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QUESTION BANK (DESCRIPTIVE)

Subject with Code : Heat Transfer (16ME320) **Course & Branch**: B.Tech -ME
Year & Sem: III-B.Tech & II-Sem **Regulation:** R16

UNIT –I
Basic Concepts and Conduction

1	a)	Define the following terms. i).Heat ii).Heat transfer	L_1	5M
	b)	List the some important areas which are covered under the discipline of heat transfer.	L_1	5M
2	a)	List the basic laws which govern the heat transfer.	L_1	5M
	b)	Name and explain the mechanism of heat transfer	L_1	5M
3	a)	What is Fourier's law of conduction? State the assumption and essential feature of it.	L_1	5M
	b)	Define the following terms. i).Thermal Conductivity ii).Thermal Resistance	L_1	5M
4	a)	Distinguish between conduction, convection and radiation modes of heat transfer	L_3	5M
	b)	Calculate the rate of heat transfer per unit area through a copper plate 45 mm thick, whose one face is maintained at 350 ^oC and the other face at 50 ^oC. Take thermal conductivity of copper as 370 W/m ^oC.	L_4	5M
5	a)	What is conduction heat transfer? Explain its parameters.	L_1	5M
	b)	A plane wall is 150 mm thick and its wall area is 4.5 m^2. If its conductivity is 9.35 W/m ^oC and surface temperature are steady at 150 ^oC and 45 ^oC, determine i).Heat transfer across the plane wall, ii).Temperature gradient in the flow direction	L_4	5M
6	a)	What is convection heat transfer? Explain its parameters.	L_1	5M
	b)	A wire 1.5 mm diameter and 150 mm long is submerged in water at atmospheric pressure. An electric current passed through the wire and is increased until the water boils at 100 ^0C. Under the condition, if convective heat transfer coefficient is 4500W/m^2 ^0C. Find how electric power must be supplied to the wire to maintain the wire surface at 120 ^0C	L_4	5M
7	a)	Write the laws of radiation? Explain its parameters.	L_1	10M
	b)	A surface having an area of 1.5 m^2 and maintained at 300 ^0C exchanges heat by radiation with another surface at 40 ^0C. The value factor due to the geometric location and emissivity is 0.52. Determine i).Heat loss by radiation ii).The value of thermal resistance iii).The value of equivalent convection coefficient	L_4	5M

8		Derive the general heat conduction equation in Cartesian coordinate.	L_3	10M
9		Derive the general heat conduction equation in Cylindrical coordinate	L_3	10M
10		Derive the general heat conduction equation in Spherical coordinate.	L_3	10M

UNIT –II
One Dimensional Steady State Heat Conduction and Transient Heat Conduction

1	a)	Derive an expression for heat conduction through a plane wall	L_3	5M
	b)	The inner surface of a plane Brick wall is at 60 ^{0}C and the outer surface is at 35 ^{0}C. Calculate the rate of heat transfer per m^2 of surface area of the wall, which is 220 mm thick. Take thermal conductivity of the brick is 0.51 W/ m ^{0}C.		5M
2	a)	Derive an expression for heat conduction through a composite wall	L_3	5M
	b)	A reactor's wall, 320 mm thick, is made up of an inner layer of fire brick (k = 0.84W/m ^{0}C) covered with a layer of insulation (k = 0.16 W/m ^{0}C). The reactor operates at a temperature of 1325 ^{0}C and the ambient temperature is 25 ^{0}C. Determine the thickness of fire brick and insulation which gives minimum heat loss.	L_4	
3		A steam pipe of outside diameter 80 mm and 25 m long conveys 800 kg of steam per hour at a pressure of 22 bar. The steam enters the pipe with a dryness fraction of 0.99 and is to leave the other end of the pipe with the minimum dryness fraction of 0.97. This is to be accomplished by using a lagging material (k = 0.2 W/m ^{0}C), determine its minimum thickness to meet the necessary condition, if the temperature of the outside surface of lagging is 25 ^{0}C. Assume that there is no pressure drop across the pipe and the resistance of the pipe material is negligible.	L_4	10M
4	a)	Obtain the expression of heat conduction through hollow cylinder.	L_3	5M
	b)	A spherical shaped vessel of 1.4 m diameter is 90 mm thick. Find the rate of heat leakage, if the temperature difference between the inner and outer surface is 220 ^{0}C. Thermal conductivity of the material of the sphere is 0.083 W/m ^{0}C.	L_4	5M
5	a)	Derive the expression for the overall heat transfer coefficient for a plane wall.	L_3	4M
	b)	A cold storage room has walls made up of 220 mm of brick on outside 90 mm of plastic foam and finally 16 mm of wood on the inside. The outside and inside air temperatures are 25 ^{0}C and -3 ^{0}C respectively. If the inside and outside and heat transfer coefficients are 30 and 11 W/$^{m2\ 0C}$ respectively the thermal conductivity of brick, plastic foam and wood are 0.99, 0.02 and 0.17 W/m ^{0}C respectively. Then determine i. The rate of heat removal by the refrigeration, if the total wall area is 85 m^2 ii. The temperature of the inside surface of the brick	L_4	6M
6	a)	Explain the concept of critical radius of insulation for a cylinder.	L_2	5M
	b)	Calculate the critical radius of insulation for asbestos (k = 0.172 W/m K) surrounding a pipe and exposed to room air at 300 K with h = 2.8 W/m K.	L_4	6M

