Seat No./Enrollment No.: ________

GUJARAT TECHNOLOGICAL UNIVERSITY

BACHELOR OF ENGINEERING – SEMESTER 5 – EXAMINATION – SUMMER 2026

Subject Code: 3151909 **Date: 25/05/2026**

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.

Q.1 **(a)** Define: 1) Conduction heat transfer **03**
2) Thermal diffusivity
3) Thermal resistance

(b) Explain mean film temperature and bulk mean temperature. **04**

(c) Derive general heat conduction equation in Cartesian coordinates and prove that the steady state heat transfer equation without heat generation is **07**

$$\frac{\partial^2 t}{\partial x^2}+\frac{\partial^2 t}{\partial y^2}+\frac{\partial^2 t}{\partial z^2}=0$$

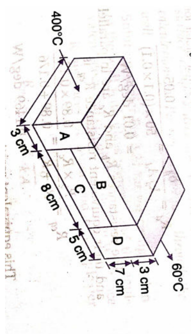
Q.2 **(a)** Define thermal boundary layer and hydrodynamic boundary layer. **03**

(b) The velocity distribution in the boundary layer is given by: $\frac{u}{U}=\frac{y}{\delta}$, where u is the velocity at a distance y from the plate and u = U at y =δ, where δ being boundary layer thickness. Find : (i) The displacement thickness, (ii) The momentum thickness, (iii) The energy thickness, and (iv) The value of $\frac{\delta^*}{\theta}$. **04**

(c) A steel pipe of 20 mm inner diameter and 2 mm thickness is covered with 20 mm thick of fiber glass insulation (k = 0.05W/ m deg). If the inside and outside convective coefficients are 10 W/ m2 deg and 5 W/ m2 deg, Calculate the overall heat transfer coefficient based on inside diameter of pipe. **07**

OR

Q.2 **(c)** Calculate the heat flow rate through the composite wall as shown in figure. Assume 1 D flow and take **07**
ka = 150W/ m deg
kb = 30 W/ m deg
kc = 65 W/ m deg
kd = 50 W/ m deg



Q.3 **(a)** Define: Fourier number and Biot number in context of lumped system analysis. **03**

(b) List the applications of Fin and explain how a fin enhances heat transfer at the surface **04**

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

OR

Q.3 **(a)** Define Fin Efficiency, Fin effectiveness with expressions. **03**

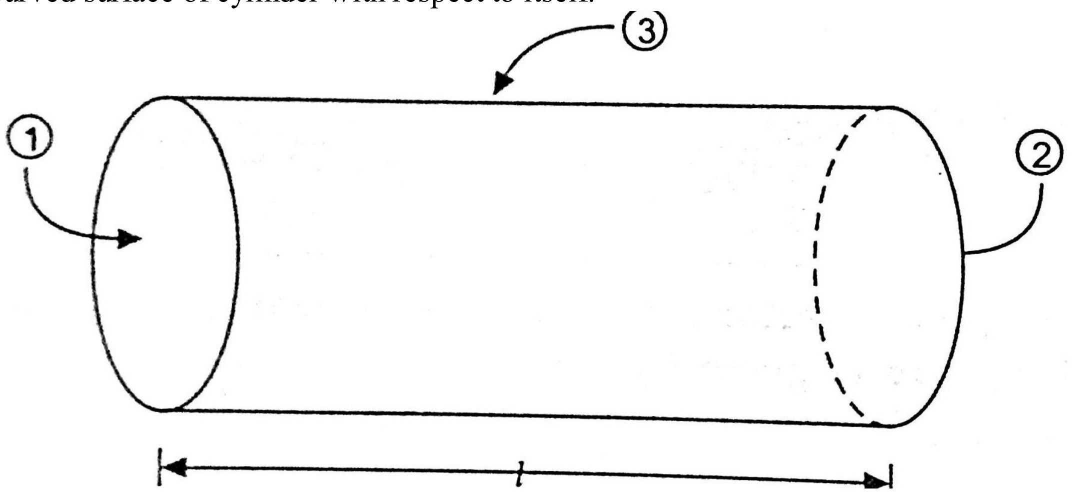
(b) Explain Critical radius of Insulation for cylinder. **04**

(c) A steel rod (k= 30W/m – deg) 1 cm in diameter and 5 cm long protrudes form a wall which is maintained at 100° C. the rod is insulated at its tip and is exposed to an environment with h = 50W/m2 –deg and ta = 30°C. Calculate the fin efficiency, temperature at the tip of fin and the rate of heat dissipation. **07**

