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December 2023 (REEXAM)

TY B.TECH (SEMESTER - I)

COURSE NAME:Heat Transfer **Branch:Mechanical** **COURSE CODE:** **MEUA31202**

(PATTERN 2020)

Time: [2 Hrs] **[Max. Marks: 60]**

(*) Instructions to candidates:

1) **Figures to the right indicate full marks.**
2) **Use of scientific calculator is allowed**
3) **Use suitable data wherever required**
4) **All questions are compulsory. Solve any two sub questions each from each Question 1 ,2, 3,4,5,and 6 respectively.**

Q. No.	Question Description	Max. Marks	CO mapped	BT Level
Q.1	a)The insulation boards for air-conditioning purposes are made of three layers, the middle being of packed grass 10cm thick (kg=0.02 W/mK) and the sides are made of plywood , each of 2cm thickness (kp=0.12 W/mK).They are glued with each other.Instead of glue, if these three boards are bolted by 4 steel bolts (ks=40 W/mK) of 1cm dia each at the corners per m2 area of the board. Draw the thermal circuit of the above geometry and comment on heat transfer rate.	[5]	1	4
	b) A long cylindrical rod of radius 12 cm, consists of nuclear reacting material (k=2 W/m K) generating heat energy at 30 kW/m^3 uniformly throughout its volume. The rod is encapsulated within another cylinder (k=5W/mK) whose outer radius is 24cm and the surface is surrounded by air at 30°C with heat transfer coefficient of 20 W/m2K. Find the temp at the at the outer surface.	[5]	1	4
	c) Insulation boards for air-conditioning purpose are made of three layers, the middle being of packed grass 10cm thick (k=0.02W/mK) and the sides are made of plywood, each of 2cm thickness (k=0.12 W/mK). They are glued with each other.Determine heat flow rate per m^2 area, if one surface is at 45°C and the other is at 20°C. Neglect the resistance of the glue.	[5]	1	4
Q2	a)Fins are provided to increase the rate of heat transfer from a hot surface. Find heat transfer rate for 6 fins with 10cm length Take conductivity of fin material as 300W/mK, h=20 W/m2K, cross sectional area of the fin=2cm2, perimeter of the fin cross section=4cm, temp of hot surface=230°C, ambient	[5]	2	4

	temp=30°C. Assume fins with insulated ends. b) One end of a long rod 3cm in diameter is inserted into a furnace with the outer end projecting into atmospheric air at 30°C with h=20 W/m2K. Once the steady state is reached, the temp of rod is measured at two points, 15 cm apart and found to be 140°C and 100°C. Calculate thermal conductivity of rod material. c) 10 rectangular fins of brass (k = 120 W/mK) are welded horizontally to a plane vertical surface of a tank, 1 m wide and 1 m high. The fins are 2 mm thick and 20 cm long. They are uniformly spaced on the vertical surface of tank, which is maintained at 200°C. If the unit is exposed to ambient air at 20°C with convective heat transfer coefficient of 20 W/m²K, find. Heat transfer rate after putting the fins.Prove that the fins are effective. Assume insulated end condition for the fins.	[5] [5]	2 2	4 4
Q3.	a)An egg with mean diameter 44mm and initially at 24°C is placed in boiling water for 3 minutes and found to be boiled to consumer's taste. If similar egg for same consumer to be boiled when taken from a refrigerator at 5°C, what time will be required for same taste? Take the following properties for egg: k=10W/mK; ρ=1200kg/m3; C=2000J/kgK; h=100W/m2 °C Verify the validity of the theory you apply. b) A sphere of 10mm diameter made of steel is initially at a temp of 300°C. It is exposed to a stream of air at a temp of 30°C with convective heat transfer coefficient of 100 W/m2K. Find:Time required for sphere to reach a temp of 50°C Properties of steel are: ρ=7897kg/m3; C=0.452kJ/kgK; k=73W/mK; =2.026x10-5m2/s t=155sec c) Show that for lumped parameter analysis $\frac{\theta}{\theta_i}=\frac{T-T_\infty}{T_i-T_\infty}=e^{-\frac{hA}{\rho C_p V}t}$	[5] [5] [5]	3 3 3	5 5 4
Q.4	a)Air at temp of 10°C flows through a square duct of side 20cm with a velocity of 12m/s and leaves the duct at 30°C due to heating by duct surface uniformly maintained at 50°C. Find heat transfer rate to air, if the length of the duct is 5m. Use the following correlations: Nu=0.023 Re0.8.Pr0.4 for turbulent flow Nu=3.66 for laminar flow Take the following air properties : Pr = 0.715; k=0.025W/mK; $\nu=13.55 \times 10^{-6} m^2/s$. b) Consider a human body in vertical position of height 167cm at an average temp of 37.3°C exposed to atmospheric air at – 5.7°C at Nainital during winters. Human body can be approximated to cylinder of diameter 40cm having surface emissivity of 0.3. Calculate total heat loss rate from the body by convection . Neglect heat loss from the feet (bottom	[5] [5]	4 4	4 4

