Enrollment No./Seat No.:

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering - SEMESTER - V EXAMINATION - WINTER 2025

Subject Code: 3151909 **Date: 19-11-2025**

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)**	How does the heat conduction differ from convection?	**03**
	(b)	What is lumped heat capacity analysis? List out the assumptions made in lumped heat capacity analysis.	**04**
	(c)	Derive expression for temperature distribution under one dimensional steady state heat conduction for plane wall.	**07**
Q.2	**(a)**	Define thermal capacity and thermal diffusivity of a material.	**03**
	(b)	Explain the criteria of selection of fins.	**04**
	(c)	Explain following: 1. Fin efficiency 2. Fin effectiveness	**07**
		OR	
	(c)	Derive the heat conduction equation through composite wall.	**07**
Q.3	**(a)**	Sate comparison between natural and forced convection heat transfer.	**03**
	(b)	Explain Newton's law of cooling and convection heat transfer coefficient	**04**
	(c)	Derive the two dimensional energy equation for thermal boundary layer over a flat plate.	**07**
		OR	
	(a)	Explain that heat transfer coefficient for free convection is lower than forced convection.	**03**
	(b)	Explain physical significance of following dimensionless numbers: 1. Grashoff number 2. Reynolds number	**04**
	(c)	By dimensional analysis show that for forced convection, $Nu = f(Re, Pr)$	**07**

Q.4 **(a)** Define: **03**

1. Black body
2. White body
3. Opaque body

(b) Sate and explain Wien's displacement law. **04**

(c) A hot body at 800 K having an area of 0.12 m^2. Calculate: (i) Total rate of energy emitted, (ii) intensity of normal radiation. **07**

OR

(a) Define Absorptivity, Reflectivity and transmissivity of radiation. **03**

(b) State and explain Kirchoff's law of radiation. **04**

(c) State Stephen Boltzman law. Determine the surface temperature of sun and emissive power at that temperature when the sun emits radiation at λ =0.52 μm. Assuming sun as black body. **07**

Q.5 **(a)** Differentiate between subcooled and saturated boiling. **03**

(b) Explain condensation process. What are the two modes of condensation. **04**

(c) Derive an expression for LMTD in case of parallel flow heat exchanger. **07**

OR

(a) Differentiate between nucleate and film boiling. **03**

(b) Explain why condenser tubes are horizontal. **04**

(c) In counter flow heat exchanger, 2.78 kg/sec of an oil having specific heat of 2.095 kJ/kg K is cooled from 80^oC to 50^oC by 2.22 kg/sec of water entering at 25^oC. Determine the area of heat exchanger. Take U = 300 W/m^2K and C_P = 4.18 kJ/kg K. **07**

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Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:3151909 Date:28-11-2024

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)**	Distinguish between the conduction, convection and radiation modes of heat transfer with suitable example.	**03**
	(b)	Draw temperature variation for the condenser of the domestic refrigerator and evaporator of the thermal power plant.	**04**
	(c)	Derive equation of logarithmic mean temperature difference for parallel flow heat-exchanger.	**07**
Q.2	**(a)**	"Generally fin is provided to increase the heat transfer rate but by providing fin heat transfer may decrease" Justify the statement in context to heat transfer.	**03**
	(b)	a) Explain the situation when the addition of fins to a surface is not useful. b) Under what situations does the fin efficiency becomes 100%.	**04**
	(c)	Write the most general equation in Cartesian coordinates for heat transfer by conduction. Hence, deduce the above equation for the following cases with suitable assumptions; (i) Laplace equation, (ii) Poisson equation, and (iii) Fourier equation.	**07**
		OR	
	(c)	A steel fin (k=55W/mK) with a cross-section of an equilateral triangle, 5mm on the side is 80mm long. It is attached to a plane wall maintained at 350^0C. The ambient air temperature is 40^0C and unit surface conductance is 100W/m^2K. Calculate the heat dissipation rate by assuming the fin as a rod with the tip of the fin is insulated.	**07**
Q.3	**(a)**	What is critical radius of insulation? Explain its importance in electrical and thermal system.	**03**
	(b)	Compare the value of effectiveness for the counter and parallel flow for regenerator for NTU = 2.5.	**04**
	(c)	Explain with neat sketch, the various regimes in boiling and explain the condition for the growth of bubbles. What is the effect of bubble size on boiling?	**07**
		OR	
Q.3	**(a)**	Write three properties of shape factor.	**03**
	(b)	Write the general differential equation in Cartesian coordinates for 3D 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 a uniform rate within the material.	**04**

(c) State the relationship between Nusselt number, Grashoff number and Prandtl number in case of heat transfer by nature convection from a vertical plate. **07**

Q.4 **(a)** Justify the use of polished surfaces in thermal insulation systems from the perspective of radiation. **03**

(b) Define Biot number and Fourier number, and point out their physical significance. **04**

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

OR

Q.4 **(a)** Differentiate mean film temperature and bulk mean temperature. **03**

