III B. Tech II Semester Regular Examinations, April/May - 2019

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**
4. Heat transfer data book allowed

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PART –A

1. a) Write the Fourier rate equation for heat transfer by conduction. Give the physical significance of each term. [2M]
   b) Define effectiveness and efficiency of a fin. [2M]
   c) Write the expression for Biot number and explain it physical significance. [2M]
   d) What is meant by a hydrodynamic boundary layer? Explain the formation of Hydrodynamic boundary layer over a flat plate [3M]
   e) Distinguish between film wise and drop wise condensation. Which of the two gives a higher heat transfer coefficient? Why? [3M]
   f) Define irradiation and radiosity. [2M]

PART -B

2. a) Derive a three dimensional generalized heat conduction equation in cylindrical co-ordinates. [7M]
   b) A furnace wall is made of 25 cm fire brick, 20 cm common brick, 6 cm of magnesia and 4mm of steel plate on the outside. The inside and the outside surface temperatures are 1200 ºC and 100 ºC respectively. Calculate the temperature between layers and rate of heat transfer. Assume the thermal conductivities of fire brick, common brick, Magnesia and steel are 1.2 W/m-K, 0.75 W/m-K, 0.07 W/m-K and 71 W/m-K respectively. [7M]

3. a) A longitudinal copper fin (k=3.5 W/m-K), 6 cm long and 5 mm in diameter is exposed to air stream at 20 ºC. The connective heat transfer coefficient is 20 w/m^2-K. If the fin has the base temperature of 150 ºC, calculate the heat transfer by the fin and fin efficiency. [7M]
   b) In quenching process a copper plate of 3 mm thickness is heated up to 350 ºC and is suddenly dipped into water bath and cooled to 25 ºC Calculate the time required for the plate to reach the temperature of 50 ºC. The heat transfer coefficient on the surface of the plate is 28 W/m^2-K. The length and width of the plates are 40 cm and 30 cm respectively. The properties of copper are as follows: specific heat=380.9 J/Kg-K, density 8800 kg/m^3 and thermal conductivity 385 W/m-K. [7M]

4. a) State and explain Buckingham π theorem. [7M]
   b) Water flows in a duct having a cross section 5 X 10 mm with a mean bulk temperature of 20 ºC. If the duct wall temperature is constant at 60 ºC and fully developed laminar flow is experienced, calculate the heat transfer per unit length. [7M]
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5. a) Air at 15 ºC and at a pressure of 1 atm is flowing along a flat plate at a velocity of 4.75 km/sec. If the plate is one meter wide and at 70 ºC, find the quantities given below at x=1m. [7M]
(i) Hydrodynamic Boundary layer thickness.
(ii) Local friction factor
(iii) Average friction
(iv) Local heat transfer co-efficient
(v) Rate of heat transfer.

b) A flat plate having dimensions 50 cm X 20 cm and at a uniform temperature of 100 ºC is kept in air stream at temperature 20 ºC. The velocity of air is 3 m/sec. Find out the rate of heat loss from the plate when the flow is (i) parallel to 50 cm (ii) parallel to 20 cm side. The Nusselt number for laminar and turbulent flows are given as $N_u=0.664\ P_r^{\ 1/3}\ R_e^{1/2}$ and $N_u=0.037\ R_e0.8P_r^{\ 1/3}$. [7M]

6. a) Explain the regimes of pool boiling. [7M]

b) A liquid chemical flows through a thin walled copper tube of 12 mm diameter at the rate of 0.5 kg/sec water flows in opposite direction at the rate 0.37 kg/sec through the annular space formed by this tube and a tube diameter of 20 mm. The liquid chemical enters and leaves at 100 ºC and 60 ºC, while water enters at 10 ºC. Find the length of tube required. Also find the length of tube required if the water flows in the same direction as liquid chemical. The properties of water and liquid chemical are: [7M]

Properties	**Liquid Chemical At 80 ºc**	**Water At 27 ºc**
p, Kg/m^3	1078	995
μ .Kg/m - Sec^2	3200 X 10^{-6}	853 X 10^{-6}
Cp, J/Kg-K	2050	4180
K, W/mK	0.261	0.614

7. a) Two large parallel plates having emissivity of 0.5 and 0.6 are maintained at 1000 K and 500 K respectively. A radiation shield having an emissivity of 0.03 on both sides is placed between the plates. Calculate: [7M]
(i) Heat transfer per unit area without shield.
(ii) Find out the temperature of the shield and heat transfer per unit area with shield.

b) Assuming the sun to be a black body having a surface temperature of 5800 K. Calculate: [7M]
(i) the total emissive power
(ii) the wave length at which the maximum spectral intensity occurs,
(iii) the maximum value of E_b and
(iv) the total amount of radiant energy emitted by the sun per unit time if its diameter can be assumed to be 1.391×10^9 m.

