PRN:		Course Code :	AER3603

Third Year **B. Tech** End Semester Examination Summer 2024

Heat Transfer

Day and Date: 25 MAI 2024, Sat Max Marks: **100**

Time : 02:00PM To 05:00PM Duration: **03** hrs

Instructions: All questions are compulsory.

Q.1		**Attempt the following**	**Marks**	**Bloom's Level**	**CO**
	a)	A jet aircraft compartment is assumed to be a cylindrical tube of 3-meter diameter and 20-meter length. It is lined inside with 3 cm of insulating material of k = 0.042 W/mK. It is flying at a height where the average outside temperature is -30oC. Determine the rate of heating required to maintain the compartment at 20oC for passenger comfort.	08	L2	1
	b)	A wire 1.5 mm diameter and 150 mm long is submerged in water at atmospheric pressure. An electric current is passed through the wire and is increased until the water boils at 100oC. Under the condition if convective heat transfer coefficient is 4500 W/m2oC. Find how much electric power must be supplied to the wire to maintain the wire surface at 120oC?	08	L2	1
		OR			
	b)	A closed system of constant volume experiences a temperature rise of 25oC when a certain process occurs. The heat transferred in the process is 30 KJ. The specific heat at constant volume for the pure substance comprising the system is 1.2 KJ/kgoC and the system contains 2.5 kg of this substance. Determine (i) the change in internal energy and (ii) The work done	08	L2	1
Q.2		**Attempt the following**			
	a)	Two long rods of the same diameter, one of brass (k = 85 W/mK) and the other of copper (k = 375 W/mK) have one of their ends inserted in a furnace and the other ends exposed to the same atmosphere. At a distance of 105 mm away from the furnace the temperature of brass rod is 120oC. Determine the distance from the furnace end the copper rod would have attain the same temperature	08	L3	2
	b)	The interior of a refrigerator having inside dimensions of 0.5m*0.5m base area and 1m height is to be maintained at 6oC. The walls of the refrigerator are constructed of two mild steel sheets 3mm thick (k = 46.5 W/moC) with 50 mm of glass wool insulation (k= 0.046 W/moC) between them. If the average heat transfer coefficients at the outer and inner surfaces are 11.6 W/m2oC and 14.5 W/m2oC respectively. Calculate (i) The rate at which heat must be removed from interior to maintain the specified temperature in the kitchen at 25oC and (ii) The	08	L3	2

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		temperature on the outer surface of the metal sheet.			
		OR			
	b)	One end of a long rod is inserted into a furnace while the other projects into ambient air. Under steady state the temperature of the rod is measured at two points 75 mm apart and found to be 125oC and 88.5oC respectively, while the ambient temperature is 20oC. If the rod is 25 mm in diameter and h is 23.36 W/m2K, Find the thermal conductivity of the rod material.	08	L3	2
Q.3		**Attempt any two from the following**			
	a)	Air at 20oC and at atmospheric pressure flows over a flat plate at velocity of 1.8 m/s. If the length of the plate is 2.2 m and is maintained at 100oC, Calculate the heat transfer rate per unit width using (i) Exact and (ii) approximate methods. The properties of air at mean bulk temperature of (100+20)/2 = 60oC are, ρ = 1.06 Kg/m3, cp = 1.005 kJ/kgoC, k = 0.02894 W/moC, Pr = 0.696 and υ = 18.97 * 10-6 m2/s.	08	L3	3
	b)	Water at 10oC flows over a flat plate at 90oC measuring 1 m* 1 m, with a velocity of 2 m/s. properties of water at 50oC are ρ = 988.1 Kg/m3, k = 0.648 W/moC, Pr = 3.54 and υ = 0.556 * 10-6 m2/s. Determine the length of plate over which the flow is laminar and the rate of heat transfer from the entire plate	08	L3	3
	c)	Nitrogen gas at 0oC is flowing over a 1.2 m long, 2 m wide plate maintained at 80oC with a velocity of 2.5 m/s. For nitrogen ρ = 1.104 kg/m3, cp = 1.04 kJ/kgK, υ = 15.63 * 10-6 m2/s and k = 0.0262 W/mK. Find the average heat transfer coefficient and total heat transfer from the plate	08	L3	3
Q.4		**Attempt any two from the following**			
	a)	Determine the area required in parallel flow heat exchanger to cool oil from 60°C to 30°C using water available at 20°C. The outlet temperature of the water is 26°C. The rate of flow of oil is 10 kg/s. The specific heat of the oil is 2200 J/kg K. The overall heat transfer coefficient U = 300 W/m2 K. Compare the area required for a counter flow exchanger	08	L3	4
	b)	In an evaporator of a refrigerator, the refrigerant evaporates at -20°C over the tubes. Water flowing inside the tubes enter at 15°C and is cooled to 5°C. The cooling capacity is 5 kW. Determine the cooling rate if the water flow is increased by 25% keeping the inlet temperature to be the same.	08	L3	4
	c)	In an open heart surgery under hypothermic conditions, the patient's blood is cooled before the surgery and rewarmed afterwards. It is proposed that a concentric tube counter flow heat exchanger of length 0.5 m is to be used for this purpose, with a thin walled inner tube having a diameter of 55 mm. If water at 60oC and 0.1 kg/s is used to heat blood entering the exchanger at 18oC and 0.05 kg/s, what is the temperature of the blood leaving the exchanger and the heat flow rate. Take Uo = 500 W/m2K, Cp of blood = 3.5 kJ/kgK and Cp of water = 4.183 kJ/kgK	08	L3	4
Q.5		**Attempt any Two of the following**			
	a)	A surface is at 200°C and is exposed to surroundings at 60°C and convects and radiates heat to the surroundings. The convection coefficient is 80W/m2K. The radiation factor is one. If the heat is conducted to the surface through a solid of conductivity 12	09	L3	5

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		W/mK, determine the temperature gradient at the surface in the solid.			
	b)	Two large parallel planes are at 1000 K and 600 K. Determine the heat exchange per unit area. (i) If surfaces are black (ii) if the hot one has an emissivity of 0.8 and the cooler one 0.5 (iii) if a large plate is inserted between these two, the plate having an emissivity of 0.2	09	L3	5
	c)	Derive the expression for radiant heat exchange between two black bodies separated by a non-absorbing medium.	09	L3	5
Q.6		**Attempt any Two of the following**			
	a)	Compare and contrast the heat transfer mechanisms in solid rocket motors and liquid rocket engines.	09	L3	5
	b)	Define ablative heat transfer and provide examples of materials used in ablative heat shields.	09	L3	5
	c)	Explain the concept of film cooling in rocket thrust chambers. Compare and contrast film cooling with other cooling techniques used in rocket engines	09	L3	5

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