Code No: RT32035 **R13** SET - 1

III B. Tech II Semester Regular/Supplementary Examinations, April - 2018

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**
4. Use of air properties table is permitted.

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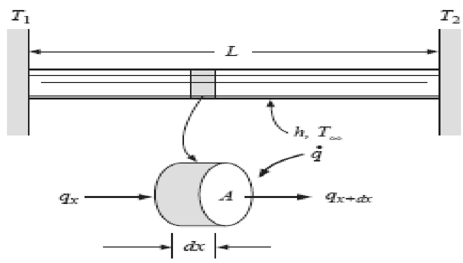
PART –A

1 a) What are the physical mechanisms associated with heat transfer by conduction, convection, and radiation? [4M]
b) What is infinite plate in analysis of transient heat conduction? [3M]
c) Draw boundary layer growth in a pipe for laminar and turbulent flows in a pipe and indicate salient features [4M]
d) Define the Grashof number. What is its physical significance? [3M]
e) Define and explain the film and dropwise condensation. [4M]
f) Define irradiation and radiosity. [4M]

PART -B

2 a) What is thermal contact resistance? [4M]
b) A rod containing uniform heat sources per unit volume $\dot{q}$ is connected to two temperatures as shown in Figure. The rod is also exposed to an environment with convection coefficient h and temperature T∞. Obtain an expression for the temperature distribution in the rod. [8M]



c) Discuss the mechanism of thermal conduction in gases and solids with neat sketch. [4M]

3 a) Briefly explain lumped heat capacity method. [2M]
b) Describe the temperature distribution along the length of a fin for various boundary conditions at tip. [8M]
c) A very long, 10 mm diameter cooper rod (k= 370 W/ (m.K)) is exposed to an environment at 20 ^{0}C. the base temperature of the rod is maintained at 120 ^{0}C. The heat transfer coefficient between the rod and the surrounding air is 10 W/m^2 K. a) Determine the heat transfer rate for finite lengths, 0.02, 0.04,0.08,0.2,0.4,0.8,1 and 10 meters assuming heat loss at the end, [6M]

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4 a) Air at 30 ^{0}C and 0.7 MPa pressure is expanded isentropically from a tank until the velocity is 300 m/s. Determine the static temperature, pressure, and Mach number of the air at the high velocity condition. γ =1.4 for air. [8M]

b) Estimate the heat loss from a vertical wall exposed to nitrogen at one atmospheric pressure and 4 ^{0}C. The wall is 0.2 m high and 2.5 m wide, and is maintained at 56 ^{0}C. The average Nusselt number N_{uH} over the height of the plate for natural convection is given by NuH = 0.13(Gr. Pr) 1/3. The properties for nitrogen at a mean film temperature of (56 + 4)/2 = 30^{0}C are given as ρ= 1.142 kg/m^3, k = 0.026 W/m K, v = 15.63 × 10-6 m^2/s, Pr = 0.713. [8M]

5 a) Liquid bismuth flows at a rate of 4.5 kg/s through a 5.0-cm-diameter stainless-steel tube. The bismuth enters at 415 ^{0}C and is heated to 440 ^{0}C as it passes through the tube. If a constant heat flux is maintained along the tube and the tube wall is at a temperature 20 ^{0}C higher than the bismuth bulk temperature, calculate the length of tube required to effect the heat transfer. [8M]
The properties of bismuth are evaluated at the average bulk temperature are
μ = 1.34×10–3 kg/m· s
cp = 0.149 kJ/kg · ^{0}C, k = 15.6 W/m· ◦C , Pr = 0.013

b) Derive the expression for thermal boundary layer thickness over flat plate. [8M]

6 a) Explain the different stages of boiling with neat sketch. [8M]

b) Derive the expression for average heat coefficient over a vertical plate for film wise condensation. [8M]

7 a) Two parallel plates 0.5 by 1.0 m are spaced 0.5 m apart. One plate is maintained at 1000 ^{0}C and the other at 500 ^{0}C. The emissivities of the plates are 0.2 and 0.5, respectively. The plates are located in a very large room, the walls of which are maintained at 27 ^{0}C. The plates exchange heat with each other and with the room, but only the plate surfaces facing each other are to be considered in the analysis. Find the net transfer to each plate and to the room. [10M]

b) A glass plate 30 cm square is used to view radiation from a furnace. The transmissivity of the glass is 0.5 from 0.2 to 3.5 μm. The emissivity may be assumed to be 0.3 up to 3.5 μm and 0.9 above that. The transmissivity of the glass is zero, except in the range from 0.2 to 3.5 μm. Assuming that the furnace is a blackbody at 2000 ^{0}C, calculate the energy absorbed in the glass and the energy transmitted. [6M]

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Code No: RT32035 **R13** SET - 2

