Dr Nitesh Kumar 6/12/2022 (131) (88)

NATIONAL INSTITUTE OF TECHNOLOGY HAMIRPUR

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

End-Term Examination Nov/Dec 2022 (Odd semester 2022-23)

Transport Phenomena **Course Code: MS 212**

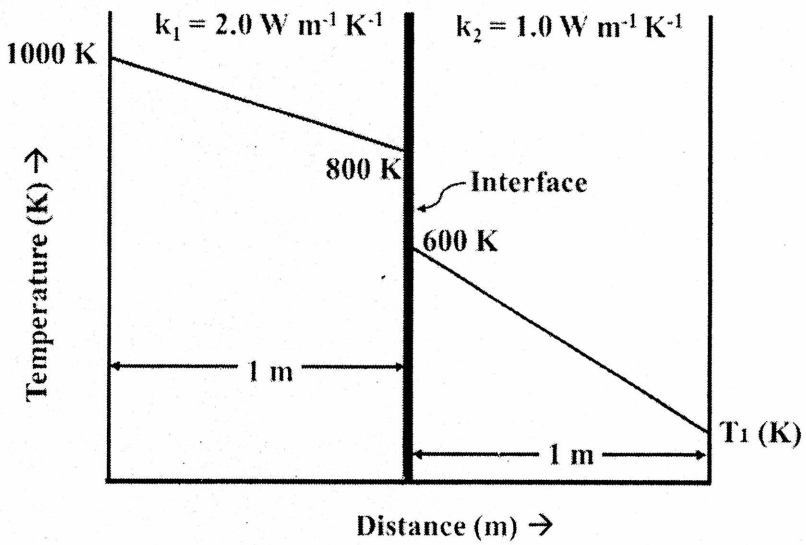
DURATION: 3 HOURS **MAX. MARKS: 50**

Note: Read the questions carefully and answer all questions. The answer of each question should be in one place. Marks for each question are mentioned in parenthesis.

Q.1 Air at 300 K is passed at a mass flow rate of 1.5 $kg \cdot s^{-1}$ through a metallic tube of inner diameter 0.08 m. Inner wall temperature of the tube is maintained at 700 K. Temperature of the air leaving the tube is 600 K. Assuming that heat transfer occurs entirely by steady state convection, Find the length of the tube in metres (round off to 2 decimal places). (10 marks)

Given: The coefficient of convective heat transfer from tube wall to air is 500 $W \cdot m^{-2} \cdot K^{-1}$. Assume specific heat capacity of air to be constant and equal to 1080 $J \cdot kg^{-1} \cdot K^{-1}$ and $\pi = 3.14$.

Q2 One-dimensional steady-state temperature distribution in two adjacent refractory blocks (with thermal conductivities, k_1 and k_2) of unit cross-sectional area are shown below. Calculate the temperature T_1 and thermal contact resistance of the interface R_{th}. (10 marks)



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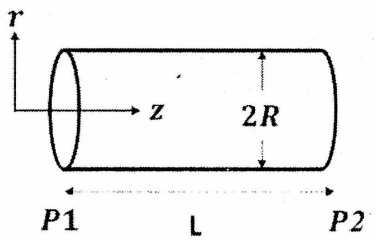
Q3 For a fully developed 1-D flow of a Newtonian fluid through a horizontal pipe of radius R (see figure), the axial velocity (v_z) is given by: (10 marks)

$$v_z = \left[\frac{\Delta P}{L}\right]\left(\frac{R^2 - r^2}{4\mu}\right)$$

where, ΔP is the pressure difference ($P1 - P2$), μ is the viscosity, r is the radial distance from the axis and **L** is the length of the tube. Find out the shear stress exerted by the fluid on the tube wall.



Q4: (a) Derive the expression for one-dimensional Non-steady state diffusion of carbon in a semi-infinite rod of mild steel with initial carbon concentration C_i and concentration of carburizing atmosphere C_o. The diffusivity of carbon in iron at temperature T can be assumed as $D_{c,Fe}$. (6 marks)

(b) Explain the phenomena of Kirkendall effect for binary solid state diffusion. (4 marks)

Q5: (a) Define a black body in radiative heat transfer. (4+6 Marks)

(b) Derive the expression for radiative heat exchange between two black bodies by help of Lambert's Law.

END OF PAPER

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