Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End-semester Examination, May- 2021

Course: Heat Transfer **Semester:** 4
Program: B. Tech (APE Gas) **Time:** 03 hrs.
Course Code: CHCE 2009 **Max. Marks:** 100

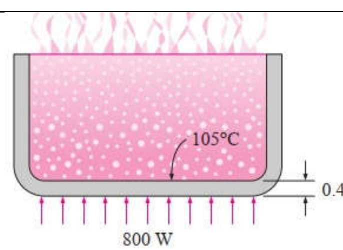
Instructions:

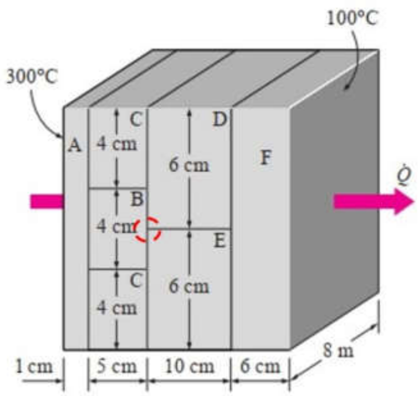
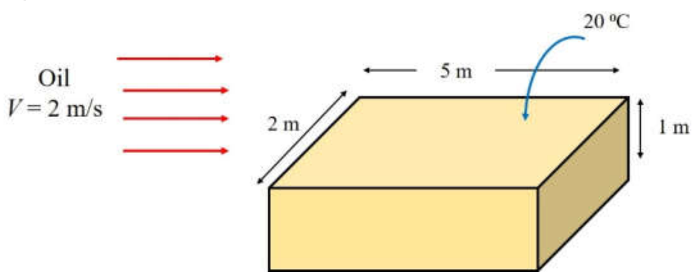
1. This is a **closed book** examination. Please write your answers with detailed information, wherever required.
2. In case of any **missing data** or information, make necessary **assumptions** with proper reason.

SECTION A

S. No.	Statement of the questions	Marks	CO
Q 1	State Fourier's law and Newton's law of cooling.	5	**CO1**
Q 2	What is thermal diffusivity? What is its significance?	5	**CO2**
Q 3	State three (3) differences between natural and forced convection? (Table not needed)	5	**CO3**
Q 4	State the Stefan–Boltzmann law for a blackbody. How can the law be applied to a real bodies.	5	**CO4**
Q 5	What is fouling? Mention one example, where it is encountered, and mention 2 (two) methods by which it can be avoided.	5	**CO5**
Q 6	State the **no-slip** condition, and **no temperature jump** condition. Mention one similarity or difference (*any one*) between them.	5	**CO3**

SECTION B

S. No.	Statement of the questions	Marks	CO
Q 7	An aluminum pan whose thermal conductivity is $\boldsymbol{k_{roll}}$ W/m · °C has a flat bottom with diameter 20 cm and thickness 0.4 cm. Heat is transferred steadily to boiling water in the pan through its bottom at a rate of 800 W. If the inner surface of the bottom of the pan is at 105°C, determine the temperature of the outer surface of the bottom of the pan. Mention all necessary assumptions. Here, $\boldsymbol{k_{roll}}$ = last two digits of your roll number. **For, example:** If, Roll number: R820219007, then thermal conductivity, $\boldsymbol{k_{roll}}$ = 07 W/m · °C 	10	**CO1**
Q 8	Consider a 5-m-high, 8-m-long, and 0.22-m-thick wall whose representative cross section is as given in the figure below. The thermal conductivities of various materials used, in W/m · °C, are $k_A = k_F = 2$, $k_B = 8$, $k_C = 20$, $\boldsymbol{k_D = k_{roll}}$, and $k_E = 35$. The left and right surfaces of the wall are maintained at uniform temperatures of 300°C and 100°C, respectively. Determine, **(a)** the rate of heat transfer through the wall; **(b)** the	10	**CO2**