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PART –A

1	a)	What is meant by thermal contact resistance? Upon what parameters does this resistance depend?	[4M]
	b)	What are Biot and Fourier numbers? Explain their physical significance.	[4M]
	c)	What is Buckingham's Π theorem?	[4M]
	d)	Discuss about hydrodynamic boundary layer.	[4M]
	e)	What is a heat exchanger? Name their types.	[3M]
	f)	What is meant by the radiation shape factor?	[3M]

PART -B

2	a)	Calculate the critical radius of insulation for asbestos [k =0.17 W/m· ^{0}C] surrounding a pipe exposed to room air at 20◦C with h=3.0 W/m^2. ^{0}C. Calculate the heat loss from a 200 ^{0}C, 5.0-cm-diameter pipe when covered with the critical radius of insulation and without insulation.	[4M]
	b)	Derive the equation of general heat conduction equation in spherical co-ordinate system.	[8M]
	c)	What is meant by conduction shape factor? Explain its significance along with periodic and a periodic heat transfer.	[4M]
3	a)	Define thermal diffusivity? What is the significance of thermal diffusivity in heat conduction process?	[3M]
	b)	A long cylinder of (α = 6.11×10-6m^2/s, k= 21W/m-K) 12 cm in diameter, initially at 20 ^{0}C is placed into a furnace at 800 ^{0}C. Calculate the time required for the centre to reach 760 ^{0}C Also calculate the temperature at a radius of 5.4 cm at the same time. (Take h= 140W/m^2-K).	[8M]
	c)	A plane wall is 150 mm thick and its wall area is 4.5 m^2. Its conductivity is 9.35 W/m-K and temperatures are steady at 150 ^{0}C and 45 ^{0}C on both sides. Determine the temperature gradient in flow direction.	[5M]
4	a)	Differentiate between mechanisms of heat transfer by free and forced convection. Mention some of the areas where these mechanisms are predominant.	[8M]

b) A nuclear reactor with its core constructed of parallel vertical plates 2.25 m high and 1.5 wide has been designed on free convection heating of liquid bismuth. Metallurgical considerations limit the maximum surface temperature of the plate to 975 ^{0}C and the lowest allowable temperature of bismuth is 325 ^{0}C. Estimate the maximum possible heat dissipation from both sides of each plate. The appropriate correlation for the convection coefficient is 1 [8M]

$Nu = 0.13(Gr\ \mathrm{Pr})^3$ where the different parameters are evaluated at the mean film temperature.

5 a) Air at 1 atm and 27 ^{0}C blows across a 12-mm-diameter sphere at a free-stream velocity of 4 m/s. small heater inside the sphere maintains the surface temperature at 77 ^{0}C. Calculate the heat lost by the sphere. [8M]

b) Determine the thickness of velocity boundary layer and local shear stress at x=2m from the leading edge of the plate for the boundary layer flow of air at atmosphere pressure of 80 ^{0}C with a velocity of 2 m/s. [8M]

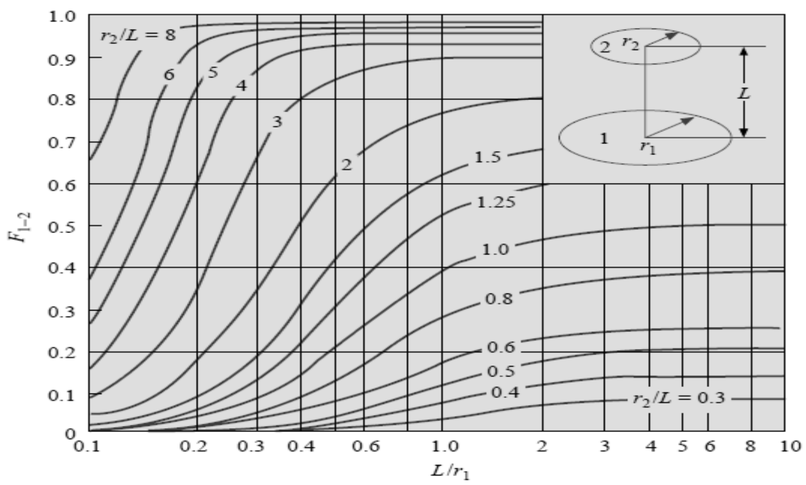
6 a) The oil makes a single pass, entering at 1500 ^{0}C and leaving at 950 ^{0}C with an average heat transfer coefficient of 400 W/m^{0}C -K, the water flow through 10 thin walled tubes of 25 mm diameter with each tube making 8 passes through the shell. The heat transfer efficient on the water side is 3000 W/m^2-K. Find the length of the tube required for the heat exchanger. [8M]

b) Derive an expression for LMTD in case of a counter and parallel– current flow double pipe heat exchanger. [8M]

7 a) Explain and derive the expression for radiation shape factor with neat sketch. [8M]

b) A truncated cone has top and bottom diameters of 10 and 20 cm and a height of 10 cm. Calculate the shape factor between the top surface and the side and also the shape factor between the side and itself. [8M]

Fig. Radiation shape factor for radiation between two parallel coaxial disks.