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III B. Tech II Semester Regular Examinations, April/May - 2019

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**
4. Heat transfer data book allowed

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PART –A

1.	a)	Define thermal resistance and thermal conductance.	[2M]
	b)	Describe various types of fins.	[2M]
	c)	Define Reynolds number. Why is it important?	[2M]
	d)	What is meant by a thermal boundary layer? How is Prandtl Number related to its thickness?	[3M]
	e)	Differentiate between pool boiling and flow boiling.	[3M]
	f)	Define Black body, White body and Grey Body.	[2M]

PART -B

2.	a)	Derive the three dimensional heat conduction equations in Cartesian coordinates for a homogeneous and isotropic material with uniform heat generation under unsteady state.	[7M]
	b)	A 1.0 mm diameter wire is maintained at a temperature of 400 ^{0}C and exposed to a convective environment at 40 ^{0}C with *h*=50W/m^{2}K. Calculate thermal conductivity which just causes an insulation thickness of 0.2 mm produce a critical radius. How much of this insulation must be added to reduce the heat transfer by 75% from that which would be experienced by ban wire?	[7M]
3.	a)	Derive an expression for temperature distribution and heat loss from a cylindrical rod extending out of a heat source. Assume the end of the rod is perfectly insulated.	[7M]
	b)	A long steel cylinder 12 cm in diameter and initially at 20 ºC is placed into a furnace at 820 ºC where the heat transfer coefficient, h=140 W/m^2.K. Calculate the time required for the axis temperature to reach 800 ºC. Calculate also, (i) The corresponding temperature at a radius of 4.8 cm at that time. (ii) The heat energy absorbed by the cylinder during this period, given that the thermal diffusivity, $\alpha = 6.11 \times 10^{-6}$ m^2/s and the thermal conductivity, k=21 W/m.K.	[7M]
4.	a)	Show by dimensional analysis that data for forced convection may be correlated by an equation of the form $N_u=f(R_e, P_r)$.	[7M]
	b)	For heating water from 20 ºC to 60 ºC an electrically heated tube resulting in a constant heat flux of 10 k/W/m^2 is proposed. The mass flow rate is to be such that Re_D=2000, and consequently the flow must remain laminar. The tube inside diameter is 25 mm. The flow is fully developed (velocity profile). Determine the length of tube required.	[7M]
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5. a) Explain the phenomena of natural convection over a vertical hot plate. Sketch the boundary layer, temperature and velocity profiles. [7M]

   b) Water at 38 ºC flows over a wide, 6 m long, heated plate at 0.06 m/s. For a surface temperature of 93 ºC, determine: (a) the hydrodynamic boundary layer thickness δ at the end of the plate (b) the total drag on the surface per unit width (c) The thermal boundary layer thickness δ_t at the end of the plate (d) the local heat transfer coefficient h_x at the end of the plate and (e) the total heat flux from the surface per unit width. [7M]

6. a) Deduce average heat transfer co-efficient equation in film condensation on a vertical flat plate using Nusselt's theory. [7M]

   b) In an industry 0.6 kg/Sec of oil (Cp=2.5 kJ/kg-K) is to be cooled in a counter flow heat exchanger from 110 ºC to 35 ºC by the use of water entering at 20 ºC. The overall heat transfer coefficient is 1500 W/m^2-K. Presuming the exit water temperature should not exceeds 80 ºC, using NTU method, Calculate: [7M]
   (i) Water flow rate
   (ii) surface area required
   (iii) The effectiveness of heat exchanger.

