Name: **Enrolment No:**	

UPES

End Semester Examination, December 2023

Course: Heat Transfer — **Semester: V**

Program: B. Tech Mechanical — **Time: 03 hrs.**

Course Code: MECH3035 — **Max. Marks: 100**

Instructions:

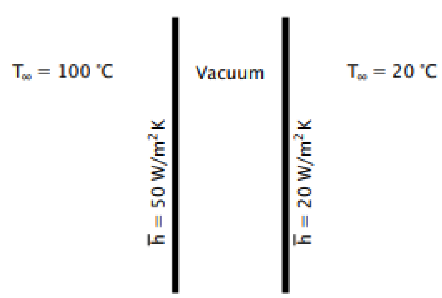
i. *There are three sections viz. Section A, Section B and Section C. Section A carries 20 marks, Section B carries 40 marks and Section C carries 40 marks*

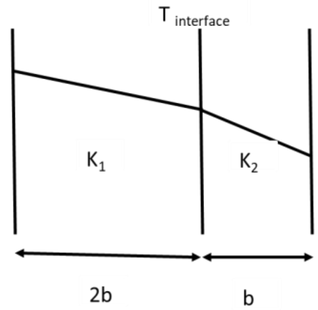
ii. *Attempt all the questions in Section A, B and C*

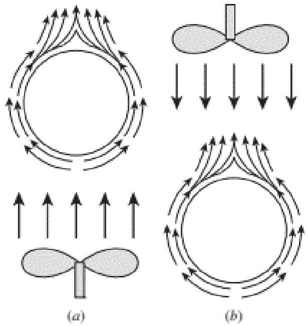
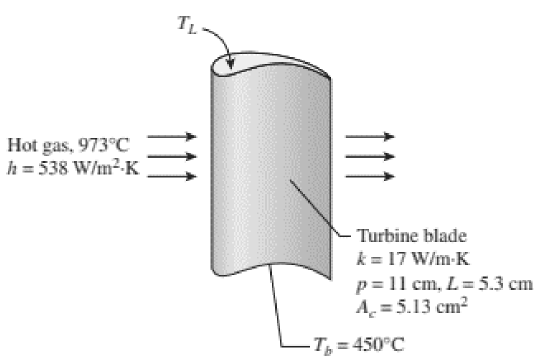
iii. *Make appropriate assumptions wherever required*

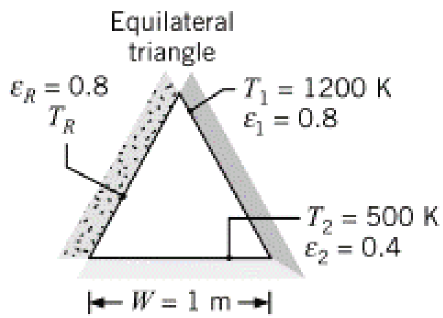
SECTION A

(5Qx4M=20Marks)

