Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2022

Course: Advanced Fluid Mechanics and Heat Transfer **Semester: I**
Program: M.Tech CFD **Time : 03 hrs.**
Course Code: ASEG7019 **Max. Marks: 100**

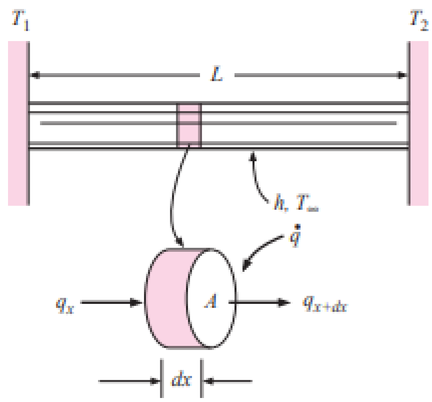
Instructions:

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	State Cauchy-Riemann conditions for a complex function to be analytic. Find complex potential function for a source (V_r = Q/2πr, V_θ = 0) and a counterclockwise irrotational vortex (V_r = 0, V_θ = K/2πr) flows located at origin.	**4**	**CO2**
Q 2	What are the different types of boundary conditions encountered in solving governing differential equation for an extended fin surface?	**4**	**CO1**
Q 3	Comment on the physical significance of Biot number and Nusselt number in heat transfer analysis.	**4**	**CO1**
Q 4	How does the relative growth of the velocity and thermal boundary layers for laminar flow over a surface depends on Prandtl number? Compare the case of water, oil, and liquid metals.	**4**	**CO1**
Q 5	What is the physical significance of the Grashof number and the Rayleigh number in natural convection?	**4**	**CO1**

SECTION B
(4Qx10M= 40 Marks)

S. No.		Marks	CO
Q 6	**(a)** What is the effect of streamlining on (a) friction drag and (b) pressure drag? Does the total drag acting on a body necessarily decrease as a result of streamlining? Explain. **(4 Marks)** **(b)** What is flow separation? What causes it? What is the effect of flow separation on the drag coefficient? Suggest possible measures to delay BL separation and benefits of delaying the BL separation. **(6 Marks)**	**10**	**CO3**
Q 7	The temperature of a gas stream is to be measured by a thermocouple whose junction can be approximated as a 1.2-mm-diameter sphere. The	**10**	**CO2**

	properties of the junction are k = 35 W/m·K, ρ = 8500 kg/m^3, and c_p = 320 J/kg·K, and the heat transfer coefficient between the junction and the gas is h = 90 W/m^2·K. Determine how long it will take for the thermocouple to read 99 percent of the initial temperature difference.		
Q 8	Air at 20°C flows past an 800 mm long plate at a velocity of 45 m/s. If the surface of the plate is maintained at 300°C determine (a). The heat transferred from the entire plate length to air taking into consideration both laminar and turbulent portions of the boundary layer, (b). the percentage error if the boundary layer is assumed to be turbulent from the leading edge of the plate. Assume unit width of the plate. Take the properties of air at 160°C as thermal conductivity 0.03638 W/m-K, υ = 30.08 × 10^{-6} m^2/s, Pr = 0.682 Laminar Region: $\bar{h} = 0.664 \frac{k}{x_c} (\mathrm{Re}_c)^{0.5} (\mathrm{Pr})^{0.333}$ Turbulent Region from the Leading edge: $\bar{h} = 0.036 \frac{k}{L} \mathrm{Re}_L^{0.8} \mathrm{Pr}^{0.333}$ Turbulent Boundary Layer Region: $\bar{h} = 0.036 \frac{k}{L - x_c} [(\mathrm{Re}_L)^{0.8} - (\mathrm{Re}_c)^{0.8}] \mathrm{Pr}^{0.333}$	**10**	**CO3**
Q 9	A rod containing uniform heat sources per unit volume Q''' is connected to two temperatures as shown in Figure below. The rod is also exposed to an environment with convection coefficient h and temperature T_∞. Obtain an expression for the temperature distribution in the rod.  **OR** Derive an expression for the temperature distribution in a plane wall in which distributed heat sources vary according to the linear relation,	**10**	**CO2**

	$$Q = Q_w [1 + \beta(T - T_w)]$$ where Q_w is a constant and equal to the heat generated per unit volume at the wall temperature T_w. Both sides of the plate are maintained at T_w, and the plate thickness is $2L$.		
	SECTION-C **(2Qx20M=40 Marks)**		
Q 10	Consider two-dimensional laminar boundary-layer flow along a flat plate. Assume the velocity profile in the boundary layer is cubic as: $u/U = (3/2)(y/\delta) - (1/2)(y/\delta)^3$ Find (a) The velocity profile, rate of growth of δ and the displacement thickness, δ^* as a function of x. **(10 Marks)** (b) The skin friction coefficient (C_f), and drag coefficient (C_D) on a plate of length L and width b. **(10 Marks)** Momentum integral equation is given below for your reference: $$\tau_w = \frac{\partial}{\partial x} U^2 \int_0^\delta \rho \frac{u}{U}\left(1 - \frac{u}{U}\right) dy + U\frac{dU}{dx}\int_0^\delta \rho\left(1 - \frac{u}{U}\right) dy$$ **OR** Drive the Blasius equation for the flow over a flat plate and specify the boundary conditions required to solve the equation. Comment on the solution approach of the equation.	**20**	**CO3/ CO4**
Q 11	In areas where the air temperature remains below 0°C for prolonged periods of time, the freezing of water in underground pipes is a major concern. Fortunately, the soil remains relatively warm during those periods, and it takes weeks for the subfreezing temperatures to reach the water mains in the ground. Thus, the soil effectively serves as an insulation to protect the water from the freezing atmospheric temperatures in winter. The ground at a particular location is covered with snowpack at -8°C for a continuous period of 60 days, and the average soil properties at that location are $k = 0.35$ W/m·K and $\alpha = 0.15 \times 10^{-6}$ m^2/s. Assuming an initial uniform temperature of 8°C for the ground, determine the minimum burial depth to prevent the water pipes from freezing. Formulate the problem as transient heat conduction in semi-infinite solids. (Given erfc(0.5) = 0.5)	**20**	**CO5**