7. a) State and prove Kirchhoff's law of radiation. [7M]

   b) Two parallel square plates each 4 m^2 area are large compared to a gap of 5 mm separating them. One plate has a temperature of 800 K and surface emissivity of 0.6, while the other has temperature of 300 K and surface emissivity of 0.9; Find the net exchange by radiation between the plates. If a thin polished metal sheet of surface emissivity 0.1 on both sides is now located centrally between the two plates, what will be its steady state temperature? [7M]

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Code No: R1632034 **R16** SET - 3

III B. Tech II Semester Regular Examinations, April/May - 2019

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**
4. Heat transfer data book allowed

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PART –A

1. a) Explain the mechanism of thermal conduction in gases, liquids and solids. [2M]
   b) Briefly explain the applications of extended surfaces. [2M]
   c) Describe the physical mechanism of convection. How is the convection heat-transfer coefficient related to the mechanism? [2M]
   d) Sketch the temperature and velocity profiles in free convection on an isothermal vertical wall, for the cases of heating and cooling of a fluid. [3M]
   e) Differentiate between film condensation and drop wise condensation. [3M]
   f) Establish the relation between emissive power and intensity of radiation of a black body. [2M]

PART -B

2. a) Derive the general heat conduction equation in spherical coordinates. Obtain the reduced form for one-dimensional unsteady conduction with variable thermal conductivity and no heat generation. [7M]
   b) A hot gas at 573 K flows through a long metal pipe of 0.1 m Outer Diameter and 0.003 m thick. From the stand point of safety and of reducing heat loss from the pipe, mineral wool insulation (k=0.052 W/m K) is wrapped around so that the exposed surface of the insulation is at a temperature of 323 K. Calculate the thickness of insulation required to achieve this temperature if hi=29 W/m^{2}K, ho=11.6 W/m^{2}K and the surrounding air temperature in 298 K. Also calculate the corresponding heat transfer rate per unit length. [7M]

3. a) A 0.5 cm thick and 4 cm long fin has its base on a plane plate which is maintained at 1100c. The ambient air temperature is 20 ^{0}C. The conductivity of the fin material is 60 W/m-K and the heat transfer coefficient h= 150 W/m^2 –K. Assume that the tip of the fin is insulated. Determine: [7M]
   (i) Temperature at the end of the fin (ii) Temperature at the middle of the fin
   (iii) Total heat dissipated by the fin.
   b) Derive An expression for instantaneous heat transfer in a lumped body. [7M]

4. a) Show by dimensional analysis that data for free convection may be correlated by an equation of the form N_u=f(G_r, P_r). [7M]
   b) How the local and average convection coefficients for flow past a flat plate are related? Derive the relationship. [7M]
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5. a) Explain the concept of boundary layer for flow over flat plate showing different regimes of fluid flow. [7M]

   b) Oil at 25 ^{0}C is heated in a horizontal tube 15 m long having a surface temperature of 50 ^{0}C. The pipe has an inner diameter of 0.05 m. The oil flow rate is 1 kg/s at inlet temperature. What will be the oil temperature as it leaves the tubes? What is the average heat transfer coefficient? The flow rate is in the laminar region. The properties of the oil are: [7M]
   Specific gravity 0.8: Thermal conductivity 0.125 W/m.K: Specific heat 3.14 kJ/kg.K. Viscosity at 50 ^{0}C is 0.025 kg/m-s; Viscosity at 25 ^{0}C is 0.015 kg/m-s.

6. a) The outer surface of a vertical tube of 1.5 m length and outer diameter of 10 cm is exposed to saturated steam at atmospheric Pressure and is maintained at 50 ºC by the flow of cool water through the tube. Calculate the rate of heat transfer to the coolant and the rate of condensation of steam. The properties of saturated vapour at atmospheric pressure are as follow. Density = 0.596 Kg/m^3, latent heat of condensation is 2257 KJ/Kg. The properties of water are p=975 Kg/m^3, μ = 375 X 10^{-6} W.Sec/m^2, K=0.668 W/m-K. [7M]

   b) Derive an expression for effectiveness of a counter flow heat exchanger using NTU method. [7M]

7. a) Define radiation Intensity. Prove that for a diffusive surface, the emissive power is equal to π times the intensity of radiation. [7M]

   b) A black body of total area 0.045 m^2 is completely enclosed in a sphere bounded by 5 cm thick walls. The walls have a surface area 0.5 m^2 and the thermal conductivity is 1.1 W/m.^{o}C if the inner surface of the enveloping wall is to be maintained at 215 ^{o}C and the outer wall surface is at 30 ^{o}C calculate the temperature of the black body. [7M]

