Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–V (NEW) EXAMINATION – WINTER 2020

Subject Code:3151909 Date:27/01/2021

Subject Name:Heat Transfer

Time:10:30 AM TO 12:30 PM Total Marks: 56

Instructions:

1. **Attempt any FOUR questions out of EIGHT questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1	**(a)**	Explain aims to study 'Heat Transfer'?	**03**
	(b)	Differentiate between: 1) Conduction and radiation. 2) Counter-flow and parallel flow heat exchanger.	**04**
	(c)	What is meant by thermal resistance? Explain the electrical analogy for solving heat transfer problems.	**07**
Q.2	**(a)**	Use of aluminum material as a cooking utensils are not desirable. Evaluate.	**03**
	(b)	Give broad classification of heat exchangers.	**04**
	(c)	Write the most general equation in Cartesian co-ordinates for heat transfer by conduction. Deduce above equation for the following cases with suitable assumptions; (i) Laplace equation, (ii) Poisson equation, and (iii) Fourier equation.	**07**
Q.3	**(a)**	In cold regions, instead of using one thick glass, two thin window glasses are preferred. Justify.	**03**
	(b)	Differentiate between: 1) Nusselt number and Reynolds number. 2) Free convection and forced convection.	**04**
	(c)	A cylinder in vertical position is having dimension of 18 cm diameter and length 1.5 m is maintained at a temperature of 100^0C. It is kept in atmosphere having temperature 20^0C. Calculate the heat lost by cylinder surface to the atmosphere by free convection. Properties of air at mean film temperature 60^0C are as follows : ρ=1.06kg/m^3, υ=18.97*10^{-6}m^2/s, k=0.1042kJ/m.hr.^{0}C, Cp=1.004kJ/kg^{0}C. Use the relation Nu=0.10(Gr.Pr)$^{1/3}$ (The symbols have their usual meanings)	**07**
Q.4	**(a)**	'It is desirable to use two thin fins instead of one thick fin for engine cooling'. Give reason.	**03**
	(b)	Write the general differential equation in Cartesian co-ordinates for 3-D unsteady heat conduction by considering an infinitesimal volume element. Deduce there from the conduction equations for the following cases; (i) Steady state 1-D flow with heat generation at uniform rate within material, (ii) Unsteady 2-D flow without heat generation.	**04**
	(c)	Consider two large parallel plates, one at 1000K with emissivity 0.8 and other is at 300K having emissivity 0.6. A radiation shield is	**07**

placed between them. The shield has emissivity as 0.1 on the side facing hot plate and 0.3 on the side facing cold plate.
Calculate percentage reduction in radiation heat transfer as a result of radiation shield.

Q.5 **(a)** Give applications of heat exchangers. **03**

(b) What is insulation? State its four applications in engineering field. **04**

(c) What is condensation? Explain film-wise condensation and drop-wise condensation. **07**

Q.6 **(a)** It is desirable to wear white clothes instead of black during the summer season. Give reason. **03**

(b) Give eight examples related to heat transfer from the routine life. **04**

(c) Derive the equation of LMTD for counter-flow heat exchangers. **07**

Q.7 **(a)** ‘Radiator of automobiles is always painted black’. Give reason. **03**

(b) Define shape factor. Discuss salient features of shape factor. **04**

(c) An egg with mean diameter of 4 cm and initially at 20^0C is placed in a boiling water pan for 4 minutes and found to be boiled to the consumer’s test. For how long should a similar egg for same consumer be boiled when taken from a refrigerator at 5^0C. Take following properties for egg :
$k = 10 W/m^0C$, $\rho = 1200 kg/m^3$, $C = 2 kJ/kg^0C$, $h = 100 W/m^2\, ^0C$ **07**

Q.8 **(a)** During the summer season, vegetable vendors are sprinkling water to keep the vegetable fresh. Evaluate in light of heat transfer. **03**

(b) Draw temperature variation for condenser and evaporator of thermal power plant. **04**

(c) Using dimensional analysis, obtain a general form of equation for forced convective heat transfer. **07**

