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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

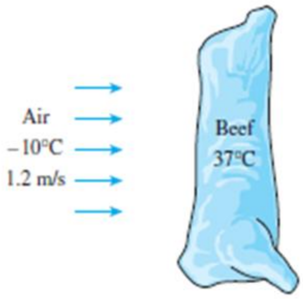
September / October 2023 Semester End Main Examinations

Programme: B.E. **Semester: IV**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 22AS4PCHMT **Max Marks: 100**
Course: Heat and Mass Transfer

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed
3. Use of heat transfer data handbook is permitted

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	*CO*	*PO*	**Marks**
1	a)	With suitable example explain the various laws governing heat transfer.	CO1	PO1	**7**
	b)	A submarine has a 25 mm thick stainless steel (K = 14.9 W/m°C) wall insulated on the inside with a 37.5 mm thick layer of PUF (K = 0.026 W/m°C). The convection heat transfer coefficient on the inside is 20 W/m^2°C. At full speed, the outside heat transfer coefficient is 750 W/m^2°C. The submarine can be approximated as a cylindrical system of 9 m dia and 72m long. If the sea water is at 5°C, at what rate should the heat be supplied in kW to the inside air to maintain it at 22°C. You can neglect heat transfer through the ends. Use necessary sketches and the electrical circuit.	CO2	PO3	**10**
	c)	Write a note on thermal contact resistance.	CO1	PO1	**3**
		OR			
2	a)	A 6.5 cm long turbine blade with a c/s area of 4.6 cm^2 and a perimeter of 12.5 cm is made of stainless steel (k = 18 W/mK). The temperature at the root is 480°C. The blade is exposed to a hot gas from the combustion chamber at 880°C and the convective heat transfer coefficient is 450 W/m^{2}K. Determine a) the temperature distribution ii) the rate of heat flow at the root of the blade iii) the temperature at the tip. Assume that the blade tip is insulated.	CO3	PO2	**6**
	b)	A furnace wall is made of inside silica brick (k = 1.6 W/mK) outside magnesia brick (k = 4.8 W/mK) 10 cm thick each. If the inner and outer surfaces are exposed to fluid temperature of 820°C and 120°C respectively. Find the heat flow through the wall per m^2 per hour. Assume a contact resistance of 0.002 m^2 K/W. Draw the temperature profile through the composite wall. The inside and outside heat transfer coefficients are 35 W/m^{2}K and 12 W/m^2 K respectively.	CO2	PO3	**10**

		c)	Write boundary conditions of first, second and third kind with suitable sketches.	CO1	PO1	**4**
			UNIT - II			
	3	a)	A 65-kg beef carcass ($k = 0.47$ W/m·K and a $\alpha = 0.13*10^{-6}$ m^2/s) initially at a uniform temperature of 37°C is to be cooled by refrigerated air at -10°C flowing at a velocity of 1.2 m/s. The average heat transfer coefficient between the carcass and the air is 22 $W/m^2 \cdot K$. Treating the carcass as a cylinder of diameter 24 cm and height 1.4 m and disregarding heat transfer from the base and top surfaces, determine how long it will take for the center temperature of the carcass to drop to 4°C. 	CO3	PO2	**8**
		b)	Derive an expression for temperature distribution for a lumped system analysis.	CO2	PO1	**7**
		c)	Explain the significance of Biot number and Fourier number.	CO1	PO1	**5**
			UNIT - III			
	4	a)	Using Buckingham's theorem, Obtain the relationship between various non-dimensional numbers for free convection heat transfer.	CO2	PO1	**10**
		b)	An appropriate expression for the temperature profile for laminar flow over a flat plate is given by $\theta(x,y) = 2\left(\frac{y}{\delta t}\right) - \left(\frac{y}{\delta t}\right)^3$; $\theta\ (x,y) = \frac{T\ (x,y) - T_w}{T_\infty - T_w}$ and $\frac{\delta t}{x} = 5.5\ R_{ex}^{\ -0.5}\ Pr^{\ -0.33}$; i) Develop an expression for local heat transfer coefficient ii) Develop an expression for average heat transfer coefficient for a total length L of the plate as average Nusselt number.	CO3	PO2	**10**
			OR			
	5	a)	Explain the following i) Nusselt number ii) Prandtl number iii) Grashoff number iv) Stanton number v) skin friction coefficient	CO1	PO1	**10**
		b)	A cool drink cans, 65 mm dia and 150 mm length are to be cooled from an initial temperature of 20°C by placing them in a bottle cooler with an ambient air temperature of 1°C. Compare the initial cooling rates, when the cans are laid horizontally, to when they are laid vertically.	CO3	PO2	**10**

			UNIT - IV			
	6	a)	A deep space probe is constructed as a 1m diameter polished aluminium sphere. Determine the equilibrium temperature that the probe reaches if the incident solar radiation is 950 W/m^2. For solar radiation, the absorptivity of aluminium is 0.3 and the emissivity of the aluminium is 0.04.	CO3	PO1	**5**
		b)	It is desired to calculate the net radiation heat exchange between the floor of a furnace 4m x 2m and a side wall 3m x 2m. The emissivity of the floor material is 0.63 and that of the side wall material is 0.2. If the temperature of the floor and side wall are 600°C and 400°C. Calculate the net heat exchange between. Draw the necessary sketches.	CO3	PO2	**10**
		c)	Write a note on shape factors and radiation shield.	CO1	PO1	**5**
			UNIT - V			
	7	a)	Sketch and explain the regimes of pool boiling.	CO3	PO1	**10**
		b)	Water at the rate of 3.783 kg/s is heated from 37.78°C to 54.44°C in a shell-and-tube heat exchanger. On the shell side one pass is used with water as the heating fluid, 1.892 kg/s, entering the exchanger at 93.33°C. The overall heat-transfer coefficient is 1419 W/m^2 °C, and the average water velocity in the 1.905-cm diameter tubes is 0.366 m/s. Because of space limitations, the tube length must not be longer than 2.438 m. calculate the number of tube passes, the number of tubes per pass, and the length of the tubes, consistent with this restriction.	CO3	PO3	**10**

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