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III B. Tech II Semester Regular Examinations, April/May - 2019

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

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3. Answer any **FOUR** Questions from **Part-B**
4. Heat transfer data book allowed

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PART –A

1. a) State the Newton's law of cooling. Discuss whether convective heat transfer coefficient is a material property. [2M]
   b) Define the term overall heat transfer coefficient? And explain its significance. [2M]
   c) List and explain various non dimensional numbers using in heat transfer. [2M]
   d) Explain the physical significance of Rayliegh Number. [3M]
   e) Drop wise condensation is faster than film condensation. State the reason. [3M]
   f) Distinguish between a black body and grey body. [2M]

PART -B

2. a) What are the various boundary conditions needed in general for the analysis of heat conduction problems. Explain with appropriate illustrations. [7M]
   b) A composite wall is made of fire clay brick of (K=1.5W/m.K) and magnesia insulation (K=0.04 W/m.K). The temperature of exposed surface of the fire clay brick is 3800 ºC and that of the external surface of the insulation is 45 ºC. Determine the insulation thickness required to provide a temperature of the interface not to exceed 300 ºC. Determine also the interface temperature if the insulation thickness is doubled. [7M]

3. a) Define fin efficiency. What are the assumptions made in deriving an expression for finding temperature distribution along a circular fin? [7M]
   b) A large aluminium plate of thickness 200 mm originally at a temperature of 530 ^{0}C is suddenly exposed to an environment at 30 ^{0}C. The convective heat transfer coefficient between the plate and the environment if 500 W/(m^2 K). Determine with the help of Heisler charts, the temperature at a depth of 20 mm from one of the faces 225 seconds after the plate is exposed to the environment. Also calculate how much energy has been lost per unit area of the plate during this time? Take for aluminium, $\alpha = 8 \times 10^{-5}$ m^2/s and k = 200 W/(m K). [7M]

4. a) Explain the physical significance of Reynolds Number, Prandtl Number and Nusselt Number [7M]
   b) Using Buckingham Π-Theorem obtain relation for natural convection in terms of dimensionless numbers. [7M]
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5. a) What is the criterion for transition from laminar to turbulent boundary layer in free convection on a vertical flat plate? Explain. [7M]
   b) Explain velocity and temperature profile for a flat plate and vertical plate in forced convention. [7M]

6. a) The condenser of a steam power plant operates at a pressure of 7.38 kPa. Steam at this pressure condenses on the outer surfaces of horizontal pipes through which cooling water circulates. The outer diameter of the pipes is 2 cm, and the outer surfaces of the pipes are maintained at 30 ºC. [7M]
   Determine
   (i) the rate of heat transfer to the cooling water circulating in the pipes
   (ii) the rate of heat transfer to the cooling water circulating in the pipes and
   (iii) The rate of condensation of steam per unit length of a horizontal pipe.
   b) Refrigeration is designed to cool 250 kg/h of hot liquids of heat 3350 J/kg k at 120 ºC using a parallel flow arrangement. 1000 kg/h of cooling water is available for cooling purpose at a temperature of 10 ºC. If the overall heat transfer co-efficient is 1160 W/m^2K and the surface area of the heat exchanger is 0.25 m^2. Calculate the outlet temperature of the cooled liquid and water and also effectiveness of the heat exchanger. [7M]

7. a) Derive an expression for radiation shape factor and hence deduce reciprocity relation. [7M]
   b) Two large parallel planes having emissivities of 0.25 and 0.5 are maintained at temperatures of 1000 K and 500 K, respectively. A radiation shield having an emissivity of 0.1 on both sides is placed between the two planes. Calculate (i) the heat-transfer rate per unit area if the shield were not present, (ii) the heat-transfer rate per unit area with the presence of the shield and (iii) the temperature of the shield. [7M]

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III B. Tech II Semester Supplementary Examinations, November -2019

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**
4. Heat transfer data book allowed