	temperature at the point where the sections B, D, and E meet represented by red dashed circle; and (c) the temperature drop across the section F. Mention other necessary assumptions with proper reasons for each. Here, k_{roll} = last two digits of your roll number. **For, example:** If, Roll number: R820219007, then thermal conductivity, k_{roll} = 07 W/m · °C 		
Q 9	Engine oil at 60°C flows over the upper surface of a 5-m-long, width 10 m, and height, 1 m, flat plate whose temperature is 20°C with a velocity of 2 m/s, shown in the image below. Determine the **(i)** total drag force and the **(ii)** heat flux over the entire plate. Mention all necessary assumptions. Given data: Density = 876 kg/m^3, k = 0.144 W/m · °C, Kinematic viscosity = 242 × 10^{-6} m^2/s, thermal diffusivity = 0.012 × 10^{-6} m^2/s, specific heat = 500 J/kg · °C Use the following correlations: **For laminar flow,** Drag coefficient, $C_D = 24/Re$ & Nusselt number, $Nu = 0.664\ Re^{0.5}\ Pr^{1/3}$ **For turbulent flow,** Drag coefficient, $C_D = 0.44$ & $Nu = 0.664\ Re^{0.2}\ Pr^{0.5}$ 	10	**CO3**
Q 10	Derive the expression for heat transfer coefficient due to radiation heat transfer with all necessary assumptions.	10	**CO4**
Q 11	Describe the working principle of any three (3) type of heat exchanger with labelled diagram. **OR** Derive the expression for log mean temperature difference in a double pipe heat exchanger. Mention all necessary assumptions.	10	**CO5**
	SECTION C		

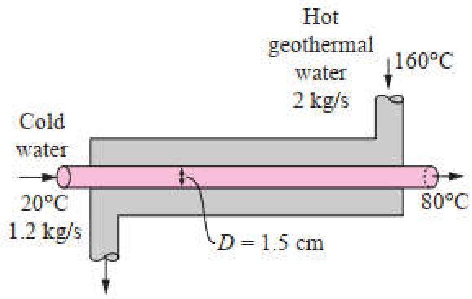
Q 12

A counter-flow double-pipe heat exchanger is to heat water from 20 °C to 80 °C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160 °C at a mass flow rate of 2 kg/s. The inner tube is thin-walled and has a diameter of 1.5 cm.

If the overall heat transfer coefficient of the heat exchanger is 640 W/m^2. °C, determine the **length of the heat exchanger** required to achieve the desired heating.

The specific heat of water and geothermal fluid is 4.18 and 4.31, with units, kJ/kg· ºC.

Mention the necessary assumptions.



OR

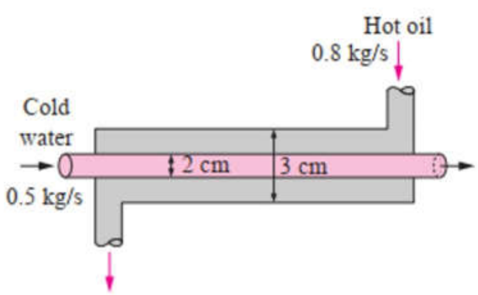
Hot oil is to be cooled in a double-tube counter-flow heat exchanger. The copper inner tubes have a diameter of 2 cm and negligible thickness. The inner diameter of the outer tube (the shell) is 3 cm. In addition, water flows through the tube at a rate of 0.5 kg/s, and the oil through the shell at a rate of 0.8 kg/s.

Taking the average temperatures of the water and the oil to be 45 °C and 80 °C, respectively, **determine the overall heat transfer coefficient** of this heat exchanger. Mention all necessary assumptions with its reasons.

Here, Nusselt number, $Nu = 0.028\, Re^{0.8}\, Pr^{0.4}$ (for turbulent flow) and the value of Nu for laminar flow is provided in the table.

The properties of water at 45°C are: ρ = 990 kg/m^3, Pr = 3.91, k = 0.637 W/m· °C, kinematic viscosity, $\upsilon = 0.602 \times 10^{-6}$ m^2/s.

The properties of oil at 80°C are: ρ = 852 kg/m^3, Pr = 490, k = 0.138 W/m · °C, kinematic viscosity, $\upsilon = 37.5 \times 10^{-6}$ m^2/s



Nu for laminar flow

D_i/D_o	Nu_i	Nu_o
0.00	—	3.66
0.05	17.46	4.06
0.10	11.56	4.11
0.25	7.37	4.23
0.50	5.74	4.43
1.00	4.86	4.86

20 | **CO5**