****

Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – WINTER 2021

Subject Code:3151909 Date:01/01/2022

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**

			MARKS
Q.1	**(a)**	What are three modes of heat transfer? Explain their differences briefly with example.	**03**
	(b)	Draw the sketch of variation of temperature along the length for parallel and counter flow heat exchangers and write their comparisons.	**04**
	(c)	A roof of the electrically heated home is 6 m long, 8 m wide and 0.25 m thick and is made of a concrete layer whose thermal conductivity is 1.0 W/m-k. The temperature of the inner and the outer surfaces of the roof are measured to be 30 °C and 15 °C respectively for a period of 12 hours. Assume steady state condition for the mentioned period of 12 hours. Determine: 1. The rate of heat loss through the roof and 2. The cost of heat loss to the home owner if the cost of electricity is Rs 0.5/kWh.	**07**
Q.2	**(a)**	Explain and differentiate natural and forced convection.	**03**
	(b)	With neat sketch explain the heat conduction through a plan wall with and without heat generation.	**04**
	(c)	Determine the amount of heat transferred through a pin fin made of aluminum, length 50 mm, width 100 mm and thickness of 5 mm. The temperature at the base of the fin is 80 °C. Take thermal conductivity k = 210 W/m°C and heat transfer coefficient h=42 W/m^2K. Also determine the temperature at tip of the fin, if the atmospheric temperature is 30 °C.	**07**
		OR	
	(c)	What is the limitation of Rayleigh's method of dimensional analysis? Which method is preferred in such case and how repeating variables are selected?	**07**
Q.3	**(a)**	What do you understand by absorptivity? How can it be improved for an opaque body?	**03**
	(b)	Prove with the usual notations that the Reynolds number for flow in a circular tube of diameter (d) can be expressed as $Re=4m/\pi d\mu$.	**04**
	(c)	Define Boit number. What is the physical significance of it? The Biot number during a heat transfer process between sphere and it surrounding is 0.02. Would you use lumped system analysis for determining the centre temperature of the sphere? Why?	**07**
		OR	
Q.3	**(a)**	What is a compact heat exchanger? Write their key areas of applications.	**03**
	(b)	State the regimes of pool boiling and define process of condensation.	**04**
	(c)	In a thermal power plant heat loss is to be minimized in a 240 mm steam main which is 210 meter long and is covered with two insulation materials. First 50	**07**

mm of high temperature insulation (k=0.092 W/m°C) and 40 mm of low temperature insulation (k=0.062 W/m°C). The inner and outer surface temperatures as measured are 390 °C and 40 °C respectively. Neglecting heat conduction through pipe material Determine:

1. The total heat loss per hour.
2. The temperature between two layers of insulation.

Q.4	**(a)**	What do you understand by fouling factor in case of heat exchanger? List the causes of fouling.	**03**
	(b)	Derive the Stefan-Boltzmann law from the Plank's law of thermal radiation. What is the value of Stefan-Boltzmann constant?	**04**
	(c)	A potato having mean diameter of 50 mm and initially at 25 °C is placed in boiling water for 4 minutes and found to be boiled to the desired level. For how long should a similar potato should be boiled in the same environment and for the same level when taken from the cold storage at 10 °C. Take the following properties for potato K=10 W/m °C, ρ = 1200 kg/m^3, c = 2000 J/kg °C, h = 100 W/m^2 °C and Use Lump Theory.	**07**

OR

Q.4	**(a)**	What do you understand by TEMA charts? How are they useful in the design of multi-pass heat exchangers.	**03**
	(b)	How is the thermal performance of a fin measured? Explain fin efficiency and effectiveness.	**04**
	(c)	Explain geometric similarity, kinematic similarity and dynamic similarity with example.	**07**
Q.5	**(a)**	List the good characteristics of thermal insulating material?	**03**
	(b)	Define radiation heat transfer coefficient? On what factor does it depend?	**04**
	(c)	In a certain mechanical industry a counter flow heat exchanger is to be used to cool the air from 540 °C to 145 °C. The flow rate of air is 12.5 kg/s and heat exchanger contains 4200 tubes each having a diameter of 30 mm. The sea water is to be used to cool the air and water enters the heat exchanger at 25 °C and leaves at 75 °C. If the water side resistance to flow is negligible, calculate the tube length required for this heat duty. For turbulent flow inside tubes use Nu = 0.023 Re$^{0.8}$ Pr$^{0.4}$ and mass flow m = NAρV where N= number of tubes The properties of the air at the average temperature are as follows: K=0.003 W/m °C, ρ = 1.09 kg/m^3, c_p = 1.008 kJ/kg °C, μ = 2.075 × 10^{-5} kg/ms (Ns/m^2)	**07**

OR

Q.5	**(a)**	Explain Displacement thickness, Momentum thickness and Energy thickness.	**03**
	(b)	Write a short note of critical radius of insulation.	**04**
	(c)	What do you understand by NTU method in case of heat transfer? Derive its expression following the usual notations for parallel flow heat exchanger.	**07**