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PART –A **(14 Marks)**

1. a) Why the metals are good conductors of both heat and electricity, while some non-metallic crystalline solids are very good conductors of heat but very poor conductors of electricity? Explain. [2M]
   b) What is the significance of Biot number? [2M]
   c) Distinguish between natural and forced convective heat transfers. [2M]
   d) What do you understand by hydrodynamic and thermal boundary layers? [3M]
   e) Why the heat transfer coefficients in condensation and boiling very high are compared to those in forced convection without phase change? [3M]
   f) What is meant by view factor and why is it so important in calculation of radiation heat transfer? [2M]

PART –B **(56 Marks)**

2. a) Explain the effect of variable thermal conductivity and deduce expression for heat transfer in a slab considering $k=k_0(1+\alpha T)$, where k_0 and α are constants. [7M]
   b) Consider a 20 mm thick plate with uniform heat generation of 80 MW/m^3. The left and right faces are kept at constant temperatures of 160^0C and 120^0C respectively. The plate has a constant thermal conductivity of 200W/m K. Determine: [7M]
      i) the expression for temperature distribution in the plate,
      ii) the location and value of maximum temperature, and
      iii) the rate of heat transfer at the plate centre.

3. a) Two fins are identical except the diameter of one is twice that of the other. Compare their efficiencies and effectiveness. [6M]
   b) Consider two very long, slender rods of the same diameter but of different materials. One end of each rod is attached to a base surface maintained at 100^0C, while the surfaces of the rods are exposed to ambient air at 20^0C. By traversing the length of each rod with a thermocouple, it was observed that the temperatures of the rods were equal at the positions X_A=0.15 m and X_B=0.075 m, where X is measured from the base surface. If the thermal conductivity of rod A is known to be k_A=72W/mK, determine the value of k_B for the rod B. [8M]

4. a) Explain the concept of momentum and energy equation. [7M]
   b) Discuss the detailed classification of convective heat transfer. [7M]

5. a) Consider two identical flat plates one above another in quiescent air. [6M]
   i) In one situation, the bottom plate is at 100^0C and the top one is at 500^0C.
   ii) In another situation, the bottom plate is at 500^0C and the top one is at 100^0C. State in which case the rate of heat transfer is expected be higher and why?
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b) Atmospheric air, T_∞=300 K and with a free stream velocity, U_∞=30 m/s flows over a flat plate parallel to a side of length 2 m and is maintained at a uniform temperature of T_w=400 K. Determine: i) The average heat transfer coefficient over the region where the boundary layer is laminar; ii) The average heat transfer coefficient over the entire length L=2m of the plate. [8M]

6. a) Under what conditions is the effectiveness-NTU method definitely preferred over the LMTD method in the analysis of a heat exchanger? [6M]

b) A counter flow heat exchanger has an overall heat transfer coefficient of 225W/m^2K and a surface area of 33m^2. The hot fluid[c_p=3.56kJ/kg K] enters at 94^0C and flows at the rate of 2.52kg/s. The cold fluid[c_p=1.67kJ/kg K] enters at 16^0C and flows at the rate of 2.27kg/s. Determine the rate of heat transfer. [8M]

7. a) State Planck's distribution law and describe how monochromatic emissive power varies with wavelength? [6M]

b) Derive the expression for surface resistance and shape resistance using electrical analogy. [8M]

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III B. Tech II Semester Regular/Supplementary Examinations, October/November - 2020

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**
4. Heat transfer data book allowed

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PART –A (14 Marks)

1. a) Define the critical thickness of insulation. [3M]
b) Define Fin effectiveness. [2M]
c) Define the thermal boundary layer. [2M]
d) Why airplanes are designed aerodynamic? [2M]
e) What are the practical difficulties in maintaining drop wise condensation? [3M]
f) What is visible light and to which part of the electromagnetic spectrum it belongs? [2M]

PART –B (56 Marks)

2. a) A metal (k=45 W/m°C) steam pipe of 5 cm ID and 6.5 cm OD is lagged with 2.75 cm radial thickness of inside and outside surface are h_i=4650 W/m^{2}K and h_o=11.5 W/m^{2}K respectively, if the steam temperature is 200°C and ambient is 25°C, Calculate: i) heat loss per meter length of pipe, and ii) temperature at interfaces. [7M]
b) Derive an expression for the variation of temperature along the radius for a solid sphere of constant, k when there is uniform internal heat generation in the solid. [7M]

