Seat No.: _____  Enrolment No. 

# GUJARAT TECHNOLOGICAL UNIVERSITY

**BE - SEMESTER–VI (OLD) EXAMINATION – WINTER 2018**

**Subject Code:161906** **Date: 13/12/2018**

**Subject Name: Heat And Mass 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.**

**Q.1** **(a)** Derive the expression for heat conduction through composite wall using electrical analogy. **07**

**(b)** Find the shape factor $F_{1-1}$, $F_{1-2 \text{ and }} F_{2-1}$ for the following geometries. **07**

(a) A black body inside a black enclosure
(b) A tube whose section is equilateral triangle
(c) Radiation exchange between a hemisphere and a plane surface.

**Q.2** **(a)** 0.5 cm thick glass (k=0.78W/m. K) is exposed to air at 25˚ C (inner side) with convection heat transfer coefficient of 15 W/m$^2$ K. The outside air is at -15˚C with convection coefficient of 50 W/m$^2$ K. Determine (1) temperatures at inner and outer glass surfaces (2) heat transfer rate. **07**

**(b)** What is critical radius of insulation? Derive the expression for condition for minimum resistance for maximum heat flow rate for solid cylinder under one dimensional steady state heat conduction. **07**

**OR**

**(b)** A circular shaft (k= 50W/m K) 60 mm diameter having 60˚ C rise in temperature due to friction. The heat transfer coefficient is 6.5W/m$^2$ K. Determine (1) the expression for temperature distribution (2) the amount of heat dissipated through the shaft. Assume the shaft is a rod of infinite length. **07**

**Q.3** **(a)** A polished metal pipe 5 cm outside diameter and 370 K 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/m$^2$ -deg. Calculate the heat transfer by radiation and natural convection per meter length of pipe. Take thermal radiation constant $\sigma_b = 5.67 \times 10^{-8}$ W/m$^2$ K$^4$. What would be the overall coefficient of heat transfer by combined mode of convection and radiation? **07**

**(b)** Derive an expression for LMTD for counterflow heat exchanger. **07**

**OR**

**Q.3** **(a)** A heat treated steel plate measures 3 m x 1 m and is initially at 30˚ C. it is cooled by blowing air parallel to 1 edge at 9 kmph. If the air is at 10˚C, calculate the convective heat transfer from both sides of the plate. Take the correlation Nu= 0.664 $(Re)^{0.5}$ $(Pr)^{0.33}$ **07**

**(b)** Derive the expression for effectiveness of parallel flow heat exchanger. **07**

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| **Q.4** | **(a)** | State and explain Wien's displacement law and define Lambert's cosine law of radiation | **07** |
| | **(b)** | Discuss the concept of thermal boundary layer in case of flow over the plates. How it differs from velocity boundary? | **07** |

**OR**

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| **Q.4** | **(a)** | What is meant by a lumped capacity? What are the physical dimensions necessary for a lumped unsteady state analysis to apply? | **07** |
| | **(b)** | State and explain Fick's law of diffusion and compare it with Fourier's law of heat conduction | **07** |
| **Q.5** | **(a)** | A steam condenser is transferring 250 kW of thermal energy at a condensing temperature of 65˚C. The cooling water enters the condenser at 20˚C with a flow rate of 7500kg/hr. calculate the log mean temperature difference. If the overall heat transfer coefficient for the condenser surface is 1250 W/ $m^2$-deg, what surface area is required to handle this load? | **07** |
| | **(b)** | By dimensional analysis show that for forced convection heat transfer the Nusselt number can be expressed as a function of Prandtl number and Reynolds number. | **07** |

**OR**

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| **Q.5** | **(a)** | A counterflow heat concentric tube heat exchanger is used to cool the lubricating oil of a large industrial gas turbine engine. The oil flows through the tube at 0.19 kg/s (Cp = 2.18 kJ/kg K), and the coolant water flows in the annulus in the opposite direction at a rate of 0.15 kg/s (Cp = 4.18 kJ/kg K). The oil enters the coolant at 425K and leaves at 345 K while the coolant enters at 285 K. How long must the tube be made to perform this duty if the heat transfer coefficient from oil to tube surface is 2250 W/$m^2$ K and form tube surface to water is 5650W/$m^2$? The tube has a mean diameter of 12.5 mm and its wall presents negligible resistance to heat transfer | **07** |
| | **(b)** | Define pool boiling. Draw pool boiling curve for water and explain various regimes of the curve. | **07** |

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