DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE
End Semester Examination *(Regular)* – December 2019

Branch: B.Tech in Mechanical Engineering | **Sem:** V
Subject Name with Code: Heat Transfer [BTMEC 501] | **Date:** 09/12/2019
Max Marks: 60 | **Duration:** 3 hr.

Instructions to the Students:

1. *Solve **ANY FIVE** questions out of the following six questions.*
2. *Each question carries 12 marks.*
3. *The level question/expected answer as per OBE or the Course Outcome (CO) on which the question is based is mentioned in ( ) in front of each question.*
4. *Use of non-programmable scientific calculator is allowed.*
5. *Assume suitable data wherever necessary and mention it clearly.*

		(Level/CO)	Ma
Q. 1	**Solve the following:**		
A)	Define overall heat transfer coefficient. How is it related to thermal resistance? Write down equation for total thermal resistance for composite hollow cylinder made up of two layers (*with thermal conductivity k_1, k_2 with thickness b_1, b_2*) and convective boundary conditions on either sides of composite cylinder with convective heat transfer coefficients h_1, h_2. Assume some notation for radii like r_1, r_2, r_3.	(CO-2)	6
B)	A composite wall of $1m^2$ surface area is constructed of two layers. The first layer is of 1 cm thick steel (k = 45 W/m K) and the second layer of 10 cm thick fiberglass insulation (k = 0.035 W/m K). Determine: a) thermal resistance of the composite wall b) overall heat transfer coefficient.	(CO-1)	6
Q.2	**Solve the following:**		
A)	Derive equation for critical radius of insulation for a cylinder. A 2 mm diameter electric wire at 46°C is covered by 0.5 mm thick plastic insulation (k = 0.03 W/m K). The insulation of the wire is exposed a medium at 10°C with convective heat transfer coefficient of 20.0 W/m^2 K. Determine the critical insulation thickness. Will plastic insulation dissipate max heat?	(CO-2)	6
B)	Write equations for Biot number & Fourier number. Aluminium sphere weighing 5.5 kg and initially at a temperature of 290°C is suddenly immersed in a fluid at 15°C. The convective heat transfer coefficient is 58 W/m^2K. Estimate the time required to cool the aluminium to 95°C. Use lumped capacity method for calculation. Assume following property values for aluminium: $\rho = 2700\ kg/m^3$ $k = 205\ W/m\ K$ $C_p = 900\ J/kg\ K$	(CO-2)	6
Q. 3	**Solve the following:**		
A)	Sketch laminar and turbulent boundary layers (BL) for flow over a flat plate. Also, show velocity profiles within the BL in the two regions: a) in the laminar region b) in the	(CO-4)	6

	turbulent region. Assume uniform velocity profile on the upstream side of the plate. State the value of Re at transition.		
B)	Air at 60°C and atmospheric pressure flows over a thin flat plate (*one side)* which is 1 m wide and 2 m in length. The free stream air velocity is 1 m/s. Calculate **a)** thickness of velocity boundary layer at a distance x = 1.5 m and **b)** total drag force on the plate. Use following values of fluid properties: $\upsilon = 18.96 \times 10^{-6}\ m^2/s$, $\rho = 1.06\ kg/m^3$ Use following equations for thickness of velocity boundary layer and drag coefficient, respectively: $\frac{\delta}{x} = \frac{5}{\sqrt{Re_x}}$ *and* $C_f = 1.328\, Re_L^{-0.5}$	(CO-4)	6
Q.4	**Solve the following:**		
A)	Water at 50°C enters 1.5 cm diameter tube of a heat exchanger. Assume velocity of water at mean temperature as 1 m/s. The tube surface is maintained at 90°C. Calculate the exit water temperature if the length of tube is 2 m Assume following properties of water at mean temperature *(neglect variation in properties with temperature):* $\mu = 489.2 \times 10^{-6}\ kg/(m.s)$ $\rho = 984.4\ kg/m^3$ $k = 0.656\ W/m\ K$ $c_p = 4178\ J/kg\ K$ Use following correlations: $f = 0.079\, Re^{-0.25}$ $Nu_D = \frac{(f/2)[Re_D - 1000].Pr}{1+12.7\left[f/2\right]^{0.5}(Pr^{2/3}-1)}$	(CO-4)	6
B)	A 15 cm diameter horizontal iron pipe with 1 m length is exposed to saturated steam at 100°C on inside and still air at 20°C on outside. Calculate the convective heat transfer rate from the outer surface of pipe and compare it with radiant heat transfer rate if the surrounding surfaces (imaginary) are at 20°C. Assume outer surface of the pipe as black. *Use following correlation for horizontal pipe:* $Nu = 0.48\, Ra^{0.25}$ *Use following values of properties of air at 60°C:* $\rho = 1.06\ kg/m^3$ $\mu = 20.1 \times 10^{-6}\ N.s/m^2$, $k = 0.029\ W/m\ K$ $C_p = 1005\ J/kg\ K$	(CO-4)	6
Q. 5	**Solve the following:**		
A)	In a double-pipe counter-flow heat exchanger 10,000 kg/h of an oil having a specific heat 2095 J/kg.K is cooled from 80°C to 50°C by 8000 kg/h of cooling water at 25°C. Assume overall heat transfer coefficient of 300 W/m²K and specific heat of water as 4180 J/kg.K. a) Determine LMTD b) Determine the heat exchanger area.	(CO-5)	6
B)	Draw the pool boiling curve & identify different boiling regimes. Define critical flux & show corresponding point on pool boiling curve.		6