3. a) Derive an expression for heat dissipation for an infinitely long fin. [7M]
b) A 50 cm x 50 cm copper slab, 6 mm thick at a uniform temperature of 350°C suddenly has its surface temperature lowered to 30°C. Find the time at which the slab temperature becomes 100°C. h = 100 W/m^2°C. Also, find the rate of cooling after 60 seconds. [7M]

4. a) Derive the momentum equation for a laminar boundary layer stating the assumptions made. [10M]
b) What are dimensional homogeneity and state its uses? [4M]

5. a) Water flows at 45°C over a flat plate 1m x 1m size maintained at 22°C with a velocity of 1.5 m/s. Estimate the variation of heat transfer coefficient along the length of heating starts from 0.25 m from the leading edge. [7M]
b) A vertical pipe 7.5 cm OD and 2.2 m long have a surface temperature of 95°C surrounded by air at 22°C, Estimate the rate of heat loss from the cylinder when i) vertical ii) horizontal. [7M]

6. a) Draw and explain with suitable graph various regimes of boiling. [7M]
b) Water at a rate of 4080 kg/h is heated from 35°C to 75°C by the oil of Cp 1.9 kJ/kgK. The heat exchanger is a double pipe counter flow. Oil enters at 110°C and leaves at 75°C. Determine: i) mass flow rate of oil, ii) area of the heat exchanger to handle heat duty if the overall heat transfer coefficient is 320 W/m^{2}K. [7M]

7. a) What is the intensity of radiation and prove total emissive power is π times the intensity of radiation. [7M]
   b) A long pipe 40 mm in diameter passes through a room and is exposed to air at 35°C. The surface temperature of the tube is 95°C. Assuming the emissivity of the pipe as 0.6, estimate the radiation heat loss per meter length. [7M]

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Code No: R1632034 **R16** SET - 1

III B. Tech II Semester Supplementary Examinations, April - 2021

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**
4. Heat transfer data book allowed

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PART –A **(14 Marks)**

1. a) In the case of insulating an electrical wire, should the outer radius of insulation be more or less than the critical radius and why? [3M]
   b) Write the expression for Fourier number and explain its physical significance. [2M]
   c) Write the continuity equation and explain its significance. [2M]
   d) What do you understand by entrance length for the flow through a tube? [2M]
   e) Write the differences between nucleate and film boiling. [3M]
   f) Explain black and grey surfaces. [2M]

PART –B **(56 Marks)**

2. a) A plane wall of thickness L and maintained at temperatures T_1 and T_2 on both of its face is generating heat internally according to the equation $\dot{q} = q_0 e^{-ax}$. Where q_0 and a are constants. Derive the expression for temperature distribution in the plate. [7M]
   b) A certain material 200 mm thick, with a cross-sectional area of 0.1 m^2, has one side maintained at 35^0C and the other at 95^0C. The temperature at the centre plane of the material is 62^0C, and the heat flow through the material is 10 kW. Obtain an expression for the thermal conductivity of the material as a linear function of temperature. [7M]

3. a) Derive the expression for temperature distribution and heat transfer for a uniform cross-sectional area fin with its end insulated. [7M]
   b) A masonry brick wall (k=0.60 W/mK and $\alpha=5x10^{-7}$ m^2/s) of 150 mm thickness and originally at 30^0C is suddenly exposed on one side to hot gases at 780^0C. The other side of the wall is already insulated. The convection heat transfer coefficient on the hot gas side is 20 W/m^2K. Determine, by making use of Heisler charts, [7M]
   i) the time required for the insulated surface to attain a temperature of 480^0C and
   ii) the heat transferred to the wall per unit area during that time.

