Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII EXAMINATION – WINTER 2015

Subject Code: 170102 **Date:07/12/2015**

Subject Name: Theory of Heat Transfer

Time: 10:30am to 1:00pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use of Tables of properties of air and water is permitted**

Q.1 **(a)** Derive general heat conduction equation in Cartesian coordinates **07**

(b) A Steel Tube (k=43.26 W/mK) of 5.08 cm. ID and 7.62 cm. OD is covered with a 2.54 cm layer of asbestos insulation (k=0.208 W/mK). The inside surface of the tube receives heat by convection from a hot gas at a temp. of T_a= 310°C with a heat transfer coefficient h_a=285 W/m^{2}K while the outer surface of the insulation is exposed to the ambient air at T_b=35°C with a heat transfer coefficient of h_b=20 W/m^{2}K. Estimate the heat loss to the ambient air for 3 m length of the tube. Draw electrical analogy , also define thermal conductivity **07**

Q.2 **(a)** Derive equations of temperature distribution and heat dissipation for fin non-insulated at tip. **07**

(b) A turbine blade made of stainless steel (k=32 W/m-k) is 60 mm long, 500 mm^2 cross-sectional area and 120 mm perimeter. The temperature of the root of the blade is 480 ^{o}C and it is exposed to products of combustion passing through the turbine at 828 ^{o}C. If the film coefficient between the blade and the combustion gases is 320 W/m^2-K, determine :(i) temperature at the middle of the blade (ii) rate of heat flow to the blade. **07**

OR

(b) What is the critical thickness of insulation on a small diameter wire and a steam pipe. Explain its physical significance in both the cases & derive an expression for the same. **07**

Q.3 **(a)** Explain unsteady state heat transfer when Bi < 0.1 **07**

(b) Consider a rectangular plate 0.2 m x 0.4 m is maintained at uniform temperature of 80°C. It is placed in atmosphere air at 24°C. Compare the heat transfer rates from the plate for the cases when the vertical height is (a) 0.2 m and (b) 0.4 m. **07**

The properties of air at mean film temperature at T_{mf} = 52°C are as follows:

ν=1.822 x 10^{-5} m^2/s , k= 0.02814 W/m.K, Pr = 0.703 , β =3.077 x 10^{-3} K^{-1}

Use the following correlation:

For laminar: Nu= 0.59 (Ra) $^{1/4}$ (104 < Ra < 10^9), where Ra= Gr x Pr

For Turbulent: Nu=0.10 (Ra) $^{1/3}$ (109 < Ra <10^{13}), where Ra= Gr x Pr

OR

Q.3 **(a)** Define velocity & thermal boundary layer thickness, explain them. **07**

	(b)	A horizontal fluorescent tube which is 3 cm in diameter and 100 cm long stands in still air at 1 bar and 35 ^{o}C. If the surface temperature is 65 ^{o}C and radiation is neglected, what is heat transfer rate by convection? Use $\overline{N}_u = 0.53\,(Gr.Pr)^{0.25}$ for air , ν x 10^6 = 17.95 m^2/s , k x 10^2 = 2.824 W/m.K , μ = 1.963x 10^{-5} kg/s, C_p=1.005 kJ/kg. K	**07**
Q.4	**(a)**	Why is counter-flow H.E. more effective than a parallel flow heat exchanger? And What is LMTD Correction Factor?	**07**
	(b)	A test is conducted on cross-flow water-to-air radiator. The radiator has 40 tubes of internal diameter of 0.55 cm and length 75 cm in a closely spaced plate-finned matrix. Hot water enters the tubes at 90°C at the rate of 0.65 kg/s and leaves at 60°C . Air flows across the radiator through the interfin spaces and is heated from 20°C to 40°C. Determine the overall heat transfer coefficient based on inner surface area of tubes and take correction factor as 0.85	**07**
		OR	
Q.4	**(a)**	What are the fouling factors? Explain their effect in Heat Exchanger design.	**07**
	(b)	Draw and Explain boiling curve for water. Explain Nucleate boiling.	**07**
Q.5	**(a)**	What is the Stephen-Boltzmann Law? Explain the concept of total emissive power of a surface.	**07**
	(b)	Write Von-karman integral momentum equation, for the hydrodynamic laminar boundary layer of fluid flowing over stationary plate. Using this equation, derive the expression for hydrodynamic boundary layer thickness considering the cubic velocity profile	**07**
		OR	
Q.5	**(a)**	Using dimensional analysis, obtain a general form of equation for forced Convective heat transfer.	**07**
	(b)	Consider two large parallel plates, one at temperature at 727 °C with emissivity 0.8 and other at 227 °C with emissivity 0.4. An aluminium radiation shield with an emissivity of 0.05 on both sides is placed between two plates. Calculate reduction in heat transfer rate between two plates as a result of shield.	**07**

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