Q.4 **(a)** Define Black body, White body, Gray body. **03**

(b) Explain the utility of radiation shields. **04**

(c) Consider a thin hollow cylinder of 8 cm diameter and 10 cm length. If the radiant shape factor of the circular surface of this cylinder is 0.172, find the shape factor of curved surface of cylinder with respect to itself. **07**



OR

Q.4 **(a)** Define shape factor and list any two salient features of it. **03**

(b) A polished metal pipe 50cm outside diameter and 370K 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/m2 deg. Calculate the heat transfer by radiation and natural convection per meter length of the pipe. Take thermal radiation constant $\sigma b = 5.67x\ 10^{-8}$ W/ m2 deg K4. Find the overall heat transfer coefficient of heat by combined mode of convection and radiation. **04**

(c) Define Intensity of radiation. Prove that the intensity of normal radiation is $1/\pi$ times the total emissive power. **07**

Q.5 **(a)** Differentiate Filmwise and Dropwise condensation. Which type has higher heat transfer film condensation and why? **03**

(b) Classify Heat Exchangers **04**

(c) Hot water having specific heat 4200J/kg K flows through a heat exchanger at the rate of 4 kg/min with an inlet temperature of 100 °C. A cold fluid having a specific heat 2400J/kg K flows in at a rate of 8 kg/min and with inlet temperature 20° C. Make calculations for the maximum possible effectiveness if the fluid flow conforms to a) parallel flow arrangement b)counter flow arrangement. **07**

OR

Q.5 **(a)** Draw the Boiling curve for water showing various regimes. **03**

(b) Show the temperature variation along length of heat exchanger when: **04**
1. Hot and cold fluids flow in parallel and counter flow.
2.Steam condenses on outside of condenser tube with water flowing inside the tube as coolant.
3.Hot fluid as used for evaporating another liquid.

(c) In a counter flow heat exchanger, oil(cp = 3KJ/kg-K at the rate of 1400 kg/hr is cooled from 100 °C to 30 °C by water that enters the exchanger at 20 °C at the rate of 1300 kg/hr. Determine the heat exchanger area for an overall heat transfer coefficient of 3975 KJ/ m^2-hr-K **07**

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Enrolment No./Seat No_______________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V EXAMINATION – SUMMER 2025

Subject Code:3151909 Date:15-05-2025

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.**
5. **Assume suitable data if required**

			MARKS
Q.1	**(a)**	Define steady-state heat conduction. How does it differ from transient heat conduction?	**03**
	(b)	Explain Fourier's law of heat conduction. How does the temperature dependency of thermal conductivity vary for gases compared to solids?	**04**
	(c)	With usual notations derive general heat conduction equation in Cartesian coordinates and explain its significance.	**07**
Q.2	**(a)**	Derive the formula for the critical radius of insulation for a spherical object. Why does the rate of heat transfer initially decrease with insulation and then increase?	**03**
	(b)	What applications of heat exchangers? Classify heat exchangers	**04**
	(c)	What are compact heat exchangers, Discuss the design and construction features of compact heat exchangers.	**07**
		OR	
	(c)	With usual notations derive the expression for effectiveness for a parallel flow heat exchanger.	**07**
Q.3	**(a)**	Define the Biot number and explain its significance in determining the applicability of the lumped capacitance method.	**03**
	(b)	What are fins, and why are they used in heat transfer applications? What are the advantages and limitations of using fins for heat transfer enhancement?	**04**
	(c)	Derive the expression for temperature distribution and heat transfer rate for a fin insulated at the tip.	**07**
		OR	
Q.3	**(a)**	Derive the governing equation for one-dimensional transient heat conduction in a plane wall with finite conduction and convective resistances.	**03**
	(b)	What is a thermometer well, and why are errors introduced during temperature measurements?	**04**
	(c)	With usual notations derive the generalized heat conduction equation in spherical coordinates and explain its specific applications.	**07**
Q.4	**(a)**	What are radiation shields, and how do they reduce heat transfer?	**03**
	(b)	What is the Von-Karman integral momentum equation, Explain the physical significance of the terms in the Von-Karman equation.	**04**
	(c)	Define the following dimensionless numbers and explain their physical significance: Reynolds number (Re), Nusselt number (Nu),	**07**

Prandtl number (Pr), Grashof number (Gr), Peclet number (Pe), Biot number (Bi)

