 300 W/m^2. It is known that there may be this layers of air between the layers of brick and steel. To how many millimetres of kaolin are these air layers equivalent? (thermal conductivity of fire clay bricks is 1.73W/m˚C, kaolin brick is 0.195 W/m˚C, steel is 45 W/m˚C, air is 0.0318 W/m˚C). *[(CO1)(Analyze/IOCQ)]*

(1 + 2 + 2) + 7 = 12

Group – E

8. The following data were obtained in a constant pressure filtration unit for filtration of a yeast suspension.
   Characteristics of the filter are as follows:
   A = 0.28 m^2, C = 1920 kg/m^3, μ = 2.9 × 10^{-3} kg/m.s, α = 4 m/kg.
   (i) Determine the pressure drop across the filter.
   (ii) Determine the filter medium resistance.

Time (min)	4	20	48	76	120
V (l of filtrate)	115	365	680	850	1130

[(CO2)(Calculate/HOCQ)]

6 + 6 = 12

9. Data for the laboratory filtration of $CaCO_3$ slurry in water at 298 K are reported as follows at a constant pressure drop of 338 KN/m^2. The filter area of the plate and frame press was A = 0.0439 m^2 and the slurry concentration was C_s = 23.74 kg/m^3. Calculate the constants α and r_m from the experimental data given, where t is time in s and V is filtrate volume collected in m^3. (Given: viscosity of water at 298 K is 8.937 × 10^{-4} kg/m.s)

t (s) 4.4	9.5	16.3	24.6	34.7	46.1	59.0	73.6	89.4	107.3
V × 10^3(m^3)	0.498	1.00	1.501	2.0	2.498	3.002	3.506	4.004	4.502
t/V × 10^{-3} (s/m^3)	8.83	9.5	10.86	12.3	13.9	15.35	16.83	18.38	19.85

[(CO6)(Calculate/HOCQ)]

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Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*32.29*	*27.08*	*40.63*

Course Outcome (CO):

After completion of this course, the students will be able to:

1. Understand thy physical properties of fluid, flow behavior and their consequence on fluid flow.
2. Apply the basic laws and equations to analyze fluid dynamics and solve numerical problems related to them.
3. Understand the importance of fluid flow measurement by various devices in industries.
4. Analyze and calculate various parameters involved in heat transfer by conduction, convection and thermal radiation.
5. Develop and design various equipment's associated with heat transfer and evaluate heat exchanger performance.
6. Develop the knowledge of principles of comminution, mechanical separation aspects, working of equipments used in mechanical operation and calculate various parameters for energy requirement related to size reduction of solid.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question*