Gandhi Institute of Engineering and Technology University, Odisha, Gunupur
(GIET University)

B. Tech (Sixth Semester - Regular) Examinations, April 2025

22BMEPC36001– Heat Transfer

(Mechanical Engineering)

Time: 3 hrs Maximum: 70 Marks

Answer ALL questions

(The figures in the right-hand margin indicate marks)

PART – A **(2 x 5 = 10 Marks)**

Q.1. Answer ***ALL*** questions		CO #	Blooms Level
a.	State Fourier law of heat conduction.	CO1	K1
b.	Define thermal diffusivity and write its unit.	CO1	K1
c.	Define Grashoff number and Prandtl number.	CO2	K1
d.	Define Stefan-Boltzmann law.	CO3	K1
e.	Differentiate between parallel and counter flow heat exchanger.	CO4	K1

PART – B **(15 x 4 = 60 Marks)**

Answer ***ALL*** questions		Marks	CO #	Blooms Level
2. a.	A homogenous wall of area A and thickness L has left and right-hand surface temperature of 0°C and 40°C respectively. Determine the temperature at the centre of the wall. How much material must be added and to which side of the wall if the temperature at the centre is to be: i) raised by 5^0C and ii) lowered by 5^0C.	8	CO1	K3
b.	i) Define conduction mode of heat transfer. Discuss the mechanism of heat conduction in solid and fluid. ii) Explain thermal contact resistance for a plane composite wall with electrical analogy.	4+3	CO1	K2 & K1
	(OR)			
c.	Derive the expression for general heat conduction equation in cartesian coordinate system.	8	CO1	K3
d.	A composite wall consists of 160 mm layer of refractory brick, 50 mm layer of steel plate, 110 mm layer of insulation brick. The maximum temperature of the wall is 1050°C and minimum temperature is 40°C on the outer side of the wall. Thermal conductivities of layers are 1.52 W/mK, 45 W/mK, 0.138 W/mK, respectively. Calculate the rate of heat loss per unit surface area of heat transfer and all the interface temperatures.	7	CO1	K3
3.a.	i) Define critical thickness of insulation and write the expression for critical radius of a sphere. ii) A wire of 5 mm diameter at a temperature of 80°C is to be insulated by a material having k = 0.1 W/mK. Convection heat transfer coefficient h_0 = 10 W/m^{2}K. The ambient temperature is 25°C. For maximum heat loss calculate critical thickness of insulation and also calculate heat lost without insulation and maximum heat lost with consideration of critical thickness.	2+1+6	CO1	K1 & K3
b.	Write short notes on the following:	6	CO1	K1

	i) Fin parameter, ii) Efficiency of a fin, iii) Relation between efficiency and effectiveness of a fin			
	(OR)			
c.	A flat plate, 1 m wide and 1.5 m long is to be maintained at 90°C in air with a free stream temperature of 10°C. Determine the velocity with which air must flow over the plate along 1.5 m side so that the rate of energy dissipation from the plate is 3.75 kW. Take the properties of air at 50°C are: ρ = 1.09 kg/m^3, k = 0.028 W/mK, Pr = 0.7, $\mu = 2.03 \times 10^{-5}$ kg/m-s, C_p = 1.007 kJ/kgK. Use the relation Nu = 0.664 $(Re)^{1/2}$ $(Pr)^{1/3}$.	9	CO2	K3
d.	Write short notes on the following: i) Natural and forced convection, ii) Dittus-Boelter correlation, iii) Thermal entry length in a tube.	6	CO2	K1
4.a.	i) Derive expression for the self-shape factor of a shallow cylindrical cavity. ii) Two large gray surfaces have emissivity of 0.2 and 0.1 respectively. It is proposed to introduce a radiation shield such that the heat transfer rate reduced to 12% of its no-shield value. Find the emissivity of the shield required.	3+5	CO3	K2 & K3
b.	Derive the expression for net thermal radiation exchange between two infinite parallel diffuse-gray plane surfaces.	7	CO3	K3
	(OR)			
c.	i) Define emissivity and absorptivity of a surface. ii) A steel plate is placed on a non-conducting opaque surface normal to incident solar radiation of 900 W/m^2. Neglecting convection effects, work out the equilibrium temperature of the plate when it is (a) oxidized with emissivity ε = 0.7 and (b) polished with emissivity ε = 0.05.	3+6	CO3	K1 & K3
d.	Write short notes on the following: i) Black body concept, ii) Gray and diffuse surface, iii) Shape factor in thermal radiation	6	CO3	K1
5.a.	i) Define heat exchanger and give some practical examples. ii) A counter flow heat exchanger is to be designed to decrease the temperature of air flowing at 3 kg/s of air from 450°C to 200°C using an equal mass flow rate of air entering at 80°C. Determine the required heat exchanger surface area, assuming the specific heat (C_p) of air on both sides is 1 kJ/kgK. Take the heat transfer coefficients: h_{hot} = 40 W/m²K and h_{cold} = 25 W/m²K.	2+7	CO4	K1 & K3
b.	Write short notes on the following: i) Recuperator and regenerator, ii) Effectiveness of a heat exchanger, iii) Number of transfer unit (NTU).	6	CO4	K1
	(OR)			
c.	Derive the expression for effectiveness of a parallel flow heat exchanger.	9	CO4	K3
d.	Write short notes on the following: i) Nucleate and film boiling, ii) Critical heat flux (CHF) in boiling heat transfer, iii) Film and dropwise condensation.	6	CO4	K1

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