P P SAVANI UNIVERSITY

Fifth Semester of B. Tech. Examination

November 2022

SECH3010 Heat Transfer Operations

22.11.2022, Tuesday **Time: 10:00 A.M. To 12:30 P.M.** **Maximum Marks: 60**

Instructions:

1. The question paper comprises of two sections.
2. Section I and II must be attempted in separate answer sheets.
3. Make suitable assumptions and draw neat figures wherever required.
4. Use of scientific calculator is allowed.

SECTION – I

			CO	BTL
Q-1	A 10-cm diameter copper ball is to be heated from 100°C to an average temperature of 150°C in 30 minutes. Taking the average density and specific heat of copper in this temperature range to be ρ = 8950 kg/m^3 and Cp = 0.395 kJ/kg ·°C, respectively, determine. (a) the total amount of heat transfer to the copper ball, (b) the average rate of heat transfer to the ball, and (c) the average heat flux.	**(08)**	**O1**	**1**
	OR			
Q-1	Define the following terms: 1. Conduction 2. Convection 3. Radiation	**(08)**	**O1**	**1**
Q-2	A 5-m-long section of an air heating system of a house passes through an unheated space in the basement. The cross section of the rectangular duct of the heating system is 20 cm *25 cm. Hot air enters the duct at 100 kPa and 60°C at an average velocity of 5 m/s. The temperature of the air in the duct drops to 54°C as a result of heat loss to the cool space in the basement. Determine the rate of heat loss from the air in the duct to the basement under steady conditions. Also, determine the cost of this heat loss per hour if the house is heated by a natural gas furnace that has an efficiency of 80 percent, and the cost of the natural gas in that area is $0.60/therm (1 therm = 100,000 Btu = 105,500 kJ).	**(08)**	**O2**	**5**
Q-3	A 2-m-long, 0.3-cm-diameter electrical wire extends across a room at 15°C. Heat is generated in the wire as a result of resistance heating, and the surface temperature of the wire is measured to be 152°C in steady operation. Also, the voltage drop and electric current through the wire are measured to be 60 V and 1.5 A, respectively. Disregarding any heat transfer by radiation, determine the convection heat transfer coefficient for heat transfer between the outer surface of the wire and the air in the room.	**(08)**	**O2**	**5**
	OR			
Q-3	Distinguish between natural and forced convection heat transfer. (Any Six)	**(08)**	**O1**	**1**
Q-4	Consider a person standing in a room maintained at 22°C at all times. The inner surfaces of the walls, floors, and the ceiling of the house are observed to be at an	**(06)**	**O2**	**5**

average temperature of 10°C in winter and 25°C in summer. Determine the rate of radiation heat transfer between this person and the surrounding surfaces if the exposed surface area and the average outer surface temperature of the person are 1.4 m^2 and 30°C, respectively. Emissivity of a person is 0.95.

SECTION – II

Q-1	Define boiling? Draw boiling curve which shows all the boiling regimes and explain nucleate boiling regime in brief.	**(06)**	**O1**	**2**
Q-2	A vertical plate, 30 by 30 cm, is exposed to steam at the atmospheric pressure. The plate is at 371 K (98°C). Calculate the mean heat transfer coefficient, the heat transfer rate and mass of steam condensed per hour. Properties of the condensate at the film temperature are: ρ = 960 kg/m^3 , μ= 2.82 × 10^{-4} kg/(m·s), k = 0.68 W/(m·K), λ = 2225 kJ/kg, Saturation temperature of steam = 373 K (100°C).	**(06)**	**O3**	**5**
Q-3	Steam in the condenser of a power plant is to be condensed at a temperature of 30°C with cooling water from a nearby lake, which enters the tubes of the condenser at 14°C and leaves at 22°C. The surface area of the tubes is 45 m^2, and the overall heat transfer coefficient is 2100 W/m^2 ·°C. Determine the mass flow rate of the cooling water needed and the rate of condensation of the steam in the condenser. Properties The heat of vaporization of water at 30°C is h_{fg} = 2431 kJ/kg and the specific heat of cold water at the average temperature of 18°C is Cp = 4184 J/kg · °C.	**(06)**	**O4**	**5**
Q-4	Calculate the inside heat transfer coefficient for a fluid flowing at a rate of 300 cm^3 /s through a 20 mm inside diameter tube of heat exchanger. Data : Properties of fluid at mean bulk temperature : Viscosity of flowing fluid = 0.8 (N.s)/m^2 Viscosity at wall temperature = 1.0 (N.s)/m^2 , Density of flowing fluid = 1.1 g/cm^3 Specific heat of flowing fluid = 1.26 kJ/(kg.K), Length of heat exchanger = 5 m Thermal conductivity of flowing fluid = 0.384 W/(m·K). The empirical relation applicable for laminar flow is $N_{Nu} = 1.86\left[N_{Re} \cdot N_{Pr} \cdot \frac{D}{L}\right]^{1/3}\left[\frac{\mu}{\mu_w}\right]^{0.14}$	**(06)**	**O4**	**5**
Q-5	Distinguish between forward feed and backward feed arrangements in evaporator system (Any eight).	**(06)**	**O1**	**2**

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CO : Course Outcome Number BTL : Blooms Taxonomy Level

Level of Bloom's Revised Taxonomy in Assessment

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create