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

III B. Tech II Semester Regular Examinations, April - 2016
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**
(Heat transfer data book allowed)

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PART –A

1 a) How does heat transfer differ from thermodynamics? Is it true to say that heat transfer is essentially thermodynamics with rate equations added? [4M]

b) What is lumped system analysis? When is it applicable? [4M]

c) Mention some of the areas where free and forced convection mechanisms are predominant. [3M]

d) How is the friction factor for flow in a tube related to pressure drop? [3M]

e) Distinguish between mechanisms of filmwise condensation and dropwise condensation. [4M]

f) How does an enclouser with a small hole in it behave as a black body? [4M]

PART -B

2 A steel pipe (k=72W/m ^{0}C) of 34 mm outer diameter and 2mm radial thickness carries dry saturated steam at 120^{0}C.The pipe has been provided with asbestos insulation (k=0.3 W/m ^{0}C) to Check and minimize the rate of steam condensation. The pipe is located in surroundings at 25^{0}C.Taking unit length of pipe, Calculate [16M]

a) Thickness of asbestos insulation for which the rate of steam condensation is same as that when the pipe is uninsulated.

b) Mass flow rate of condensation when the above insulation is provided, and

c) Highest rate of condensation and corresponding insulation thickness,

Take surface conductance's on air-side and steam-side as 13 W/m^2 ^{0}C and 500 W/m^2 ^{0}C respectively and h_{fg} at 120^{0}C =2300kJ/kg.

3 a) Explain how the triangular fin is of the best shape. [6M]

b) Both ends of a 5mm diameter U-shaped copper (k= 300 W/m ^{0}C) rod are rigidly fixed to a vertical wall which is at 120^0 C temperature. The length of U-shaped rod is 50 cm and it is exposed to air at 30^{0}C.The combined radiative and convective heat transfer coefficient for the rod is 25 W/m^2 ^{0}C.Make calculations for the temperature at the centre of U-shaped rod and the heat transfer. [10M]

4 Under steady state conditions, the rate of conduction heat transfer through a plane wall is known to depend upon the length of the heat flow passage, its cross-sectional area, temperature difference across the faces and thermal conductivity of the wall material. Through dimensional analysis, establish an expression for the heat flow rate in terms of other variables. [16M]

5 A steam pipe 6 cm in diameter is covered with 2 cm thick layer of insulation which has a surface emissivity of 0.92.The insulation surface temperature is 75^0C and the pipe is placed in atmospheric air at 25^0C.Considering heat loss both by radiation and natural convection, estimate the heat loss from 5 m length of the pipe. Also calculate the overall heat transfer coefficient and the heat transfer coefficient due to radiation alone. [16M]

6 a) What do you understand by nucleation in nucleate boiling? Explain subsequent growth and motion of bubbles. [8M]

b) Dry saturated steam at atmospheric pressure condenses on the surface of a horizontal tube of 35 mm diameter. What should be the surface temperature of the tube if the rate of heat flow is required to be $6x10^4$ W/ m^2? Also, determine the heat transfer coefficient under these conditions. [8M]

7 a) Show that the hemispherical black cavity with a flat cover over it emits 50% of radiation to the surface itself and is absorbed. [8M]

b) A dead black cylinder of emissivity 0.95 is kept at 95^0C in a large enclosure at 10^0C. Find the radiation heat loss per square meter of its surface. What would be radiation loss become if the cylinder were surrounded by a concentric cylinder with its inner surface of a brightly polished metal of emissivity 0.10? Take radiation constant σ_b=5.67x10^{-8} W/m^2 K^4. [8M]

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PART –A

1	a)	Cite few examples where conduction plays a major role.	[4M]
	b)	How does transient heat conduction differ from steady conduction?	[4M]
	c)	Explain the significance of non-dimensional numbers.	[3M]
	d)	What is critical Reynolds number for flow over a flat plate? On what does it depend?	[4M]
	e)	In the design of condensers, which of the two types of condensation is usually selected? Why?	[4M]
	f)	What is a solid angle? What is its unit? What is a steragon?	[3M]

