BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(MID SEMESTER EXAMINATION MO/2024)

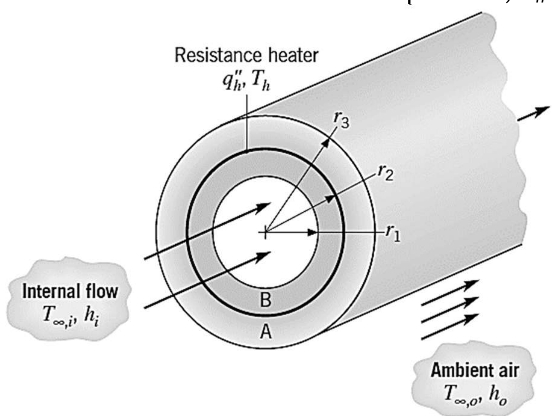
CLASS: B.TECH | **SEMESTER: V**
BRANCH: MECHANICAL | **SESSION: MO/2024**

SUBJECT: ME315 HEAT AND MASS TRANSFER

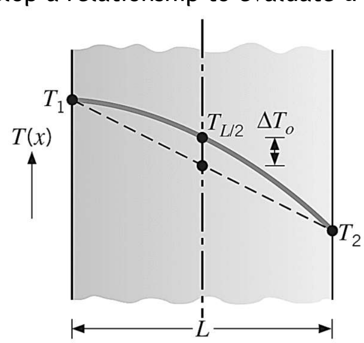
TIME: 02 Hours | **FULL MARKS: 25**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 5 marks and total 25 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.

			CO	BL
Q.1	A composite cylindrical wall is composed of two materials of thermal conductivity k_A and k_B, which are separated by a very thin, electric resistance heater for which interfacial contact resistances are negligible. Liquid pumped through the tube is at a temperature $T_{\infty,i}$ and provides a convection coefficient h_i at the inner surface of the composite. The outer surface is exposed to ambient air, which is at $T_{\infty,o}$ and provides a convection coefficient of h_o. Under steady-state conditions, a uniform heat flux of q_h'' is dissipated by the heater. (a) Sketch the equivalent thermal circuit of the system and express all resistances in terms of relevant variables. (b) Obtain an expression to determine the heater temperature, T_h.	[5]	3-5	3-4



			CO	BL
Q.2	Measurements show that steady-state conduction through a plane wall without heat generation produced a convex temperature distribution such that the midpoint temperature was ΔT_o higher than expected for a linear temperature distribution. Assuming that the thermal conductivity has a linear dependence on temperature, $k = k_o(1 + aT)$, where a is a constant, develop a relationship to evaluate a in terms of ΔT_o, T_1, and T_2.	[5]	3-5	3-4



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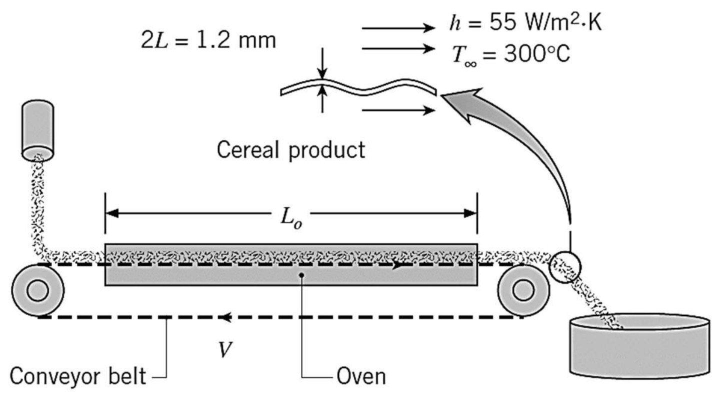
Q.3 A flaked cereal is of thickness $2L$ = 1.2 mm. The density, specific heat, and thermal conductivity of the flake are ρ = 700 kg/m^3, C_p = 2400 J/kg·K, and k = 0.34 W/m·K, respectively. The product is to be baked by increasing its temperature from T_i = 20 °C to T_f = 220 °C in a convection oven, through which the product is carried on a conveyor. If the oven is L_o = 3 m long and the convection heat transfer coefficient at the product surface and oven air temperature are h = 55 W/m^2·K and T_∞ = 300 °C respectively, determine the required conveyor velocity, 'V'. [5] 3-5 3-4



Q.4 Consider an alloyed aluminum (k =180 W/m·K) rectangular fin of length L = 10 mm, thickness t = 1 mm, and width w >> t. The base temperature of the fin is T_b = 100 °C, and the fin is exposed to a fluid of temperature T_∞ = 25 °C and h = 100 W/m^2·K, with insulation at its tip. Determine the fin heat transfer rate per unit width, efficiency, effectiveness, and the tip temperature. [5] 3-5 3-5
What will happen to the fin efficiency and effectiveness if the fin thickness is doubled? Discuss qualitatively without calculation.

Q.5 State the Stefan-Boltzmann law and Wein's displacement law for thermal radiation from a blackbody, and describe their connection with Planck's law. Also define the Kirchoff's law for a diffuse and gray body, and derive the corresponding relation between the emissivity and absorptivity. [5] 1 1-2

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