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

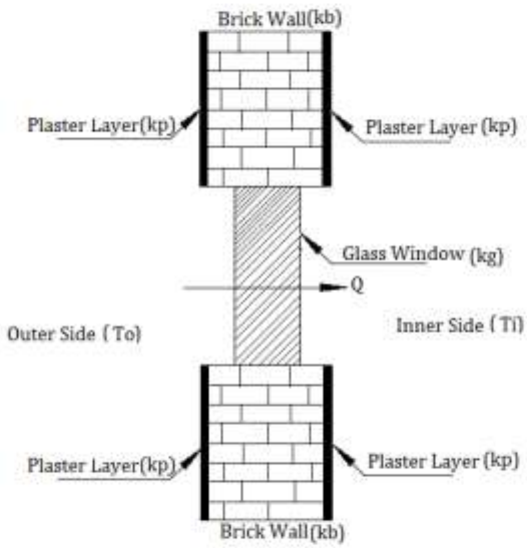
Q.1 **(a)** State how density of fluid play an important role in natural convection heat transfer? **03**

(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 **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)** 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**

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

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

Pr = 0.682 and

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

Use following relation for convective heat transfer coefficient,

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

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

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

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/m³; $\mathbf{C_p}$ = 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 $\boldsymbol{N_u = 0.1(Gr.Pr)^{1/3}}$

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