OR

Q.4	**(a)**	Explain the physical significance of the momentum equation in fluid flow.	**03**
	(b)	Outline the assumptions made in deriving the Blasius solution for a laminar boundary layer and describe the steps involved in solving the Blasius equation for boundary layer thickness.	**04**
	(c)	Define the following terms : Reflectivity, transmissivity, Emissivity, Kirchhoff's law, Planck's law, Wien's law, Stefan-Boltzmann law.	**07**
Q.5	**(a)**	What is a shape factor, and why is it important in radiation heat exchange?	**03**
	(b)	Explain the significance of the overall heat transfer coefficient in heat exchanger analysis.	**04**
	(c)	Derive the expression for radiation heat exchange between two black bodies.	**07**

OR

Q.5	**(a)**	Distinguish between the hydrodynamic and thermal boundary layers..	**03**
	(b)	What is the fouling factor, and how does it affect the performance of a heat exchanger?	**04**
	(c)	Define the overall heat transfer coefficient and derive its expression for a heat exchanger. How does the overall heat transfer coefficient vary for single-phase and two-phase heat transfer?	**07**

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Enrolment No./Seat No_____________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – SUMMER 2024

Subject Code:3151909 Date:18-05-2024

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)**	Do as directed : 1) Define : Thermal diffusivity. 2) Arrange the material in descending order of their thermal conductivity; i) Water ii) Copper iii) Air and iv) Wood. 3) Define: Anisotropic material.	**03**
	(b)	Give four examples of free convection and four examples of forced convection observed from day to day life.	**04**
	(c)	Explain the following with reference to a heat exchanger: 1. Fouling factor, 2. Effectiveness of heat exchanger, 3. Correction factor for multipass arrangement.	**07**
Q.2	**(a)**	What do you mean by radiation shiled? Give two examples of use of radiation shield.	**03**
	(b)	With suirable example, explain in brief abour black body, white body, opquae body and transperant body.	**04**
	(c)	An aluminim fin (k = 200W/mK, 2.5cm long,1m width, and 3.5mm thick) protrudes from a wall. The base is at 420^0C and surrounding air temperature is 30^0C. Determine the heat dissipated from the fin and fin efficiency for the fin is of finite length and heat loss from fin tip is negligible. Take h = $11 W/m^2K$.	**07**
		OR	
	(c)	A furnace wall, 32 cm thick, is made up of an inner layer of brick (k=0.84W/mK) covered with a layer of insulation (k=0.16W/mK). The furnace operates at a temperature of 1325^0C and the ambient temperature is 25^0C. i) Determine the thickness of brick and insulation which gives minimum heat loss, ii) Calculate the heat loss presuming that the insulating material has a maximum temperature of 1200^0C. If the calculated heat loss is not accepted than state whether addition of another layer of insulation would provide a satisfactory solution.	**07**
Q.3	**(a)**	Explain mean film temperature and bulk mean temperature.	**03**
	(b)	Differentiate between boiling and condensation.	**04**
	(c)	Discuss the electrical analogy for radiant heat transfer.	**07**

OR

Q.3	**(a)**	Justify that a good absorber is also a good emitter for radiation heat transfer.	**03**
	(b)	Explain in detail about cross flow heat exchanger with its advantages. Give suitable examples.	**04**
	(c)	Define condensation process. Also explain film condensation and drop-wise condensation.	**07**
Q.4	**(a)**	'It is desirable to use two thin fins instead of one thick fin for engine cooling'. Give reason.	**03**
	(b)	What is insulation? State its four applications in engineering field.	**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**

OR

Q.4	**(a)**	Use of aluminum material as a cooking utensils are not desirable. Evaluate.	**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)	Explain physical significance of critical radius of insulation and derive an expression for the same critical radius in case of sphere.	**07**
Q.5	**(a)**	Differentiate natural and forced convection.	**03**
	(b)	State the similarities and difference between: 1) Nusselt number and Biot number, 2) Grashof Number and Reynold number.	**04**
	(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**

OR

Q.5	**(a)**	Define: Nusselt number, Grashof Number and Reynold number.	**03**
	(b)	State the governing law for convection heat transfer. Explain in brief about convection heat transfer coefficient.	**04**
	(c)	Using Buckingham–π theorem show that, $Nu = f\,(Re, Pr)$ for forced convection.	**07**

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Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER- V EXAMINATION-SUMMER 2023

Subject Code: 3151909 Date: 26/06/2023

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.**

Q.1 **(a)** Give difference between free and forced convection. **03**

(b) Explain the terms thermal diffusivity and thermal contact resistance. **04**

(c) A mild steel tank of wall thickness 10 mm contains water at 90° C. The thermal conductivity of mild steel is 50 W/m°C , and the heat transfer coefficient for inside and outside of the tank area are 2800 and 11 W/m^2 °C, respectively. If the atmospheric temperature is 20°C , calculate **07**
(i) The rate of heat loss per m^2 of the tank surface area.
(ii) The temperature of the outside surface tank.

