Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V(New) • EXAMINATION – WINTER 2016

Subject Code:2151909 Date:02/12/2016

Subject Name:Heat Transfer

Time:10:30 AM to 01:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

			MARKS
Q.1		**Short Questions**	**14**
	1	How does heat transfer differ from thermodynamics?	
	2	What is physical significance of thermal diffusivity?	
	3	Define critical radius of insulation.	
	4	Explain the situation when the addition of fins to a surface is not useful.	
	5	Under what situations does the fin efficiency becomes 100%	
	6	How does transient heat conduction differ from steady state heat conduction?	
	7	What is Fourier number? What is its physical significance?	
	8	Define critical Reynolds number in case of flow over flat plate. What is its numerical value?	
	9	Define thermal entry length for flow in circular tube.	
	10	Define volumetric expansion coefficient.	
	11	Write Momentum equation and Energy equation for laminar boundary layer.	
	12	What is a black body? What are its properties?	
	13	What do you mean by spectral and total emissivity?	
	14	Define the effectiveness and NTU of heat exchanger.	
Q.2	**(a)**	What is grey body approximation? Explain how the average emissivity of a grey surface can be determined?	**03**
	(b)	What is Radiosity (J)? Show that the net radiant energy leaving the surface is given by $Q = \frac{A\varepsilon\left(E_b - J\right)}{1-\varepsilon}$	**04**
	(c)	A spherical liquid oxygen tank 0.3 m in diameter is enclosed concentrically in a spherical container of 0.4 m diameter and the space in between is evacuated. The tank surface is at -183°C and has an emissivity 0.2. The container surface is at 15°C and has an emissivity of 0.25. Determine the net radiant heat transfer rate and rate of evaporation of liquid oxygen if its latent heat is 220 kJ/kg.	**07**
		OR	
	(c)	(a) Explain Wien's displacement law of radiation. (b) Explain Kirchoff's law of radiation.	**07**
Q.3	**(a)**	Differentiate mean film temperature and bulk mean temperature.	**03**
	(b)	Explain the physical significance of following numbers (a) Nusselt number (b) Grashof number	**04**
	(c)	Air at 27°C is flowing across a tube with a velocity of 25 m/s. The tube could be either a square of 5 cm side or circular cylinder of 5 cm diameter. Compare the rate of heat transfer in each case if the tube surface is at 127°C. Use the correlation: $Nu = C\,\mathrm{Re}^n\,\mathrm{Pr}^{1/3}$ C = 0.027, n = 0.805 for cylinder	**07**

C = 0.102, n = 0.675 for square tube
Use following properties of air

$\rho = 0.955$ kg/m^3, $k_f = 0.03$ W/mK, $\upsilon = 20.92\times10^{-6}$ m^2/s,

$C_p = 1.009$ kJ/kgK, Pr = 0.7

OR

Q.3	**(a)**	What do you mean by hydrodynamically developed flow?	**03**
	(b)	Explain Chilton Colburn analogy for turbulent flow inside a smooth tube.	**04**
	(c)	Water at 20°C enters a 2 cm diameter tube with a velocity of 1.5 m/s. The tube is maintained at 100°C. Find the tube length required to heat the water to a temperature of 60°C. Use following properties of water $\rho = 992.2$ kg/m^3, $k_f = 0.634$ W/mK, $\upsilon = 0.659\times10^{-6}$ m^2/s, $C_p = 4174$ J/kgK, Pr = 4.31	**07**
Q.4	**(a)**	A plane wall of thickness L is subjected to a heat flux q_0 at its left surface, while its right surface dissipates heat by convection with a heat transfer coefficient h in to an ambient at T_∞. Write the boundary conditions at the two surfaces of the wall.	**03**
	(b)	Explain shortly (a) efficiency and effectiveness of fin (b) time constant and response of thermocouple	**04**
	(c)	Write the governing differential equation for conduction heat transfer in spherical coordinate. Show that the resistance offered by it is given as $R_{sph} = \dfrac{r_2 - r_1}{4\pi k r_1 r_2}$	**07**

OR

Q.4	**(a)**	What is lumped system analysis? What are the assumption made in the lumped system analysis and when it is applicable?	**03**
	(b)	If the general solution for temperature distribution in fin is given by $T - T_\infty = C_1 e^{-mx} + C_2 e^{mx}$ where C_1 and C_2 are constant, show that the temperature distribution in infinite long fin is $\dfrac{T - T_\infty}{T_0 - T_\infty} = e^{-mx}$	**04**
	(c)	A steam pipe is covered with two layered of insulation, first layer being 3 cm thick and second 5 cm. The pipe is made of steel (k = 58 W/mK) having ID of 160 mm and OD of 170 mm. The inside and outside film coefficients are 30 and 5.8 W/m^{2}K respectively. Calculate the heat loss per meter of pipe if the steam temperature is 300°C and air temperature 50°C. The thermal conductivity of two insulating materials are 0.17 and 0.093 W/mK respectively.	**07**
Q.5	**(a)**	Explain multi pass heat exchanger including correction factor. Where it is used.	**03**
	(b)	Explain working of storage type heat exchanger and direct contact type heat exchanger with example.	**04**
	(c)	prove that the effectiveness of parallel flow heat exchanger is given by $\varepsilon = \dfrac{1-\exp\left[-NTU\left(1+C\right)\right]}{1+C}$	**07**

OR

Q.5	**(a)**	Discuss the conditions under which the drop wise condensation can take place. Why the rate of heat transfer in drop wise condensation is many time that of film condensation.	**03**
	(b)	(a)What is critical heat flux? How it is useful to designers of heat	**04**

exchangers?

(b) Calculate the critical heat flux for mercury at 1 atm. Use the following properties of mercury

$h_{fg} = 301$ kJ/kg, $\rho_v = 3.90$ kg/m^3, $\rho_l = 12740$ kg/m^3, $\sigma = 417 \times 10^{-3}$ Nm

Use modified Zuber-Kutateladze correlation

$$q_{\max} = 0.149 \rho_v^{1/2} h_{fg} \left[\sigma g \left(\rho_l - \rho_v \right) \right]^{1/4}$$

(c) A vertical plate 0.4 m high and 0.41 m wide at 50°C is exposed to steam at 100°C. Calculate the following **07**

(a) Film thickness at bottom of the plate

(b) Maximum velocity at the bottom of the plate

(c) Total heat transfer rate and heat flux

Assume at mean temperature of 75°C

$\rho = 976$ kg/m^3, $k_f = 0.668$ W/mK, $\mu = 405 \times 10^{-6}$ kg/ms,

$h_{fg} = 2258$ kJ/kg

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