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)	Mar
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. (CO-4) **6**

Use following values of fluid properties:

$\upsilon = 18.96 \times 10^{-6}$ m²/s, $\rho = 1.06$ kg/m³

Use following equations for thickness of velocity boundary layer and drag coefficient, respectively:

$$\frac{\delta}{x} = \frac{5}{\sqrt{Re_x}} \qquad and \qquad C_f = 1.328\, Re_L^{-0.5}$$

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 (CO-4) **6**

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/m³
k = 0.656 W/m K
$c_p = 4178$ J/kg K

Use following correlations:

$$f = 0.079\, Re^{-0.25}$$

$$Nu_D = \frac{(f/2)[Re_D - 1000].Pr}{1 + 12.7\left[f/2\right]^{0.5}(Pr^{2/3} - 1)}$$

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. (CO-4) **6**

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/m³ $\mu = 20.1 \times 10^{-6}$ N.s/m², k = 0.029 W/m K $C_p =$ 1005 J/kg K

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. (CO-5) **6**

a) Determine LMTD
b) Determine the heat exchanger area.

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: (CO-6) **6**

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.

B) State various shape factor relations (algebra) in radiation heat transfer. (CO-6) **6**

***** End *****

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