Q.2 **(a)** A spherical shaped vessel of 1.2 m diameter is 100 mm thick. Find the rate of heat leakage, if the temperature difference between the inner and outer surfaces is 200° C. Thermal conductivity of material is 0.3 kJ /mh°C. **03**

(b) Write the general three dimensional heat conduction equation in **04**
i) Cylindrical coordinates
ii) Spherical coordinates

(c) A 12 cm diameter long bar initially at a uniform temperature of 40°C is placed in a medium at 650°C with a convective co efficient of 22 W/m^2K. Calculate the time required for the bar to reach 255^0C. Take k = 20W/mK, ρ = 580 kg/m^3 and c = 1050 J/kg K. **07**

OR

(c) A motor body is 360 mm in diameter (outside) and 240 mm long. Its surface temperature should not exceed 55 °C when dissipating 340 W. Longitudinal fins of 15 mm thickness and 40 mm height are proposed. The convection coefficient is 40W/m^2 °C. Determine the number of fins required. Atmospheric temperature is 30°C. Take thermal conductivity = 40 W/m°C. **07**

Q.3 **(a)** Explain Displacement thickness, Momentum thickness and Energy thickness. **03**

(b) Differentiate between steady state and transient heat conduction and give some examples of unsteady state heat conduction. **04**

(c) For natural convection heat transfer, show that Nu = C (Pr^n , Gr^m). **07**

OR

Q.3 **(a)** Define radiation. State the range of wavelengths for ultraviolet, visible and thermal radiations. **03**

(b) Discuss the significance of Prandtl, Nusselt and Stanton numbers in convection. **04**

(c) Define and discuss velocity boundary layer and thermal boundary layer over a flat plate. Show the thickness of thee layers for different Prandtl numbers. **07**

Q.4 **(a)** Explain the terms absorptivity, reflectivity and transmissivity of radiant energy. **03**

(b) The filament of a 75 W light bulb may be considered as a black body radiating into a black enclosure at 70^0 C. the filament diameter is 0.10 mm and length is 5 cm. Considering the radiation, determine the filament temperature . **04**

(c) State and prove Kirchhoff's law. **07**

OR

Q.4 **(a)** Calculate the shape factor for cylindrical cavity shown in Fig. 1 with respect to itself. **03**

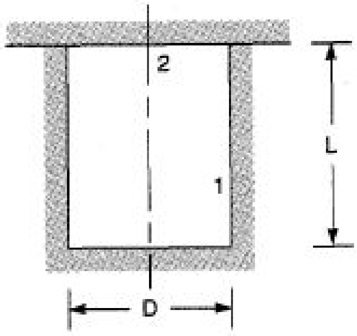


Fig. 1

(b) Define Heat exchanger. Give classification of heat exchangers. **04**

(c) Define intensity of radiation and show that for a unit surface the intensity of normal radiation is $1/\pi$ times the total emissive power. **07**

Q.5 **(a)** What do you understand by fouling factor in case of heat exchanger? List the causes of fouling. **03**

(b) Define and explain types of condensation. **04**

(c) What is boiling? Explain different regimes of boiling. **07**

OR

Q.5 **(a)** What do you understand by TEMA charts? How are they useful in the design of multi-pass heat exchangers. **03**

(b) Differentiate between pool boiling and forced convection boiling. **04**

(c) Derive LMTD formula for counter flow heat exchanger. **07**

Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:3151909 Date:04/06/2022

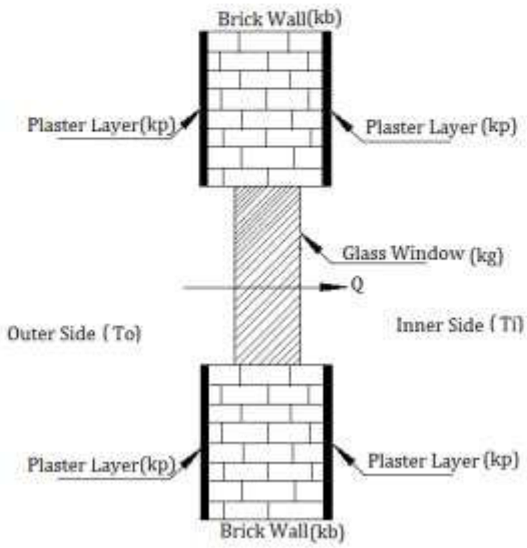
Subject Name:Heat Transfer

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 **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**

***k* = 3.64x10^{-2}W/m-deg**
***ν* = 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 $\boldsymbol{N_u = 0.1(Gr.Pr)^{1/3}}$

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