****

Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – SUMMER 2021

Subject Code:3151909 Date:09/09/2021

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.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Write any three assumptions of Nusselt theory for film condensation.	**03**
	(b)	Draw boiling curve for water at 1 atm. Pressure and Represent different regimes on that.	**04**
	(c)	Steam enters a counter flow heat exchanger dry saturated at 10 bar and leaves at 350 ^{0}C. The mass flow of steam is 800 kg/min. the gas enters the heat exchanger at 650 ^{0}C and mass flow rate is 1350 kg/min. if the tubes are 30mm diameter and 3m long. Determine the number of tubes required. Neglect the resistance offered by metallic tubes. Use following data : Tsat = 180 ^{0}C (At 10 bar) Cps =2.71 kJ/kg-K Cpg =1 kJ/kg-K Heat transfer co-efficient steam side = 600 W/m^2-K Heat transfer co-efficient gas side = 250 W/m^2-K	**07**
Q.2	**(a)**	Define : 1) Critical thickness of insulation for cylinder 2) Thermal diffusivity 3) Thermal resistance	**03**
	(b)	Determine the overall heat transfer coefficient U_0 based on the outer surface of a 2.54 cm O.D 2.286 cm I.D. heat exchanger tube (K= 102 W/mK).If the heat transfer co-efficient at the inside and outside of the tube are hi = 5500 W/m^{2}K and ho = 3800 W/ m^{2}K respectively and the fouling factors are R_{fi} = R_{fo} = 0.0002 m^2-K/W	**04**
	(c)	Superheated steam at 330^{0}C is flowing at 20m/s velocity (h = 110 W/m^{2}K) through a pipe 120 mm in diameter. The temperature of steam is to be measured by putting a pocket in the pipe of 15mm ID and 1mm thickness. Pocket material thermal conductivity is 50W/m^{2}K. 1) Determine length of insertion so that error in the thermometer is 0.5%. 2) If pipe wall is maintained at temperature of 40^{0}C ,find temperature measured by thermometer.	**07**
		OR	
	(c)	A cylindrical hot ingot of 50mm diameter and 200mm long is	**07**

taken out from the furnace at 800^0C and dipped into the water till its temperature becomes 500^0C. After that it is exposed to air till its temperature becomes 100^0C. Find the total time required to reduce its temperature from 800^0C to 100^0C.
Use following data:
k for ingot = 60 W/m-K.
specific heat for ingot = 200 J/m-K
h_{air} =20 W/m^2-K ,h_{water} = 200 W/m^2-K
Density of ingot material = 800kg/m^3
Temperature of water and air both = 30^0C

Q.3 **(a)** Differentiate fin efficiency and fin effectiveness. **03**

(b) Prove that logarithmic mean area of hollow sphere is geometric mean of its inner and outer surface area. **04**

(c) A standard cast iron pipe ID = 50mm and OD =55mm is insulated with 85% Magnesium insulation (k = 0.02W/m-K). Temperature at the interface between the pipe and insulation is 300^oC. The allowable heat loss through the pipe is 600 W per meter length of pipe and the safety, The temperature of the outside surface of insulation must not exceed 100^0C. **07**
Determine :
1) Minimum thickness of insulation required
2) The temperature of inside surface of the pipe assuming its thermal conductivity 20 W/m-K.

OR

Q.3 **(a)** Define time constant of thermocouple and state parameters which affect time constant of thermocouple. **03**

(b) "Generally fin is provided to increase the heat transfer rate but by providing fin heat transfer may decrease" Justify the statement analytically. **04**

(c) A 240mm steam main 210 m long is covered with 50mm high temperature insulation (k = 0.092 W/m-K) and 40 mm of low temperature insulation (k = 0.062 W/m-K). The inner and outer surface temperatures are measured 390^0C and 40^0C respectively. Calculate **07**
1) Total heat loss per hour
2) The temperate at two insulation interface
3) The heat loss per unit outer surface area.