Q. 6	**Solve the following:**		
A)	Consider a 20 cm diameter spherical ball at 800 K suspended in air. Assuming the ball closely approximates a blackbody, determine: **a)** The total blackbody emissive power **b)** The amount of radiant energy emitted by the ball in 5 min. **c)** The monochromatic blackbody emissive power at a wavelength of 3 micrometers.	(CO-6)	6
B)	State various shape factor relations (algebra) in radiation heat transfer.	(CO-6)	6
	***** End *****		

	DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE **Supplementary Examination – Summer 2022** **Course: B. Tech. Branch : Mechanical Engineering Semester : V** **Subject Code & Name: BTMEC501 & Heat Transfer** **Max Marks: 60 Date: Duration: 3 Hr.**		
	Instructions to the Students: *1. All the questions are compulsory.* *2. Use of Heat Transfer data book is allowed.* *3. Use of non-programmable scientific calculators is allowed.* *4. Assume suitable data wherever necessary and mention it clearly.*		
		(Level/CO)	Marks
Q. 1	**Solve Any Two of the following.**		
A)	**A gas filled tube has 2 mm inside diameter and 25 cm length. The gas is heated by an electrical wire of diameter 50 microns(0.05 mm) located along the axis of the tube. Current and voltage drop across the heating element are 0.5 amps and 4 volts, respectively. If the measured wire and inside tube wall temperatures are 175 ^{o}C and 150 ^{o}C respectively, find the thermal conductivity of the gas filling the tube.**	**L3/CO1**	**06**
B)	**Derive an equation for heat conduction through composite cylinder with neat sketch.**	**L1/CO1**	**06**
C)	**An electric hot plate is maintained at a temperature of 350 ^{o}C, and is used to keep a solution boiling at 95 ^{o}C. The solution is contained in a cast-iron vessel of wall thickness 25 mm, which is enamelled inside to a thickness of 0.8 mm. The heat transfer coefficient for the boiling solution is 5.5 kW/m^{2}K, and the thermal conductivities of the cast iron and enamel are 50 and 1.05 W/mK, respectively. Calculate:** **(i) The overall heat transfer coefficient.** **(ii) The rate of heat transfer per unit area.**	**L1/CO1**	**06**
Q.2	**Solve Any Two of the following.**		
A)	**Write the assumptions made for the analysis of heat flow through fin. Derive an equation to find heat dissipation from a fin insulated at the tip.**	**L1/CO3**	**06**
B)	**Derive an equation to find critical thickness of insulation for sphere.**	**L1/CO2**	**06**
C)	**What is meant by transient heat conduction? Explain the significance of Heisler charts in solving transient conduction problems.**	**L2/CO2**	**06**
Q. 3	**Solve Any Two of the following.**		

A)	**What are the assumptions for momentum equation for hydrodynamic boundary layer over a flat plate, derive an expression for the same.**	**L1/CO4**	**06**
B)	**Air at 20 ^{o}C is flowing over a flat plate which is 200 mm wide and 500 mm long. The plate is maintained at 100 ^{o}C. Find the heat loss per hour from the plate if the air is flowing parallel to 500 mm side with 2 m/s velocity. What will be the effect on heat transfer if the flow is parallel to 200 mm side. The properties of air at (100+20)/2=60 ^{o}C are k= 0.025 W/m ^{o}C and Pr=0.7, ν=18.97 *10^{-6} m^2/s.**	**L3/CO4**	**06**
C)	**Calculate the heat transfer from a 60 W incandescent bulb at 115 ^{o}C to ambient air at 25 ^{o}C. Assume the bulb as sphere of 50 mm diameter. Also, find the percentage of power lost by free convection.** **The correlation is given by: Nu= 0.60 $(Gr*Pr)^{1/4}$**	**L3/CO4**	**06**
Q.4	**Solve Any Two of the following.**		
A)	**Explain briefly the various regimes of saturated pool boiling with neat sketch.**	**L1/CO5**	**06**
B)	**Derive an equation to determine LMTD for parallel flow heat exchanger.**	**L1/CO5**	**06**
C)	**An oil cooler for a lubrication system has to cool 1000 kg/h of oil (Cp=2.09 kJ/kg ^{o}C from 80^{o}C to 40^{o}C by using a cooling water flow of 1000 kg/h at 30^{o}C. Give your choice for parallel flow or counter flow heat exchanger, with reasons. Calculate the surface area of the heat exchanger, if the overall heat transfer coefficient is 24 W/m^{2} ^{o}C.** **Take Cp of water =4.18 kJ/kg ^{o}C.**	**L3/CO5**	**06**
Q. 5	**Solve Any Two of the following.**		
A)	**For a hemispherical furnace, the flat floor is at 700K and has emissivity of 0.5. The hemispherical roof is at 1000K and has emissivity of 0.25. Find the net radiative heat transfer from roof to floor.**	**L3/CO6**	**06**
B)	**State and prove reciprocity theorem with neat sketch.**	**L1/CO6**	**06**
C)	**Two large parallel plates with ε =0.5 each, are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer.**	**L3/CO6**	**06**
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