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Code No: RT32035 **R13** SET - 3

III B. Tech II Semester Regular/Supplementary Examinations, April - 2018

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

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PART –A

1 a) Enumerates the basic laws which govern the heat transfer and explain in brief. [4M]
b) Explain briefly the terms thermal capacity and thermal diffusivity of a material. [4M]
c) What do you mean by 'Characteristic length or Equivalent diameter'? [3M]
d) Explain the displacement thickness with neat sketch. [3M]
e) Define and explain 'heat exchanger effectiveness'. [4M]
f) Define and explain the Kirchhoff's law of thermal radiation. [4M]

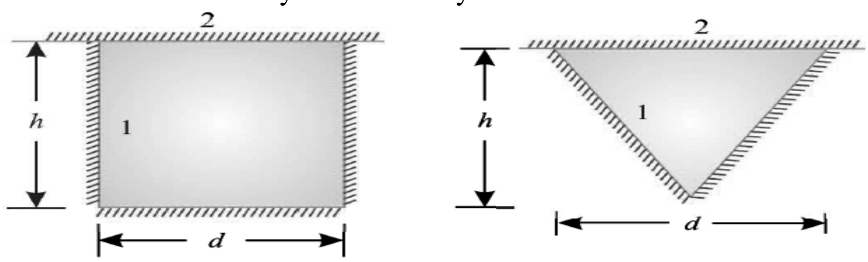
PART -B

2 a) A wire 1.5 mm in diameter and 150 mm long is submerged in water at atmospheric pressure. An electric current is passed through the wire and is increased until the water boils at 100°C. Under the condition if convective heat transfer coefficient is 4500 W/m^2°C find how much electric power must be supplied to the wire to maintain the wire surface at 120°C? [4M]
b) An exterior wall of a house may be approximated by a 0.1 m layer of common brick (k 0.7 W/m.°C) followed by a 0.04 m layer of gypsum plaster (k 0.48 W/m.°C). What thickness of loosely packed rock wool insulation (k 0.065 W/m.°C) should be added to reduce the heat loss or (gain) through the wall by 80 per cent? [8M]
c) What is critical radius of insulation? Discuss its significance. [4M]

3 a) A short aluminum cylinder 5.0 cm in diameter and 10.0 cm long is initially at a uniform temperature of 200 ^{0}C. It is suddenly subjected to a convection environment at 70 ^{0}C, and h=525 W/m^2.^{0}C. Calculate the temperature at a radial position of 1.25 cm and a distance of 0.625 cm from one end of the cylinder 1 min after exposure to the environment. [5M]
b) Discuss about efficiency of fin and effectiveness of fin. [6M]
c) A very long 25 mm diameter copper rod (k 380 W/m°C) extends horizontal from a plane heated wall at 120°C. The temperature of the surrounding air is 25°C and the convective heat transfer coefficient is 9.0 W/m^2 .°C. [5M]
(i) Determine the heat loss; (ii) How long the rod be in order to be considered infinite

4 a) Air at 1 atm and 10 ^{0}C flows across a bank of tubes 15 rows high and 5 rows deep at a velocity of 7 m/s measured at a point in the flow before the air enters the tube bank. The surfaces of the tubes are maintained at 65 ^{0}C. The diameter of the tubes is 2.54 cm; they are arranged in an in-line manner so that the spacing in both the normal and parallel directions to the flow is 3.81 cm. Calculate the total heat transfer per unit length for the tube bank and the exit air temperature. [8M]

	b)	Discuss the physical significance of the following dimensionless number Re, Nu, Pr, St, Gr.	[8M]
5	a)	Air at 1 atm and 27 ^{0}C enters a 5.0-mm-diameter smooth tube with a velocity of 3.0 m/s. The length of the tube is 10 cm. A constant heat flux is imposed on the tube wall. Calculate the heat transfer if the exit bulk temperature is 77 ^{0}C. Also calculate the exit wall temperature and the value of *h* at exit.	[8M]
	b)	Explain the energy thickness and derive the expression for its thickness over flat plate.	[8M]
6	a)	Derive an expression for logarithmic mean temperature difference (LMTD) in the case of counter-flow heat exchangers.	[8M]
	b)	A vertical plate 350 mm high and 420 mm wide, at 40°C, is exposed to saturated steam at 1 atm. Calculate the following: (i) The film thickness at the bottom of the plate (ii) The maximum velocity at the bottom of the plate; (iii) The total heat flux to the plate. Assume vapour density is small compared to that of the condensate.	[8M]
7	a)	Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500 °C (i) Monochromatic emissive power at 1.2 μm length, (ii) Wavelength at which the emission is maximum, (iii) Maximum emissive power, (iv) Total emissive power, and (v) Total emissive power of the furnace if it is assumed as a real surface with emissivity equal to 0.9.	[8M]
	b)	Derive expressions for shape factors of the cavities (each enclosed on its surface with a flat surface) shown in the Figure. Also, calculate the net irradiative heat transfer from the cavities, if h = 20 cm, d = 15 cm, temperature inside surface of each cavity 400 ^{0} C and the emissivity of each cavity surface is 0.8.	[8M]



