Name: **Enrolment No:**	

UPES

End Semester Examination, May 2025

Course: Heat and Mass Transfer **Semester: IV**

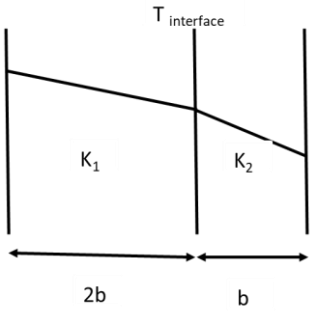
Program: B. Tech-Biotechnology, Biomedical Engineering and Food Technology **Time : 03 hrs.**

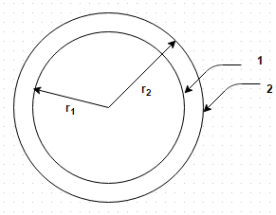
Course Code: MECH2037 **Max. Marks: 100**

Instructions: Attempt all questions.

Note: Students are permitted to use their own data handbook (either printout or handbook), provided they contain no additional markings or annotations.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Explain the physical significance of Prandtl number in velocity and thermal boundary layer formations?	**4**	**CO1**
Q 2	In a composite slab, the temperature at the interface between two materials is equal to the average temperature at the two ends. Assuming steady one-dimensional heat conduction, find relation between thermal conductivity of two materials. 	**4**	**CO2**
Q 3	Discuss the formation of velocity and thermal boundary layer thickness using Prandtl number. Also discuss the condition when the thermal boundary layer thickness is higher than the velocity boundary layer thickness.	**4**	**CO1**
Q 4	Consider a system of concentric spheres of radius r_1 and r_2 (r_2 is greater than r_1). If r_1 = 5 cm, determine the radius r_2 if it is desired to have the value of shape factor F_{21} equal to 0.6	**4**	**CO2**

			
Q 5	Discuss the applications of steam distillation and illustrate the complete process using a block diagram.	**4**	**CO1**
SECTION B (4Qx10M= 40 Marks)			
Q 6	Discuss the working principle of heat exchangers and provide a detailed classification based on construction, flow arrangement, and application.	**10**	**CO1**
Q 7	Discuss the formation of the boundary layer in free convection and explain how the Rayleigh number influences the nature of the flow, including the transition from laminar to turbulent regimes.	**10**	**CO1**
Q 8	Explain the effect of temperature on thermal conductivity of metals and non-metal?	**10**	**CO1**
Q 9	A horizontal high pressure steam pipe of 0.1 m outside diameter passes through a large room whose wall and air temperature are 23 ^{0}C. The pipe has an outside surface temperature of 165 ^{0}C. Estimate the heat loss from the pipe per unit width. *Thermophysical properties of air at T_f = 367 K: k = 0.0313 W/mK, $\upsilon = 22.8x10^{-6}$ m^2/s.* ***OR*** Air at 25 ^{o}C flows past a flat plate at 2.5 m/s. The plate measures 600 mm X 300 mm and is maintained at a uniform temperature at 95 ^{o}C. Calculate the heat loss from the plate, if the air flows parallel to the 600 mm side. How this heat loss would be affected if the flow of air is made parallel to the 300 mm side.	**10**	**CO2**
SECTION-C (2Qx20M=40 Marks)			
Q 10	A counterflow, concentric tube heat exchanger is used to cool the lubricating oil for a large industrial gas turbine engine. The flow rate of cooling water through the inner tube (Di = 25 mm) is 0.2 kg/s, while the flow rate of oil through the outer annulus (Do = 45 mm) is 0.1 kg/s. The oil and water enter at temperatures of 100 and 30°C, respectively. How long must the tube be made if the outlet temperature of the oil is to be 60°C? $Properties\ of\ unused\ engine\ oil\ (Th = 80°C = 353\ K)$: $cp = 2131\ J/kg-K, \mu = 3.25\ x\ 10^{-2} Pasec, k = 0.138\ W/mK.$	**20**	**CO3**

	$Properties\ of\ water\ (Tc\ =\ 35°C)$: $cp\ =\ 4178\ J/kgK$, $\mu\ =\ 725x10^{-6}\ Pa-sec;\ k\ =\ 0.625\ W/m-K, Pr\ =\ 4.85$		
Q 11	A long carbon steel rod of length 40 cm and diameter 10 mm (k = 40 w/mK) is placed in such that one of its end is 400 ^{o}C and the ambient temperature is 30^{o} C. The film co-efficient is 10 w/m^2 K. Determine (i) Temperature at the mid length of the fin. (ii) Fin efficiency (iii) Heat transfer rate from the fin (iv) Fin effectiveness **OR** Two large parallel planes with emissivity of 0.3 and 0.5 are maintained at temperatures of 527 ^{0}C and 127 ^{0}C respectively. A radiation shield having emissivities of 0.05 on both sides is placed between them. Calculate (i) Heat transfer rate between them without shield. (ii) Heat transfer rate between them with shield.	**20**	**CO3**