	surface). You may use the following empirical correlations: $Nu=0.56\ (Gr.Pr)^{0.25}$ for vertical surface Take the following air properties : Pr = 0.715; k=0.025W/mK; $\nu=13.55 \times 10\text{-}6m^2/s$. Characteristic length for horizontal surface can be taken as A/P; where A is the area of surface and P is its perimeter. c) Water at 20°C enters a 2cm diameter tube with a velocity of 90m/min. The tube is maintained at 100°C. Find the tube length required to heat the water to a temp of 60°C. Take properties of water at 40°C as: Pr=4.31; $\rho=992.2\ kg/m^3$; Cp=4174J/kg.K; kw=0.634 W/mK; ktube=16W/mK; $v=0.659 \times 10\text{-}6\ m^2/s$. Use Dittus Boelter equation.$Nu=0.023\ Re^{0.8}Pr^{0.4}$	[5]	4	4
Q.5	a) A cubical room 4m x 4m x 4m is heated through the ceiling by maintaining it at uniform temp of 350K, while walls and the floor are at 300K. Assuming that all surfaces have emissivity of 0.8, determine the rate of heat loss from the ceiling by radiation. b)Two large parallel planes with emissivity 0.6 are at 900K and 300K. A radiation shield with one side polished and having emissivity of 0.05, while emissivity of other side is 0.4 is proposed to be used. Which side of the shield to face the hotter plane, if the temp of the shield is to be kept minimum? Justify. c) A pipe carrying steam having an outside diameter of 20cm runs in a large room and is exposed to air at 30°C. The pipe surface temp is 400°C. Calculate the heat loss to the surroundings per meter length of pipe due to thermal radiation. Emissivity of pipe surface is 0.8.	[5] [5] [5]	5 5 5	4 4 4
Q.6)	a)A vehicle running at a speed of 120 km/hr having capacity of 2500 cm^3. The frontal area of heat exchanger given is 30 cm x30cm. Design a heat exchanger to decipate the heat from the engine. Sketch with temperature profile. b)A chemical having specific heat of 3.3kJ/kg.K flowing at a rate of 20,000kg/h enters parallel flow HE at 120°C. The flow rate of cooling water is 50,000kg/h with an inlet temp of 20°C. The heat transfer area is $10m^2$ and the over all heat transfer coefficient is $1050W/m^2K$. Specific heat for water is 4.186kJ/kgK. Find :The effectiveness of the heat exchanger c)A counter flow HE is used to heat air entering at 400°C with a flow rate of 6kg/s by exhaust gases entering at 800°C with a flow rate of 4kg/s. Over all heat transfer coefficient is 100W/m2K and outlet temp of air is 551.5°C. Take Cp=1100 J/kgK for both air and exhaust gases. Calculate heat transfer area and number of transfer units.	[5] [5] [5]	6 6 6	5 4 4

Note: BT level-1-Remember ,2-Understand , 3-Apply , 4-Analyze, 5 –Evaluate ,6- Create