Q.4 **(a)** Define thermal boundary layer and hydrodynamic boundary layer. Draw them for very low Prandtl number fluid. **03**

(b) Air at 27^OC and 1 atm. flow over a flat plate at a speed of 2m/s. Calculate boundary layer thickness at a distance 40 cm from leading edge of plate. At 27^OC viscosity (air) = 1.85 *10^{-5} kg/m-s. **04**

(c) Ait at 1 bar and a temperature 30^0C, dynamic viscosity = 0.06717 kg-ms flows at a speed of 1.2m/s over a flat plate. Determine the boundary layer thickness at of 250mm and 500mm from the leading edge of the plate. Also calculate the mass entrapment between these two sections. Assume the parabolic velocity distribution as: **07**

$$\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

OR

Q.4 **(a)** Write the value of critical Reynolds Number for flow over a flat plate. Differentiate viscous sub layer and buffer layer. **03**

(b) Velocity distribution in the boundary layer is given by **04**

$\frac{u}{U} = \frac{y}{\delta}$, where u is velocity at distance y from the plate and at y = δ, u =U. Calculate energy thickness.

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

Q.5 **(a)** State Wien's displacement law and write its significance. **03**

(b) With respect to shape factor explain : **04**

1) Superposition rule
2) Summation rule

(c) Consider two large parallel plates one at 727^0C with the emissivity 0.8 and other 227^0C with the emissivity 0.4. A plate of emissivity 0.05 on the both the sides is placed between the plates. Calculate percentage reduction in the heat transfer rate between the two plates as a result of the shield. **07**

OR

Q.5 **(a)** Define gray body. Differentiate between surface resistance and space resistance w.r.to radiation heat transfer between two grey bodies. **03**

(b) Calculate the shape factor of cylinder cavity w.r.to itself. Take depth of cavity h and diameter of cylinder is d. it is enclosed with flat surface. **04**

(c) Define radiation shield. Prove that if radiation shield of the emissivity same as the emissivity of two parallel plate is inserted between two parallel plates net heat transfer rate due to radiation is reduced to half as compared to without shield. **07**

****

Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V(NEW) EXAMINATION – SUMMER 2022

Subject Code:3151909 **Date:04/06/2022**

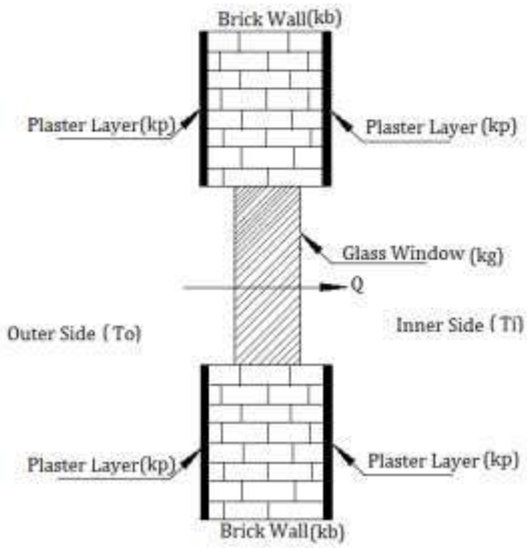
Subject Name:Heat Transfer

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.**

			MARKS
Q.1	**(a)**	State how density of fluid play an important role in natural convection heat transfer?	**03**
	(b)	Write Fourier rate equation of heat transfer by conduction. Give units of each parameter appearing in this equation.	**04**
	(c)	Derive general heat conduction equation in Cartesian coordinates and prove that the steady state heat transfer equation without heat generation is $\frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2} + \frac{\partial^2 t}{\partial z^2} = 0$	**07**
Q.2	**(a)**	As shown in the figure, thickness of plaster is t_p, thickness of glass window is t_g, thickness of brick wall is t_b, and the thermal conductivity for plaster, brick wall and glass is k_p, k_b and k_g respectively. Inner temperature is T_i and outer temperature is T_o. Draw thermal circuit for the given figure and write equation of heat transfer.	**03**



	(b)	Give applications with explanation where poor thermal conductivity of air restricts the heat transmission by conduction.	**04**
	(c)	A steel rod of thermal conductivity **30**W/m-deg is **1** cm in diameter and **5** cm long protrudes from a wall which is maintained at **100°C**. The rod is insulated at the tip and is exposed to an environment with convective heat transfer coefficient of **50**W/m^2-deg and t_a=**30**°C. Calculate the fin efficiency, temperature at the tip of fin and the rate of heat dissipation.	**07**

OR

(c) A thermometric pocket is a hollow tube of thermal conductivity of **82** W/m-deg having outer and inner diameter of **18**mm and **12**mm respectively. The pocket extends upto **6**cm depth from the wall of a **18**cm diameter tube which carries hot fluid. The heat transfer coefficient between the pocket and fluid is prescribed by the following relation **07**

$\mathbf{N_u=0.175(Re)^{0.62}}$

Make the calculations for the error in temperature measurement. Considering following data:

Fluid temperature is **150°**C and tube wall temperature **50°**C. Reynolds Number is **25000** and thermal conductivity of fluid is **0.04** W/m-deg.

