Course Code: 20ME0315 **R20**

SIDDHARTH INSTITUTE OF ENGINEERING & TECHNOLOGY:: PUTTUR
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QUESTION BANK (DESCRIPTIVE)

Subject with Code: Heat & Mass Transfer (20ME0315) **Course & Branch:** B.Tech-AGE

Year &Sem: II-B.Tech &I-Sem **Regulation: R20**

UNIT –I
BASIC CONCEPTS

1.	a) Define the following terms. i).Heat ii).Heat transfer	[L1][CO1]	**[6M]**
	b) Enumerate the some important areas which are covered under the discipline of heat transfer.	[L1][CO1]	**[6M]**
2.	a) List the basic laws which govern the heat transfer	[L1][CO1]	**[6M]**
	b) Name and explain the mechanism of heat transfer	[L1][CO1]	**[6M]**
3.	a) What is Fourier's law of conduction? State the assumption and essential feature of it	[L1][CO1]	**[6M]**
	b) Define the following terms i)Thermal Conductivity ii) Thermal Resistance	[L1][CO1]	**[6M]**
4.	a) Distinguish between conduction, convection and radiation modes of heat transfer	[L3][CO1]	**[6M]**
	b) Calculate the rate of heat transfer per unit area through a copper plate 45 mm thick, whose one face is maintained at 350 ^{0}C and the other face at 50 ^{0}C. Take thermal conductivity of copper as 370 W/m ^{0}C.	[L4][CO1]	**[6M]**
5.	a) What is conduction heat transfer? Explain its parameters	[L1][CO1]	**[6M]**
	b) A plane wall is 150 mm thick and its wall area is 4.5 m2. If its conductivity is 9.35 W/m ^{0}C and surface temperature are steady at 150 ^{0}C and 45 ^{0}C, determine i).Heat transfer across the plane wall, ii).Temperature gradient in the flow direction	[L4][CO1]	**[6M]**
6.	a) What is convection heat transfer? Explain its parameters	[L1][CO1]	**[6M]**
	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 ^{0}C. Under the condition, if convective heat transfer coefficient is 4500W/m^2 ^{0}C. Find how electric power must be supplied to the wire to maintain the wire surface at 120 ^{0}C	[L4][CO1]	**[6M]**
7.	a) Write the laws of radiation? Explain its parameters	[L1][CO1]	**[6M]**
	b) A surface having an area of 1.5 m2 and maintained at 300 ^{0}C exchanges heat by radiation with another surface at 40 ^{0}C. 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	[L4][CO1]	**[6M]**
8.	Derive the general heat conduction equation in Cartesian coordinate	[L3][CO1]	**[12M]**
9.	Derive the general heat conduction equation in Cylindrical coordinate	[L3][CO1]	**[12M]**
10	A carbon steel plate (thermal conductivity 45 W/m ˚ C) 600 mm X 900 mm X25 mm is maintained at 310 ˚C. Air at 15 ^{0}C C blows over the hot plate. If convection heat transfer coefficient is 22 W/m^{20}C and 250 W is lost from the plate surface by radiation, calculate the inside plate temperature.	[L5][CO1]	**[12M]**

UNIT –II
ONE DIMENSIONAL STEADY STATE HEAT CONDUCTION, EXTENDED SURFACES &TRANSIENT HEAT CONDUCTION

1.	The inner surface of a plane brick wall is at 60 °C and the outer surface is at 35 °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 ◦C.	[L4][CO2]	**[12M]**
2.	a) Derive an expression for heat conduction through a composite wall	[L3][CO2]	**[6M]**
	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.	[L4][CO2]	**[6M]**
3.	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 trough the wall by 80 percent.	[L4][CO2]	**[12M]**
4.	a) Obtain the expression of heat conduction through hollow cylinder	[L3][CO2]	**[6M]**
	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 0C.	[L4][CO2]	**[6M]**
5.	a) Derive the expression for the overall heat transfer coefficient for a composite wall.	[L3][CO2]	**[6M]**
	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 m2 c) ii. The temperature of the inside surface of the brick	[L4][CO2]	**[6M]**
6.	a) Derive an expression for heat conduction through a plane wall	[L1][CO2]	**[6M]**
	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. Calculate the heat loss from a 475 K, 60 mm diameter pipe when covered with the critical radius of insulation and without insulation.	[L4][CO2]	**[6M]**
7.	a) What is lumped system analysis? Derive the expression for it	[L2][CO2]	**[6M]**
	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 ^{0}C. Take ρ = 9000 kg/m3, c = 0.38 kJ/kg 0C, k = 370 W/m ^{0}C and h = 90 W/m^2 ^{0}C.	[L4][CO2]	**[6M]**
8.	a) Write short note on transient heat conduction	[L1][CO2]	**[6M]**
	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.	[L4][CO2]	**[6M]**
9.	a) Sketch various types of fins. Give examples of use of fins in various engineering applications	[L3][CO2]	**[6M]**
	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	[L4][CO2]	**[6M]**
10.	a) Explain the fin effectiveness and fin efficiency	[L2][CO2]	**[6M]**
	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	[L4][CO2]	**[6M]**