S. No.		**Marks**	**CO**
Q 1	The two walls facing each other are thin, very large in extent, highly conducting, and radiatively black on the facing surfaces. They are separated by a vacuum. The outside of a plates experiences convection as shown in the figure. Set up an equation for the temperature of the left-hand side plate and solve it. 	**4**	**CO1**
Q 2	A slab of finite thickness heated on one side and held horizontal will lose more heat per unit time to the cooler air if the hot surfaces face upward when compared with the case where the hot surfaces faces downward. Illustrate?	**4**	**CO1**
Q 3	It is proposed to make a picnic cups, 0.005 m thick, of a new plastic for which $k = k_0(1 + aT^2)$, where T is expressed in ^{0}C, K_0 = 0.15 W/mK, and a = 10^{-04} $^0C^{-2}$. We are concerned with thermal behavior in the extreme case in which T = 100 ^{0}C in the cup and 0 ^{0}C outside. find the heat loss, q.	**4**	**CO1**
Q 4	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 5	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**	**CO1**
	SECTION B **(4Qx10M= 40 Marks)**		
Q 6	We use the following experiment to measure heat transfer coefficients, h, inside pipes that carry flowing liquids. We pump liquid with a known bulk temperature through a pipe which serves as an electric resistance heater, and whose outside is perfectly insulated. A thermocouple measures its outside temperature. We know the heat release in the pipe wall, $\dot{q}$, from resistance and current measurements. We also know the pipe diameter and wall thickness. Derive an equation for h. Remember that, since h is unknown, a boundary condition of the third kind is not sufficient to find T(r)	**10**	**CO3**
Q 7	A single-pass heat exchanger condenses steam at 1 atm on the shell side and heats water from 10 ^oC to 30 ^oC on the tube side with U = 2500 W/m^2K. The tubing is thin-walled, 5 cm in diameter, and 2 m in length. (a) How do you advise your boss, who wants to know whether the exchanger should be counterflow or parallel flow? Evaluate: (b) the LMTD; (c) mass flow rate; and (d) effectiveness, ε.	**10**	**CO4**
Q 8	A system for heating water from an inlet temperature of T_{mi} = 20 ^0C to an outlet temperature of T_{mo} = 60 ^oC involves passing the water through a thick-walled tube having inner and outer diameter of 20 and 40 mm. The outer surface of the tube is well insulated and electrical heating within the wall provides for a uniform generation rate of 10^6 W/m^3. (a) For a water mass flow rate of 0.1 kg/s, how long must the tube be to achieve the desired outlet temperature? (b) If the inner surface temperature of the tube is T_s = 70 ^oC at the outlet, what is the local convection coefficient at the outlet?	**10**	**CO3**
Q 9	A 15-cm-diameter horizontal cylinder has a surface temperature that is maintained at 120 ^oC. Water at 40 ^oC is flowing across the cylinder with a velocity of 0.2 m/s. Determine the Nusselt number if the water is flowing (a) upward and (b) downward.	**10**	**CO3**

			
SECTION-C **(2Qx20M=40 Marks)**			
Q 10	You have been asked to develop a model that can determine the relationship between the temperature of a bullet at impact and the distance that it traveled after it was fired. Such a model may be useful for forensic science by allowing investigators to ascertain details of the crime from the characteristics of the entrance wound. The bullet can be modelled as a sphere with diameter D = 0.635 cm. Develop the model assuming that the velocity of the bullet as it leaves a gun is uinit = 350 m/sec and the initial temperature of the bullet is Tinit = 267 ^{o}C; these parameters can be adjusted depending on the model of the gun. The bullet travels through the still air at T∞ = 21 ^{o}C. The bullet can be modelled as a lumped capacitance and the bullet material has density ρ = 8303 kg/m^3 and c = 4.1868 kJ/kg-K. Neglect the effects of radiation and gravity in this analysis. Develop a model that can relate temperature to distance traveled. ***OR*** A turbine blade made of a metal alloy (k = 17 W/m.K) has a length of 5.3 cm, a perimeter of 11 cm, and a cross-sectional area of 5.13 cm^2 . The turbine blade is exposed to hot gas from the combustion chamber at 973°C with a convection heat transfer coefficient of 538 W/m^2 ·K. The base of the turbine blade maintains a constant temperature of 450 °C and the tip is adiabatic. Determine the heat transfer rate to the turbine blade and temperature at the tip. 	**20**	**CO2**

Q 11	A paint baking oven consists of a long, triangular duct in which a heated surface is maintained at 1200 K and another surface is insulated. Painted panels, which are maintained at 500 K, occupy the third surface. The triangle is of width W = 1 m on a side, and the heated and insulated surfaces have an emissivity of 0.8. The emissivity of the panels is 0.4. During steady-state operation, at what rate must energy be supplied to the heated side per unit length of the duct to maintain its temperature at 1200 K? What is the temperature of the insulated surface? 	**20**	**CO2**