(b) What is lumped system analysis? What are the assumption made in the lumped system analysis and when it is applicable? **04**

(c) What is heat exchanger? Classify the heat exchanger types with example. **07**

Q.5 **(a)** What is the significance of thermal conductivity in material selection for heat exchangers and insulators? Discuss its role in optimizing heat transfer. **03**

(b) Why is it important to analyze heat conduction through composite walls in industrial applications? Explain in brief, how to calculate the overall heat transfer rate in such systems. **04**

(c) An egg with mean diameter of 4 cm and initially at 20°C 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°C. **07**

Take following properties for egg :

$k = 10 W / m^0C$, $\rho = 1200 kg /m3$, $c = 2 kJ / kg^0C$, $h = 100 W /m^2 {}^0C$

OR

Q.5 **(a)** What is the relevance of one-dimensional heat conduction analysis in practical applications? Explain with the example of heat transfer through a plane wall or cylinder. **03**

(b) Discuss the principle behind why black surfaces absorb more radiant energy and how it enhances the efficiency of solar panels in converting sunlight to electricity. **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. **07**

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 :

$\rho = 1.06 kg/m^3$, $\upsilon = 18.97 * 10^{-6} m^2/s$, $k = 0.1042 kJ/m.hr.^0C$, $Cp = 1.004 kJ/kg^0C$.

Use the relation $Nu = 0.10 (Gr.Pr)^{1/3}$

(The symbols have their usual meanings)

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – WINTER 2023

Subject Code:3151909 Date:07-12-2023

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.**

Q.1 **(a)** Explain critical radius of insulation and its importance in electrical and thermal systems heat transfer problems. **03**

(b) With appropriate diagram explain the temperature variation in parallel flow heat exchanger, counter flow heat exchanger, temperature distribution for evaporator and condenser. **04**

(c) A thermopane window consist of two 5 mm thick glass (k=0.78 W/m-K) sheets separated by 10 mm stagnant air gap (k=0.025 W/m-K). The convection heat transfer coefficient for inner and outer air are 10 W/m^2-K and 50 W/m^2-K, respectively. (a) Determine the rate of heat loss per m^2 of the glass surface for a temperature difference of 60 Celsius between the inside and outside air (b) compare the result with the heat loss, if the window had only a single sheet of glass of thickness 5 mm instead of thermopane (c) compare the result with the heat loss, if window has no stagnant air (i.e., a sheet of glass, 10 mm thick. **07**

Q.2 **(a)** What is lumped system analysis? Under what conditions it is applicable? **03**

(b) What are the fundamental dimensions? Express thermal resistance, thermal diffusivity and convective heat transfer coefficient in fundamental dimensions. **04**

(c) Find out the amount of heat transferred through an iron fin of length 50 mm, width 100 mm and thickness 5 mm. Assume k = 58.33 W/m-K and h = 11.66 W/m^2-K for the material of the fin and temperature at the base of the fin as 80 Celsius. Also determine the temperature at tip of the fin, if the atmospheric temperature is 20 Celsius. **07**

OR

(c) Derive general heat conduction equation in cylindrical coordinate system. **07**

$$\frac{\partial^2 t}{\partial r^2}+\frac{1}{r}\frac{\partial t}{\partial r}+\frac{1}{r^2}\frac{\partial^2 t}{\partial \emptyset^2}+\frac{\partial^2 t}{\partial z^2}+\frac{q_g}{k}=\frac{1}{\alpha}\frac{\partial t}{\partial \tau}$$

Q.3 **(a)** Define Absorptivity, reflectivity and transmissivity with proper example. **03**

(b) What is the efficiency and effectiveness of fin? **04**

(c) Dry saturated steam at 10 bar enters a counter flow heat exchanger at the rate of 15 kg/s and leaves at 300 Degree Celsius. The entry of gas at 600 Degree Celsius is with mass flow rate of 25 kg/s. If the condenser tubes are 30 mm diameter and 3 m long, make calculations for the heating surface area and the number of tubes required. Neglect the resistance offered by the metallic tubes. Take the following properties for steam and gas: For steam: t_{sat}=180 ^{o}C (at 10 bar), C_{ps}=2.7 kJ/kgK, h_s=600 W/m^{2}K for Gas: C_{pg}=1 kJ/kgK, h_g=250 W/m^{2}K **07**

OR

Q.3 **(a)** Define thermal diffusivity and explain its physical significance. **03**

(b) What is meant by transient heat transfer? Mention some of the situations where transient conduction occurs. **04**

(c) Derive the equation of effectiveness for the parallel flow heat exchanger **07**

$$\in = \frac{1-exp[-NTU(1+C)]}{(1+C)}$$

Q.4 **(a)** State and prove Kirchoff's law of radiation. **03**

(b) Differentiate between mechanism of heat transfer by free and forced convection. Mention some of the areas where these mechanisms are predominant. **04**