PART -B

2	a)	Derive an expression for heat flow through a composite cylinder taking into account the film heat transfer coefficients on the inside and outside surface of the cylinder. Find the log mean area of the cylinder neglecting film heat transfer coefficients.	[10M]
	b)	A 15cmx18 cm epoxy glass laminate (k=0.26 W/mK) of 0.14mm thickness has 1 mm diameter cylindrical copper fillings (k=386 W/mK) planted throughout the board with centre-to-centre distance of 3mm.Determine the thermal resistance of the epoxy board for heat conduction.	[6M]
3	a)	The fin is exposed to air at 25^0C with a convective coefficient of $22 W/m^2\ ^0C$.If thermal conductivity o the fin material is 200 W/m^0C, determine the heat dissipation. Consider 1m width of fin.	[16M]
	b)	To increase the heat dissipation, the following two alternatives have been suggested with the same material volume. (i) Split the fin into two fins of 5mm thickness each (ii) Single fin 5mm thick and 160 mm long Which will be the better choice? The fins may be considered short with tip insulated.	
4	a)	Explain the Buckingham's π- theorem for dimensional analysis? What are repeating variables and how are they selected for dimensional analysis?	[10M]
	b)	Explain the concept of momentum equation? Explain its significance.	[6M]

5 Atmospheric air at 25^0C flows at 50 m/s velocity past a flat plate 0.6 m long with its surface maintained at 295^0C.Under these conditions, the air may be treated as incompressible. Make calculations for heat transferred to air from the entire plate length taking into account both laminar and turbulent portions of boundary layer. Presume unit width of plate and the critical Reynolds number to be $5x10^5$.What percentage error would be introduced if the boundary layer is presumed to be of turbulent nature from the very leading edge of plate. [16M]

6 a) Explain Pool boiling. How does it differ from forced convection boiling? [8M]

b) Dry saturated steam at 120^0C saturation temperature condenses on a vertical plate, 100 mm in height and 50 mm in width having a uniform surface temperature of 100^0C.Estimate the average condensing film coefficient, heat transfer rate to the plate and the steam condensation rate. [8M]

7 a) By using one radiation shield between two surfaces and if all the three surfaces have the same emissivity, show that the net radiant heat transfer is reduced by 50%. [8M]

b) Explain the radiant energy exchange between two small gray surfaces. Show that $F_{12} = \varepsilon_1\varepsilon_2$. [8M]

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PART –A

1 a) Define thermal conductivity. What is the difference between thermal conductivity and thermal conductance? [3M]

b) List the assumptions made while analyzing the heat flow from a finned surface. [4M]

c) What is meant by dimensional homogeneity? Explain some of its applications. [4M]

d) What do you mean by local and convective differentials? [3M]

e) Discuss the importance of heat exchangers for industrial use. [4M]

f) What is a black body? Give some examples of some surfaces which do not appear black, but have high values of absorptivities. [4M]

PART -B

2 A furnace wall comprises two layers: 8 cm of fire clay (k=1.2 W/mK) next to the fire box and 0.6 cm of mild steel (k=35W/mK) on the outside. The inside surface of brick is at 900K and the steel is surrounded by air at 300K with an outside surface coefficient of $5W/m^2K$.Estimate the heat flux through square meter of furnace wall and the outside surface temperature of steel. What would be the percentage increase in heat flux if in addition to the conditions specified eighteen steel bolts of 1.8 cm diameter pass through the composite wall per square meter of wall area. [16M]

3 a) Consider a sphere and a cylinder of equal volume made of copper. Both the sphere and the cylinder are initially at the same temperature, and are exposed to convection in the same environment. Which do you think will cool faster, the cylinder or the sphere? Why? [8M]

b) A short cylindrical aluminum bar of diameter 6 cm and height 3 cm is initially at a uniform temperature of 175^0C.Suddenly the surfaces are subjected to convective cooling with a h=250 W/m^2K into an ambient at 25^0C. Calculate the centre temperature of the cylinder 1 min after the start of cooling. [8M]

4 Show by dimensional analysis that data for forced convection may be correlated by an equation of the form Nu= φ(Re,Pr) Where Nusselt number Nu=(hl/k),Reynolds number Re ($Vl\rho/\mu$) and prandtl number pr=($\mu C_p/k$). [16M]

5 a) Air at 20^0C flowing at 25 m/s passes over a flat plate, the surface of which is maintained at 270^0C.Calculate the rate at which heat is transferred from both sides of the plate per unit width over a distance of 0.25 m from the leading edge. Properties of air at 145^0C are Pr=0.687,ν =2.8×10^{-5} m^2/s and k=3.49×10^{-5}kW/m K. [10M]

b) Explain the effect of prandtl number on the temperature gradient in turbulent flow for a given Reynolds's number in tubes. [6M]