		Calculate the heat loss from a 475 K, 60 mm diameter pipe when covered with the critical radius of insulation and without insulation.		
7	a)	What is lumped system analysis? Derive the expression for it.	L_2	4M
	b)	A 50 cm x 50 cm copper slab 6.25 mm thick has a uniform temperature of 300 ^{0}C. Its temperature is suddenly lowered to 36 ^{0}C. Calculate the time required for the plate to reach the temperature of 108 . Take ρ = 9000 kg/m^3, c = 0.38 kJ/kg ^{0}C, k = 370 W/m ^{0}C and h = 90 W/m^2 ^{0}C.	L_4	6M
8	a)	Write short note on transient heat conduction.	L_1	4M
	b)	A steel ingot (large in size) heated uniformly to 745 ^{0}C is hardened by quenching it in an oil bath maintained at 20 ^{0}C. Determine the length of time required for the temperature to reach 595 ^{0}C at a depth of 12 mm. The ingot may be approximated as a flat plate. For steel ingot take α(thermal diffusivity) = 1.2x10^{-5} m^2/s.	L_4	6M
9	a)	Sketch various types of fins. Give examples of use of fins in various engineering applications	L_3	5M
	b)	Calculate the amount of energy required to solder together two very long pieces of bare copper wire 1.5 mm diameter with solder that melts at 190 ^{0}C. The wires are positioned vertically in air at 20 ^{0}C. Assume that the heat transfer coefficient on the wire surface is 20 W/m^2 ^{0}C and thermal conductivity of wire alloy is 330 W/m ^{0}C.	L_4	5M
10	a)	Explain the fin effectiveness and fin efficiency	L_2	5M
	b)	A longitudinal copper fin (k = 380 W/m ^{0}C) 600 mm long and 5 mm diameter is exposed to air stream at 20 ^{0}C. The convective heat transfer coefficient is 20 W/ m^2 ^{0}C. If the fin base temperature is 150 ^{0}C, determine i. The heat transferred, and ii. The efficiency of the fin	L_4	5M

UNIT –III

Convection

1		Explain hydrodynamic and thermal boundary layer with reference to flow over flat plate.	L_2	10M
2	a)	What is convective heat transfer? Distinguish between free and forced convection	L_1	5M
	b)	Derive the expression for Reynolds number and how flows are determined by Reynolds number?	L_3	5M
3		Air at 20 ^{0}C and at a pressure of 1 bar is flowing over a flat plate at a velocity of 3 m/s. If the plate is 280 mm wide and at 56 ^{0}C. Calculate the following quantities at x = 280 mm, given that properties of air at the bulk mean temperature $(\frac{20+56}{2})$ = 38 ^{0}C are ρ = 1.1374 kg/m^3, k = 0.02732 W/m ^{0}C, c_p = 1.005 kJ/kg K, υ = 16.76x10^{-6} m^2/s, Pr = 0.7 i. Boundary layer thickness ii. Local friction coefficient iii. Average friction coefficient iv. Thickness of the boundary layer	L_4	10M

v. Local convective heat transfer
vi. Average convective heat transfer
vii. Rate of heat transfer by convection