	i. The heat transferred, and ii. The efficiency of the fin		

UNIT –III
CONVECTION, FREE CONVECTION & FORCED CONVECTION

1.	Explain hydrodynamic and thermal boundary layer with reference to flow over flat plate.	[L1][CO3]	**[12M]**
2.	a) What is convective heat transfer? Distinguish between free and forced convection	[L1][CO3]	**[6M]**
	b) Derive the expression for Reynolds number and how flows are determined by Reynolds number?	[L3][CO3]	**[6M]**
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 ^{0}C are ρ = 1.1374 kg/m^3, k = 0.02732 W/m ^{0}C, cp = 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 v. Local convective heat transfer vi. Average convective heat transfer vii. Rate of heat transfer by convection viii. Rate of convective heat transfer	[L4][CO3]	**[12M]**
4.	a) What is the physical significance of the Nusselt number? How is it defined	[L1][CO3]	**[6M]**
	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. Take k=2.59 x10^{-6} ^{W}/m ^{0}C, υ = 15x10^{-6} m^2/s, Pr = 0.707.	[L4][CO3]	**[6M]**
5.	a) Define Nusselt number, Prandtl number and their significance	[L1][CO3]	**[6M]**
	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. Take k=0.03 w/m ^{0}C, υ = 2.08x10^{-5} m^2/s, Pr = 0.697.	[L4][CO3]	**[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. Take k=61.718 x10^{-2} ^{W}/m ^{0}C, υ = 0.805x10^{-6} m^2/s, Pr = 5.42,ρ=995.7 kg/m^3,Cp=4.174 kj/kg k.	[L4][CO3]	**[12M]**
7.	a) Mention the empirical correlation of free convection	[L3][CO3]	**[6M]**
	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	[L4][CO3]	**[6M]**
8.	a) Differentiate between laminar and turbulent flow.	[L3][CO3]	**[6M]**
	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/m2 0C. where T_f is the mean film temperature in degree Kelvin	[L4][CO3]	**[6M]**
9.	A cylinder body of 300 mm diameter and 1.6 m height is maintained at a constant temperature of 36.5 ^{0}C. The surrounding temperature is 13.5 ^{0}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, cp = 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)$^{1/3}$.	[L4][CO3]	**[12M]**
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)$^{1/4}$ .Take	[L4][CO3]	**[12M]**

	$k=2.964 \times 10^{-2}$ W/m ^{0}C, $\upsilon = 20.02 \times 10^{-6}$ m^2/s, Pr = 0.694.		

UNIT –IV
BOILING & CONDENSATION AND RADIATION

1.	a) Define Radiation heat transfer	[L1][CO4]	**[4M]**
	b) Define the term absorptivity, reflectivity and transmittivity of radiation.	[L1][CO4]	**[8M]**
2.	Explain briefly the various regimes of saturated pool boiling with diagram	[L3][CO4]	**[12M]**
3.	a) Mention correlation in boiling with proper expression	[L3][CO4]	**[6M]**
	b) Discuss the different types of processes for condensation of vapours on a solid surface	[L3][CO4]	**[6M]**
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, ρl = 974 kg/m3, k_t = 0.668 W/mK, $\mu_l = 0.335 \times 10^3$ kg/m^3, h_{fg} = 2309 kJ/kg, $\rho_v << \rho_l$	[L4][CO4]	**[12M]**
5.	a) What are the applications of boiling and condensation process?	[L1][CO4]	**[6M]**
	b) Explain Stefan Boltzmann Law, Kirchhoff‟s Law	[L1][CO4]	**[6M]**
6.	a) Differentiate between the mechanism of film wise and drop wise condensation	[L3][CO4]	**[6M]**
	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	[L4][CO4]	**[6M]**
7	Calculate the following for an industrial furnace in the form of black body and emitting radiation at 2500 ^{0}C . i. Monochromatic emissive power at 1.2 μm length ii. Wave length at which the emission is maximum iii. Maximum emissive power iv. Total emissive power v. Total emissive power of the furnace if the assumed as a real surface with emissivity equal to 0.9.	[L5][CO4]	**[12M]**
8.	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	[L4][CO4]	**[12M]**
9.	a) Explain the concept of black body	[L1][CO4]	**[6M]**
	b) Explain the surface emissive properties	[L1][CO4]	**[6M]**
10	a) Distinguish between Boiling and Condensation	[L1][CO4]	**[6M]**
	b) What is black body? How is differ from a gray body?	[L1][CO4]	**[6M]**

UNIT –V
HEAT EXCHANGERS AND MASS TRANSFER

1.	Which of the arrangement of heat exchangers is better, (i) parallel flow,(ii) Counter flow. Explain the reasons	[L2][CO5]	**[12M]**
2	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	[L4][CO5]	**[12M]**
3	Derive the expression for Logarithmic Mean Temperature Difference (LMTD) in case of counter flow	[L3][CO5]	**[12M]**
4	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 ◦C enters the heat exchanger. The flow conditions are that L4overall heat transfer coefficient remains constant at 2270 W/m2 K. Determine the heat transfer area required and the effectiveness, assuming two streams are in parallel flow. Assume for the both the streams cp = 4.2 kJ/kg K	[L4][CO5]	**[12M]**
5	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/m2 ^{0}C, calculate the area of heat exchanger	[L4][CO5]	**[12M]**
6	Define Fick's law. Explain briefly.	[L1][CO5]	**[12M]**
7	How heat exchangers are classified based on direction of fluid motion. Explain with neat diagram	[L1][CO5]	**[12M]**
8	Derive the expression for Logarithmic Mean Temperature Difference (LMTD) in case of parallel flow.	[L3][CO5]	**[12M]**
9	a) Explain the modes of Mass transfer	[L2][CO6]	**[8M]**
	b) What is Mass transfer coefficient?	[L2][CO6]	**[4M]**
10	a) Explain correlation for mass transfer	[L2][CO6]	**[6M]**
	b) List out the application of Mass Transfer	[L1][CO6]	**[6M]**

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