4. a) What do you understand by Nusselt number and Rayleigh number? Discuss their significance. [6M]
   b) Explain the procedure to form dimensionless groups by Buckingham π-theorem. [8M]

5. a) Discuss the criteria in natural convection to decide whether it is laminar or turbulent? [6M]
   b) Air at one atmospheric pressure and 75^0C enters a tube of 4 mm internal diameter with an average velocity of 2 m/s. The tube length is 1 m and a constant heat flux is imposed by the tube surface on the air over the entire length. An exit bulk mean temperature of air of 125^0C is required. Determine: (i) the heat transfer coefficient at exit h_L, (ii) the constant surface heat flux q_W, and (iii) the exit tube surface temperature. [8M]

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6. a) Discuss the differences between drop-wise and film condensation. Which of the two is the more effective way of condensation and why? [7M]

   b) A double-pipe counter flow heat exchanger is to cool ethylene glycol [c_p=2.56 kJ/kg K] flowing at the rate of 2 kg/s from 80^0C to 40^0C by water [c_p=4.18 kJ/kg K] that enters at 20^0C and leaves at 60^0C. The overall heat transfer coefficient based on the inner surface area of the tube is 250 W/m^2K. Determine: [7M]
   i) the rate of heat transfer,
   ii) the mass flow rate of water, and
   iii) the heat transfer surface area on the inner side of the tube.

7. a) State and explain Lambert`s cosine law and its significance. [6M]

   b) State the important properties of view factor. Determine the view factors from the base of a cube to each of the other five surfaces. [8M]

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Code No: **R1632034** **R16** SET - 1

III B. Tech II Semester Regular/Supplementary Examinations, August-2021

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**
4. Heat transfer data book allowed

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PART –A (14 Marks)

1. a) What is electrical analogy in heat transfer? [3M]
   b) Define fin efficiency. [2M]
   c) What is the physical significance of Prandtl number? [2M]
   d) What are the criteria for transition from laminar to turbulent flow in natural convection? [3M]
   e) Define the effectiveness of heat exchanger. [2M]
   f) Write the properties of view factor. [2M]

PART –B (56 Marks)

2. a) A large window glass of thickness 4 mm is exposed to warm air at 20^0C at its inner surface with h_i = 155 W/m^2 ^0C. Outside air is at 10^0C and h_o = 45 W/m^2 ^0C. Find the inner and outer surface temperature of glass and the overall heat transfer coefficient. [7M]
   b) A hollow cylinder whose k varies with temperature as k(T)=0.5(1+0.001T), where T is in 0C has an ID of 7.5 cm and OD of 12.55 cm. If the inside and outside surfaces are at a uniform temperature of 250^0C and 100^0C respectively. Find the steady state heat transfer per meter length of tube. [7M]

3. a) Calculate the rate of heat transfer from a rectangular fin of length 2 cm, on a plane wall. Thickness of the fin is 2 mm and its breadth is 20 cm. Take T_1 = 200^0C, h = 17.5/m^2 ^0C, k = 52 W/m^0C. Assume the heat loss from the tip is negligible. [7M]
   b) A house hold electric iron has aluminum base which weighs 1.4 kg. Total area of the iron is 0.05 m^2 and is heated with a 500 W heating element. Initially the iron is at ambient temperature of 20^0C. How long will it take for the iron to reach 120^0C once it is switched on? Take heat transfer coefficient as 18 W/m^2 ^0C. [7M]

4. a) Using dimensional analysis prove: Nu = f(Re,Pr). [7M]
   b) Briefly explain how roughness affect pressure drop and heat transfer in internal flows. [7M]

5. a) A 10 mm diameter cable carrying a current of 75 A and its resistance of 0.005 Ω/m. Determine the surface temperature of the cable if air is blowing at 25^0C across the cable at a velocity of 1.25 m/s. [7M]

   b) A hot plate 100 cm height and 25 cm width is exposed to atmospheric air at 20^0C. The surface temperature of the plate is 100^0C. Find the heat loss from both surface of the plate. If the height of the plate is reduced to 50 cm and width increased to 40 cm, what will be change in heat transfer? [7M]

6. a) Differentiate between nucleate boiling and film boiling. [7M]

   b) A double pipe heat exchanger is used to heat water with a mass flow rate of 12 kg/s from 22^0C to 45^0C. The hot fluid enters at 75^0C with a capacity rate 25 kW/K and overall heat transfer coefficient is 1550 W/m^{2}K. Determine the surface area for counter and parallel flow arrangement. [7M]

7. a) State Weins law of displacement and prove that monochromatic emissive power of black body is maximum when λT = 2900 μmK. [7M]

   b) Two parallel rectangular surfaces 1m x 2m are opposite to each other at a distance of 4 m. The surfaces are black and at temperatures of 100^0C and 200^0C respectively. Calculate the net rate of heat exchange by radiation between the two surfaces. [7M]

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