4	a)	What is the physical significance of the Nusselt number? How is it defined	L_1	4M
	b)	Assuming that a man can be represented by a cylinder 350 mm in diameter and 1.65 m high with a surface temperature of 28 ^{0}C. Calculate the heat he would lose while standing in a 30 km/h wind at 12 ^{0}C.	L_4	6M
5	a)	Define Nusselt number, Prandtl number and their significance.	L_1	4M
	b)	Air stream at 24 ^{0}C is flowing at 0.4 m/s across a 100 W bulb at 130 ^{0}C. If the bulb is approximately by a 65 mm diameter sphere. Calculate i. The heat transfer rate, ii. The percentage of power lost due to convection	L_4	6M
6		In a straight tube of 60 mm diameter, water is flowing at a velocity of 12 m/s. The tube surface temperature is maintained at 70 ^{0}C and the following water is heated from the inlet temperature 15 ^{0}C to an outlet temperature of 45 ^{0}C. taking the physical properties of water at its mean bulk temperature, Calculate the following: i. The heat transfer coefficient from the tube surface to the water ii. The heat transferred iii. The length of the tube	L_4	10M
7	a)	Mention the empirical correlation of free convection	L_3	4M
	b)	A vertical cylinder 1.5m high and 180mm in diameter is maintained at 100^{0}C in an atmosphere environment of 20 ^{0}C. Calculate heat loss by free convection from the surface of the cylinder. Assume properties of air at mean temperature as ρ = 1.06 kg/m^3,ν = 18.97 x 10^{-6} m^2/s, c_p = 1.004 kJ/kg^{0}C and k = 0.1042kJ/mh^{0}C	L_4	6M
8	a)	Mention correlation for flow over a horizontal plate	L_3	5M
	b)	A horizontal plate measuring 1.5 m x 1.1 m and at 215 ^{0}C, taking upward is placed in still air at 25 ^{0}C. Calculate the heat loss by natural convection. The convective film coefficient for free convection is given by the following empirical relation $h = 3.05(T_f)^{1/4}$ W/m^2 ^{0}C. where T_f is the mean film temperature in degree Kelvin	L_4	5M
9	a)	Mention correlation for across bank of tubes.	L_3	4M
	b)	A cylinder body of 300 mm diameter and 1.6 m height is maintained at a constant temperature of 36.5 ^{o}C. The surrounding temperature is 13.5 ^{o}C. Find out the amount of heat to be generated by the body per hour if ρ = 1.025 kg/m^3,ν = 15.06 x 10^{-6} m^2/s, c_p = 0.96 kJ/kg^{0}C and k = 0.0892 kJ/mh^{0}C and β=1/298 K^{-1}. Assume Nu=0.12(Gr.Pr)$^{1/3}$.	L_4	6M
10		Calculate the heat transfer from a 60 W in candescent bulb at 115 ^{0}C to ambient air at 25 ^{0}C. Assuming the bulb as a sphere of 50 mm diameter. Also, find the percentage of power lost by free convection. The correlation is given by: Nu = 0.60 (Gr.Pr)$^{1/4}$.	L_4	10M

UNIT –IV

Phase Change Heat Transfer and Heat Exchangers

1	a)	Differentiate between the mechanism of filmwise and dropwise condensation	L_3	5M
	b)	Explain briefly the condensation mechanism on the vertical plate	L_2	5M
2		Explain briefly the various regimes of saturated pool boiling with diagram	L_3	10M
3	a)	Mention correlation in boiling with proper expression	L_3	5M
	b)	Mention correlation in condensation with proper expression	L_3	5M
4		Saturated steam at t_{sat} = 90 ^{0}C (P= 70.14 kPa) condenses on the outer surface of a 1.5 m long 2.5 m OD vertical tube maintained at a uniform temperature t_∞ = 70 ^{0}C. Assuming film condensation. Calculate i). The local transfer coefficient at the bottom of the tube, and ii). The average heat transfer coefficient over the entire length of the tube. Properties of water of 80 ^{0}C, ρ_l = 974 kg/m^3, k_t = 0.668 W/mK, μ_l = 0.335x10^3 kg/m^3, h_{fg} = 2309 kJ/kg, $\rho_v << \rho_l$	L_4	10M
5	a)	What are the applications of boiling and condensation process?	L_1	4M
	b)	A vertical tube of 60 mm outside diameter and 1.2 m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 50 ^{0}C by circulated cold water through the tube. Calculate the following i). The rate of heat transfer to the coolant, and ii). The rate of condensation of steam	L_4	6M
6	a)	What is heat exchanger?	L_1	3M
	b)	How are heat exchangers classified explain with neat diagram	L_2	7M
7	a)	Derive the expression for Logarithmic Mean Temperature Difference (LMTD) in case of parallel flow	L_3	5 M
	b)	Derive the expression for Logarithmic Mean Temperature Difference (LMTD) in case of counter flow	L_3	5 M
8		The flow rate of hot and cold water streams running through a parallel flow heat exchanger are 0.2 kg/s and 0.5 kg/s respectively. The inlet temperatures on the hot and cold sides are 75 ^{0}C and 20 ^{0}C respectively. The exit temperature of hot water is 45 ^{0}C. If the individual heat transfer coefficients on the both sides are 650 W/m^2 ^{0}C, calculate the area of heat exchanger.	L_4	10M
9	a)	Draw the boiling curve of the water and explain.	L_3	4M
	b)	In a certain double pipe heat exchanger hot water flow at a rate of 5000 kg/h and gas cooled from 95 ^{0}C to 65 ^{0}C. At the same time 50000 kg/h of cooling water at 30 ^{0}C enters the heat exchanger. The flow conditions are that L_4overall heat transfer coefficient remains constant at 2270 W/m^2 K. Determine the heat transfer area required and the effectiveness, assuming two streams are in parallel flow. Assume for the both the streams c_p = 4.2 kJ/kg K	L_4	6M
10	a)	Distinguish between Boiling and Condensation	L_3	4M

