Seat No./Enrollment No.: _____

GUJARAT TECHNOLOGICAL UNIVERSITY
BACHELOR OF ENGINEERING – SEMESTER 5 – EXAMINATION – SUMMER 2026

Subject Code: 3151909 **Date: 25/05/2026**

Subject Name: Heat Transfer

Time: 02:30 PM TO 05:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1 **(a)** Define: 1) Conduction heat transfer **03**
2) Thermal diffusivity
3) Thermal resistance

(b) Explain mean film temperature and bulk mean temperature. **04**

(c) Derive general heat conduction equation in Cartesian coordinates and prove that the steady state heat transfer equation without heat generation is **07**

$$\frac{\partial^2 t}{\partial x^2}+\frac{\partial^2 t}{\partial y^2}+\frac{\partial^2 t}{\partial z^2}=0$$

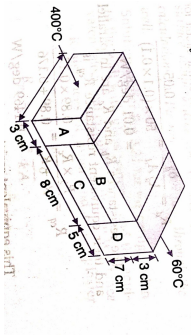
Q.2 **(a)** Define thermal boundary layer and hydrodynamic boundary layer. **03**

(b) The velocity distribution in the boundary layer is given by: $\frac{u}{U}=\frac{y}{\delta}$, where u is the velocity at a distance y from the plate and u = U at y =δ, where δ being boundary layer thickness. Find : (i) The displacement thickness, (ii) The momentum thickness, (iii) The energy thickness, and (iv) The value of $\frac{\delta^*}{\theta}$. **04**

(c) A steel pipe of 20 mm inner diameter and 2 mm thickness is covered with 20 mm thick of fiber glass insulation (k = 0.05W/ m deg). If the inside and outside convective coefficients are 10 W/ m2 deg and 5 W/ m2 deg, Calculate the overall heat transfer coefficient based on inside diameter of pipe. **07**

OR

Q.2 **(c)** Calculate the heat flow rate through the composite wall as shown in figure. Assume 1 D flow and take **07**
ka = 150W/ m deg
kb = 30 W/ m deg
kc = 65 W/ m deg
kd = 50 W/ m deg



Q.3 **(a)** Define: Fourier number and Biot number in context of lumped system analysis. **03**

(b) List the applications of Fin and explain how a fin enhances heat transfer at the surface **04**

(c) Using Buckingham π theorem, show that the Nusselt number for free convection is a function of Grashof Number and Prandtl number **07**

OR

Q.3 **(a)** Define Fin Efficiency, Fin effectiveness with expressions. **03**

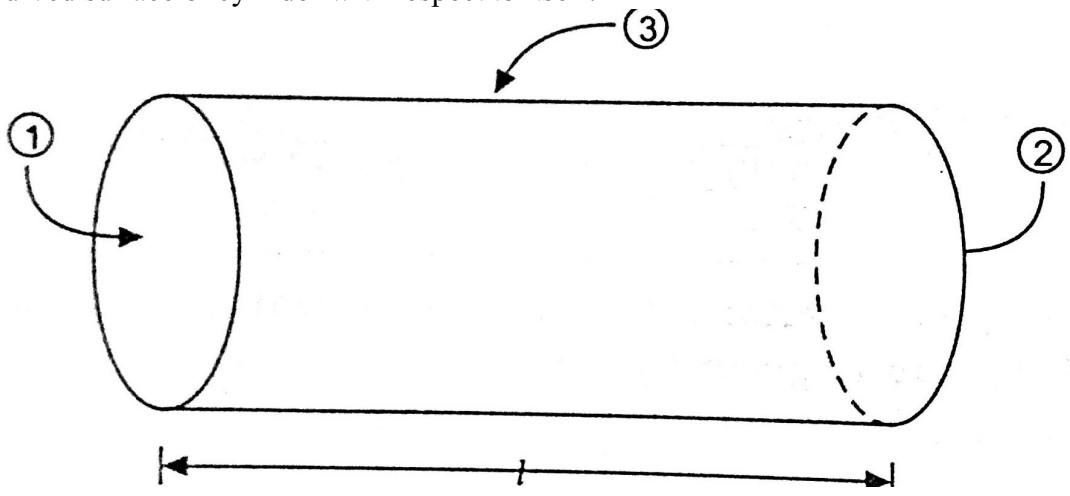
(b) Explain Critical radius of Insulation for cylinder. **04**

(c) A steel rod (k= 30W/m – deg) 1 cm in diameter and 5 cm long protrudes form a wall which is maintained at 100° C. the rod is insulated at its tip and is exposed to an environment with h = 50W/m2 –deg and ta = 30°C. Calculate the fin efficiency, temperature at the tip of fin and the rate of heat dissipation. **07**

Q.4 **(a)** Define Black body, White body, Gray body. **03**

(b) Explain the utility of radiation shields. **04**

(c) Consider a thin hollow cylinder of 8 cm diameter and 10 cm length. If the radiant shape factor of the circular surface of this cylinder is 0.172, find the shape factor of curved surface of cylinder with respect to itself. **07**



OR

Q.4 **(a)** Define shape factor and list any two salient features of it. **03**

(b) A polished metal pipe 50cm outside diameter and 370K temperature at the outer surface is exposed to ambient conditions at 295 K temperature. The emissivity of the surface is 0.2 and the convection coefficient of heat transfer is 11.35 W/m2 deg. Calculate the heat transfer by radiation and natural convection per meter length of the pipe. Take thermal radiation constant $\sigma b = 5.67 \times 10^{-8}$ W/ m2 deg K4. Find the overall heat transfer coefficient of heat by combined mode of convection and radiation. **04**

(c) Define Intensity of radiation. Prove that the intensity of normal radiation is $1/\pi$ times the total emissive power. **07**

Q.5 **(a)** Differentiate Filmwise and Dropwise condensation. Which type has higher heat transfer film condensation and why? **03**

(b) Classify Heat Exchangers **04**

(c) Hot water having specific heat 4200J/kg K flows through a heat exchanger at the rate of 4 kg/min with an inlet temperature of 100 °C. A cold fluid having a specific heat 2400J/kg K flows in at a rate of 8 kg/min and with inlet temperature 20° C. Make calculations for the maximum possible effectiveness if the fluid flow conforms to a) parallel flow arrangement b)counter flow arrangement. **07**

OR

Q.5 **(a)** Draw the Boiling curve for water showing various regimes. **03**

(b) Show the temperature variation along length of heat exchanger when: **04**
1. Hot and cold fluids flow in parallel and counter flow.
2.Steam condenses on outside of condenser tube with water flowing inside the tube as coolant.
3.Hot fluid as used for evaporating another liquid.

(c) In a counter flow heat exchanger, oil(cp = 3KJ/kg-K at the rate of 1400 kg/hr is cooled from 100 °C to 30 °C by water that enters the exchanger at 20 °C at the rate of 1300 kg/hr. Determine the heat exchanger area for an overall heat transfer coefficient of 3975 KJ/ m^2-hr-K **07**

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