Cylindrical cavity (*i*) Conical cavity (*ii*)

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PART –A

1 a) What is 'Fourier's law of conduction'? State also the assumptions on which this law is based? [4M]
b) What is meant by a lumped capacity? What are the physical assumptions necessary for a lumped-capacity unsteady-state analysis to apply? [3M]
c) What are the advantages and limitations of 'Dimensional analyses? [4M]
d) Explain the boundary thickness with neat sketch. [4M]
e) Explain the critical diameter of bubble. [3M]
f) Explain absorptivity, transmissivity and reflectivity with neat sketch. [4M]

PART -B

2 a) A plate 2 cm thick and 10 cm wide is used to heat a fluid at a 30°C. The heat generation rate inside the plate is 7×10^6 W/m^3. Determine the heat transfer coefficient to maintain the temperature of the plate below 180°C. Given k (plate) = 26 W/m.°C. Neglect heat losses from the edge of the plate. [4M]
b) Derive the equation of general heat conduction equation in polar co-ordinate system. [8M]
c) What is meant by conduction shape factor? Explain its significance along with periodic and a periodic heat transfer. [4M]

3 a) What is meant by a semi-infinite solid? Explain with neat sketch. [3M]
b) A semi-infinite aluminum cylinder 5 cm in diameter is initially at a uniform temperature of 200 ^{0}C.It is suddenly subjected to a convection boundary condition at 70 ^{0}C with h=525 W/m^2.^{0}C. Calculate the temperatures at the axis and surface of the cylinder 10 cm from the end 1 min after exposure to the environment. [8M]
c) It is required to heat oil to about 300°C for frying purpose. A laddle is used in the frying. The section of the handle is 5mm x 18 mm. The surroundings are at 30°C. The conductivity of the material is 205 W/m °C. If the temperature at a distance of 380 mm from the oil should not reach 40°C, determine the convective heat transfer coefficient. [5M]

4 a) The pressure difference Δp in a pipe of diameter D and length l due to turbulent flow depends on the velocity V viscosity μ, density ρ, and roughness k. Using Buckingham's it-theorem, obtain an expression for Δp. [8M]
b) Derive the following mass momentum equation for the fluid flowing over flat plate. [8M]

$$\rho\left(u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right)=\mu\frac{\partial^2 u}{\partial y^2}-\frac{\partial p}{\partial x}$$

5 a) Air at 2 atm and 200 ^{0}C is heated as it flows through a tube with a diameter of 2.54 cm at a velocity of 10 m/s. Calculate the heat transfer per unit length of tube if a constant-heat-flux condition is maintained at the wall and the wall temperature is 20 ^{0}C above the air temperature, all along the length of the tube. How much would the bulk temperature increase over a 3-m length of the tube? [8M]

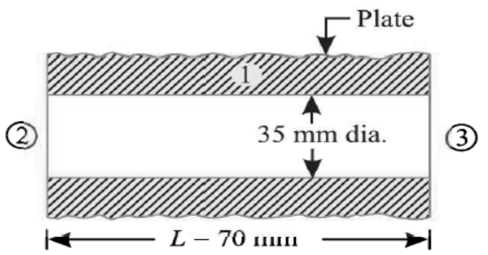
b) Determine the thickness of velocity boundary layer and local shear stress at x=2m from the leading edge of the plate for the boundary layer flow of air at atmosphere pressure of 80 ^{0}C with a velocity of 2 m/s. [8M]

6 a) Water at atmospheric pressure is to be boiled in polished copper pan. The diameter of the pan is 350 mm and is kept at 115 °C. Calculate the following: [8M]
(i) Power of the burner;
(ii) Rate of evaporation in kg/h;
(iii) Critical heat flux for these conditions.

b) Derive expressions for effectiveness by NTU (number of transfer units) method for the following cases: *(i)* Parallel flow; *(ii)* Counter flow heat exchangers. [8M]

7 a) What is shape factor? Derive an expression for the shape factor in case of radiation exchange between two surfaces. [8M]

b) A 70 mm thick metal plate with a circular hole of 35 mm diameter along the thickness is maintained at a uniform temperature 250 ° C. Find the loss of energy to the surroundings at 27 ° C, assuming the two ends of the hole to be as parallel discs and the metallic surfaces and surroundings have black body characteristics. [8M]



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