	b)	Two fluids A and B exchange heat in a counter-current heat exchanger. Fluid A enters at 420 ^{0}C and has a mass flow rate of 1 kg/s. Fluid B enters at 20 ^{0}C and has a mass flow rate of 1 kg/s. Effectiveness of heat exchanger is 75 %. Determine: i). The heat transfer rate ii). The exit temperature of fluid B. Specific heat of fluid A is 1 kJ/kg and that of fluid B is 4 kJ/kg K.	L_4	6M

UNIT –V
Radiation

1	a)	Define Radiation heat transfer	L_1	5M
	b)	Define the term absorptivity, reflectivity and transmittivity of radiation	L_1	5M
2	a)	State the following law: i) Wien's displacement law ii) Stefan Boltzmann law	L_1	5M
	b)	State the following law: i) Krichhoff's law ii) Planck's law	L_1	5M
3	a)	What is black body ? How is differ from a gray body ?	L_1	4M
	b)	The effective temperature of the body having an area of 0.12 m^2 is 527 ^{o}C. Calculate the following i) The total rate of energy emission ii) The wave length of maximum monochromatic emissive power	L_4	6M
4		Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500 ^{o}C. i) Monochromatic emissive power at 1.2 μm length ii) Wave length at which the emissive is maximum iii) Maximum emissive power iv) Total emissive power v) Total emissive power of the furnace if its assumed as a real surface with emissivity equal to 0.9	L_4	10M
5	a)	Define Shape factor and mention salient features of its.	L_1	4M
	b)	Mention the shape factor's fact and properties for specific geometries and for the analysis of radiant relation exchange between surfaces.	L_3	6M
6	a)	The radiation shape factor the circular surface of a thin hollow cylinder of 10 cm diameter and 10 cm length is 0.1716. What is the shape factor of the curved surface of the cylinder with respect to itself.	L_4	10M
7	a)	Discuss electrical network analogy for thermal radiation system	L_3	5M
	b)	Write short note on radiation shields	L_1	5M
8		Calculate the net radiant exchange per m^2 area for two large parallel plates at temperature at 427 ^{o}C and 27 ^{o}C respectively. ε (hot plate)=0.9 and ε (cold plate)=0.6. If a polished aluminium shield is placed between them, find the percentage reduction in the heat transfer, ε(shield)=0.4	L_4	10M
9	a)	Determine the radiant heat exchanger in W/m^2 between two large parallel steel plates of emissivities 0.8 and 0.5 held at temperature of 1000 K and 500 K respectively, if a thin copper plate of emissivity 0.1 is introduced as a	L_4	5M

		radiation shield between the two plates. Use σ= 5.67×10^{-8} W/m^2K^4.		
	b)	Assuming the sun to be a black body emitting radiation with maximum intensity at λ = 0.49 µm, Calculate the following i). The surface temperature of the sun ii). The heat flux at surface of the sun	L_4	5M
10		Consider two large parallel plates one at t_1 = 727 °C with emissivity ε_1 = 0.8 and other t_2 = 227 °C with emissivity ε_2 = 0.4. An aluminium radiation shield with an emissivity, ε_s = 0.05 on both side is placed between the plates. Calculate the percentage reduction in heat transfer rate between the plates as result of the shield. Use σ= 5.67×10^{-8} W/m^2K^4.	L_4	10M