(c) Following data are obtained from a metallic cylinder of 15 mm diameter and 100 mm in length heated internally by an electric heater and subjected to cross flow of air in a low-speed wind tunnel: velocity of free stream air = 15 m/s, temperature of free stream air = 25 ºC, average temperature of cylinder surface = 130 ºC, power dissipation by heater is 63 W. Calculate the experimental convective heat transfer coefficient for such a system. Compare this value with that obtained from the correlation suitable for this arrangement. **07**

$$Nu = 0.26\, Re^{0.6}\, Pr^{0.36}\left({Pr}/{Ps}\right)^{0.25}$$

Thermophysical properties of air at the mean bilk temperature at 25 Celsius are: k =2.6325 x 10^{-2} W/m^2K, υ = 15.53 x 10^{-6} m^2/s, Pr = 0.702, Prs = 0.685

OR

Q.4 **(a)** What do you mean by geometrical or shape factor in case of radiation exchange between two surfaces? **03**

(b) The expression ${h\,l}/{k}$ gives the Biot number as well as the Nusselt number. What is the difference between the two? **04**

(c) Explain the essential features of Blasius method of solving laminar boundary layer equations for flat plate. Derive expressions for boundary layer thickness and local skin friction coefficient from this solution. **07**

Q.5 **(a)** Explain the physical mechanism of boiling. **03**

(b) Explain construction and working of heat-pipe. **04**

(c) Two concentric spheres 25 cm and 35 cm in diameter with the space between them evacuated are used to store liquid air (-150 ºC) in a room at 20 ºC. The surfaces of the spheres are flushed with aluminum ($\epsilon = 0.04$). Calculate the rate of evaporation of liquid air if the latent heat of vaporization of liquid air is 218 kJ/kg. Assume that other modes of heat transfer are absent. **07**

OR

Q.5 **(a)** List the applications of boiling heat transfer. **03**

(b) How does film wise condensation differ from drop wise condensation? Which type has a higher heat transfer film coefficient and point out the reason thereof. **04**

(c) Derive a general relation for the radiation shape factor in case of radiation between two surfaces. **07**

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:3151909 Date:06-01-2023

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)**	Define the conduction, convection and radiation modes of heat transfer with suitable example.	**03**
	(b)	Describe the thermal conductivity and explain its significance in heat transfer.	**04**
	(c)	A steel fin (k = 54 W/mK) with a cross section of an equilateral triangle, 5 mm in side and 80 mm long. It is attached to a plane wall maintained at 400°C. The ambient air temperature is 50°C and convective heat transfer coefficient at surface is 90 W/m^2K. Calculate the heat dissipation rate from the rod.	**07**
Q.2	**(a)**	Define fin efficiency and fin effectiveness.	**03**
	(b)	Give eight examples related to heat transfer from the routine life.	**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	
	(c)	Derive general heat conduction equation in cylindrical coordinates	**07**
Q.3	**(a)**	Define Grashof number. Explain its significance in natural convection heat transfer.	**03**
	(b)	Differentiate between: 1) Nusselt number and Reynolds number. 2) Free convection and forced convection.	**04**
	(c)	Using Buckingham – π theorem show that Nusselt number for free convection is a function of Grashof Number and Prandtl number.	**07**
		OR	
Q.3	**(a)**	Describe mean film temperature and bulk mean temperature.	**03**
	(b)	Explain the concept of thermal boundary layers.	**04**
	(c)	A horizontal fluorescent tube which is 3.8 cm in diameter and 120 cm long stands in still air at 1 bar and 20 °C. If the surface temperature is 40 °C and radiation is neglected, calculate heat transfer rate by convection. Use $\bar{N}u = 0.53\ (Gr.Pr)^{0.25}$ From Air Table (Properties of Air) at Tmf ν =15.06 X 10-6 m2/sec Pr=0.701 K= 2.673 X 10-2 W/mK	**07**

Q.4	**(a)**	Define absorptivity, emissivity and monochromatic emissive power.	**03**
	(b)	Describe shape factor. Discuss salient features of shape factor.	**04**
	(c)	Define total emissive power (Eb) and intensity of radiation (Ib). Show that $Eb = \pi \times Ib$	**07**

OR

Q.4	**(a)**	It is desirable to wear white clothes instead of black during the summer season. Give reason.	**03**
	(b)	Draw temperature variation for condenser and evaporator of thermal power plant.	**04**
	(c)	Two large parallel plates with $\epsilon = 0.4$ each are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.04 are introduced in parallel to the plates. Find the percentage reduction in net radiation heat transfer.	**07**
Q.5	**(a)**	Justify that a good absorber is also a good emitter for radiation heat transfer.	**03**
	(b)	Give broad classification of heat exchangers.	**04**
	(c)	Derive the equation of LMTD for counter-flow heat exchangers.	**07**

OR

Q.5	**(a)**	Define fouling factor in case of heat exchanger? List the causes of fouling.	**03**
	(b)	Discuss the various regimes of boiling.	**04**
	(c)	Define condensation? Explain film-wise condensation and drop-wise condensation.	**07**

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