6 a) Give a comparison of parallel-flow and counter flow heat exchangers. Why are counter flow heat exchangers mostly used? [6M]

b) Water is evaporated continuously at 100^0C in an evaporator by cooling 500 kg of air per hour from 260^0C to 150^0C.Calculate the heat transfer surface area required and the steam evaporation per hour, if the liquid enters at 100^0C.Take U_0=46W/m^2K and C_p of air 1.005kJ/kg k. At 100^0c, h_{fg}=2257kJ/kg. [10M]

7 a) Explain how the shape factors are different surfaces evaluated. [6M]

b) The inner sphere of a Dewar flask is of 300 mm diameter and outer sphere is of 360 mm diameter. Both spheres are plated for which ε=0.5.The space between them is evacuated. Determine the rate at which liquid oxygen would evaporate at -183^0C when the outer sphere temperature is 20^0C.The latent heat of vaporization of liquid oxygen is 14.2 kJ/kg. [10M]

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PART –A

1	a)	Why are metals good thermal conductors, While non-metals are poor conductors of heat?	[3M]
	b)	What is the utility of extended surfaces?	[4M]
	c)	The expression $\frac{hl}{k}$ gives the Biot number as well as the Nusselt number. What is the difference between the two?	[4M]
	d)	When is the forced convection heat transfer in two systems physically similar?	[3M]
	e)	What is mean by fouling factor? How does it affect the performance of a heat exchanger?	[4M]
	f)	Explain how thermal radiation exhibits wave particle duality.	[4M]

PART -B

2	a)	Derive a three dimensional general heat conduction equation in spherical co-ordinates for a homogeneous material. Deduce there from an expression for unidirectional unsteady state system when heat is generated within it at the rate of q_g per m^3 of the material.	[10M]
	b)	A cubical tank of water of volume $1.5m^3$ is kept at a steady temperature of 65^0C by a 1kW heater. The heater is switched off. How long does the tank to cool to 50^0C if the room temperature is 15^0C .	[6M]
3		A orange of diameter 10 cm is initially at a uniform temperature of 30^0C.It is placed in a refrigerator in which the air temperature is 2^0C.If the heat transfer coefficient between the air and the orange surface is 50 W/m^2K,determine the time required for the centre of the orange to reach 10^0C.Assume the thermal properties of the orange to reach 10^0C.Assume the thermal properties of the orange are the same as those of water at the same temperature (α =1.4 x $10^{-7}m^2/s$ and k= 0.59 W/mK).	[3M]
	b)	What is lumped system analysis? When is it applicable?	[6M]
4	a)	Show that the resistance R to the motion of a sphere of diameter D moving with uniform velocity V through a real fluid of density ρ and viscosity μ is given by $R=\rho D^2V^2f$ (**$\mu/\rho VD$**) where f stands for a function of	[8M]
	b)	Explain the Rayleigh's method for dimensional analysis.	[8M]

5 a) Calculate the heat generated in a body of a man if for comfortable living, the body is to be at 35^0C whilst the environmental conditions are at 15^0C.The body of the man may be idealized as a cylinder of 30cm diameter and 160 cm height.
Use the correlation $Nu=0.12(Gr\ Pr)^{(1/3)}$. [10M]

b) How does the friction factor for turbulent flow through a tube depend on the Reynolds number? [6M]

6 Hot oil is to be cooled by water in a one shell pass and eight tube passes heat exchanger. The tubes are thin-walled and made of copper with an internal diameter of 14 mm. The length of each tube pass is 5 m and U_0 =310 W/m^2 K. Water flows through the tubes at a rate of 0.2 kg/s and oil through the shell at a rate of 0.3 kg/s. The water and the oil enter at temperatures of 20^0C and 150^0C respectively. Determine the rate of heat transfer and the exit temperatures of the water and the oil. [16M]

7 a) Show that the emissive power of a black body is π-times the intensity of emitted radiation. [8M]

b) Determine the heat lost by radiation per meter length of a 75 mm oxidized steel pipe at 327^0 C if [8M]
(i) located in a large room with red brick walls at a temperature of 27^0C
(ii) Enclosed in a 150mm x150mm red brick walls at a temperature of 27^0C. Emissivites of oxidized steel and red brick are 0.79 and 0.93 respectively.

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