Q.3 **(a)** Enlist factors need consideration for the optimum design of fins. **03**

(b) Show the temperature variation along the length of heat exchanger when **04**

(1) Steam condenses on the outside of a condenser tube with water flowing inside the tube as coolant

(2) Hot fluid used for evaporating another liquid

(c) Working in terms of inlet and outlet temperatures of the fluids and overall heat transfer coefficient, develop an expression for the heat transfer from one fluid to another in a conventional parallel flow heat exchanger. **07**

OR

Q.3 **(a)** Explain meaning of following as applied to heat exchangers: **03**

(1) Heat capacity ratio,

(2) Effectiveness and

(3) Number of Transfer Units.

(b) In a chemical plant, a chemical solution is heated from **-15**°C to **-8.5°**C in tube in tube parallel flow heat exchanger by a fluid entering at **40**°C and leaving at **25.5**°C at the rate of **10** kg/min. Determine the heat exchanger area for an overall heat transfer coefficient of **850**W/m^{2}K. For fluid C_P = **4186**J/kgK. **04**

(c) In an application of heat exchanger, the exhaust gas is used to heat the compressed air so that capacity ratio is very close to unity. Under this situation, show that **07**

$\epsilon = \frac{1}{2}[1 - \exp(-2NTU)]$ for parallel flow heat exchanger

Q.4 **(a)** List the salient features of a black body radiation. **03**

(b) Radiant energy with an intensity of **800**W/m^2 strikes a flat plate normally. The absorptivity is twice the transmitivity and trice the reflectivity. Determine the rate of absorption, transmission and reflection of energy. **04**

(c) Prove that total emissive power of a diffused surface is equal to π times its intensity of radiation. **07**

OR

Q.4 **(a)** Give statements of: **03**

(a) Kirchoff's Law

(b) Stefan-Boltzman Law

(c) Wein's displacement Law

(b) Prove that $\varepsilon = \frac{E}{E_b}$ where ε is the emissivity of the body, E is the emissive power of the body and E_b is the emissive power of the black body. **04**

(c) The temperature of the flame in a furnace is **1900** K. Take $\mathbf{C_1=0.374x10^{-15}Wm^2, C_2=14.4x10^{-3}mK}$. **07**

Find:

1. Monochromatic energy emission at **1**μ per m^2
2. λ_{max}
3. Monochromatic energy emission at λ_{max} and at **1900** K.
4. Total energy emitted/m^2.

Q.5 **(a)** Using usual notations, write dimensions of **03**

(1) Dynamic viscosity
(2) Thermal Conductivity
(3) Specific Heat

(b) A steam pipe **60**mm in diameter and **3** meter long has been placed horizontal in still air environment at **20**°C. If the pipe wall is maintained at **300**°C, determine the rate of heat loss. At the mean temperature of **160**°C, the thermophysical properties of air are as follow: **04**

$\boldsymbol{k}$ **= 3.64x10^{-2}W/m-deg**

$\boldsymbol{\nu}$ **= 30.09x10^{-6} m^2/sec**

Pr = 0.682 and

$\boldsymbol{\beta = \frac{1}{160+273} = 2.32x10^{-3}\, per\ K}$

Use following relation for convective heat transfer coefficient,

Nu=0.53(Gr.Pr)$^{0.25}$

(c) Prove that the temperature of a body at any time τ during Newtonian heating or cooling is given by **07**

$$\frac{t - t_a}{t_i - t_a} = exp[-B_i F_o]$$

Where Bi is Biot Number, Fo is Fourier Number, t_a is the ambient temperature and t_i is the initial temperature of the body

OR

Q.5 **(a)** State advantages of dimensional analysis. **03**

(b) What assumptions are to be made while deriving differential equation for hydrodynamic boundary layer? **04**

(c) A large vertical flat plate **3** m high and **2** m wide is maintained at **75**°C and is exposed to atmosphere at **25**°C. Calculate the rate of heat transfer. **07**

The thermophysical properties of air are evaluated at the mean temperature and are as follow:

ρ **= 1.088 kg/m^3; C_p = 1.00 kJ/kg.K;**

μ **= 1.96 × 10^{-5} Pa-s k = 0.028 W/mK.**

Pr = 0.7

Use the following correlation for convective heat transfer coefficient $\boldsymbol{N_u = 0.1(Gr.Pr)^{1/3}}$

****