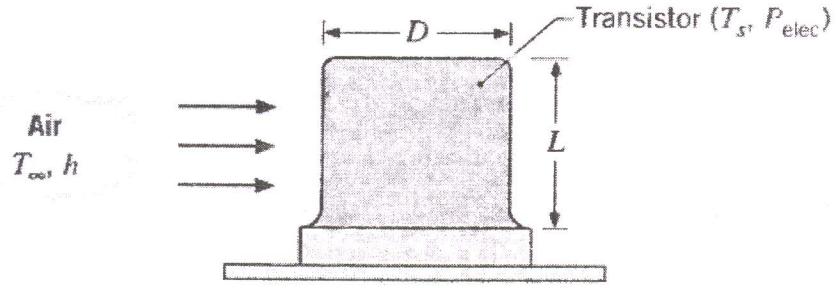
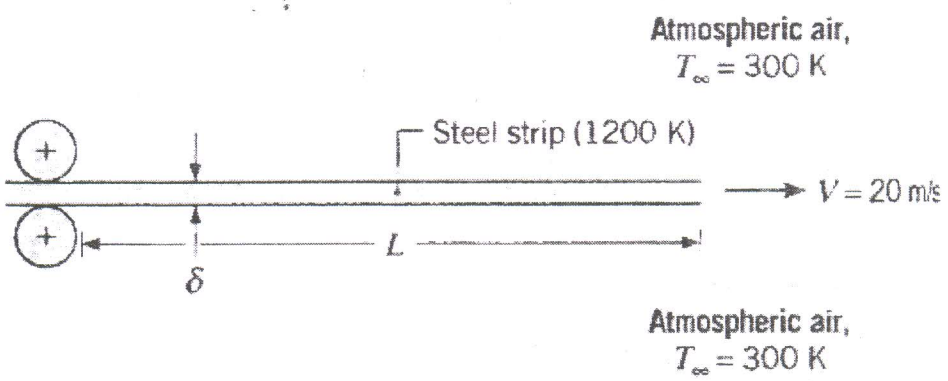
COLLEGE OF ENGIEERING PUNE
End Semester Exam
Transport Phenomena (MT-9001)

Class: T.Y.B.Tech. (Met.Engg) **Time: 3 hours**
Year 2014-2015 2.00pm - 5.00pm **Marks: 60**
Instructions:

25 NOV 2014

a) Any **Six** out of Seven questions
b) Assume suitable data if necessary, draw neat figures.
c) Use of calculators is allowed.

Q1	The case of a power transistor, which is of length L= 10 mm and diameter D =12 mm, is cooled by an air stream of temperature T_∞ = 25°C. Under conditions for which the air maintains an average convection coefficient of h = 11 W/m^2.K on the surface of the case, what is the maximum allowable power dissipation if the surface temperature is not to exceed 85°C. 	10
Q2	An electrical current of 700 A flows through a stainless steel cable having a diameter of 5 mm and an electrical resistance of 6 x 10^{-4} Ω/m. The cable is an environment having a temperature of 30°C and the total coefficient associated with convection and radiation between the cable and the environment is approximately 25 W/m^2.K. a. If the cable is bare, what is the surface temperature? b. If a very thin coating of electrical insulation is applied to the cable, with a contact resistance of 0.02 m^2. K/W, what are the insulation and cable surface temperature?	10
Q3	Annealing is a process by which steel is reheated and the cooled to make it less brittle. Consider the reheat stage for a 100 mm thick steel plate (ρ = 7830 kg/m^3, c = 550 J/kg.K, k = 48 W/m.K) which is initially at a uniform temperature of T_i = 200°C and is to be heated to a minimum temperature of 550°C. Heating is effected in a gas fired furnace, where products of combustion at T_∞ = 800°C maintain a convection coefficient of h = 50 W/m^2.K on both surfaces of the plate. How long the plate should be left in the furnace?	10
Q4	A steel emerges from the hot roll section of a steel mill at a speed of 20 m/s and a temperature of 1200 K. Its length and thickness are L = 100 m and δ = 0.003m respectively, and its density and specific heat are 7900 kg/m3 and 640 J/kg.K respectively. Accounting for heat transfer from the top and bottom surfaces and neglecting radiation and strip conduction effects, determine the time rate of change of the strip temperature at a distance of 1m from the leading edge and at the trailing edge. Determine the distance from the leading edge at which the minimum cooling rate is achieved.	10



PROPERTIES: Steel (given): $\rho = 7900$ kg/m^3, $c_p = 640$ J/kg·K. *Table A-4*, Air $(\bar{T} = 750\text{K}, 1\text{ atm})$: $\nu = 76.4 \times 10^{-6}$ m^2/s, $k = 0.0549$ W/m·K, $Pr = 0.702$.

$C_{f,x} = 0.664 Re_x^{-1/2}$	(7.20)	Flat plate	Laminar, local, T_f
$Nu_x = 0.332 Re_x^{1/2} Pr^{1/3}$	(7.23)	Flat plate	Laminar, local, T_f, $Pr \gtrsim 0.6$
$\delta_t = \delta Pr^{-1/3}$	(7.24)	Flat plate	Laminar, T_f

Q5 Dry air at 35°C and a velocity of 20 m/s flows over a wetted plate of length 500 mm and width 150 mm. An imbedded electrical heater supplies power to maintain the plate surface temperature at 20°C. 10

a. What is the evaporation rate (kg/h) of water from the plate? What electrical power is required to maintain steady-state conditions?

b. After a long period of operation, all the water is evaporated from the plate and its surface is dry. For the same free stream conditions and heater power of part (a), estimate the temperature of the plate?

PROPERTIES: *Table A.4*, Air $(T_f = (T_s + T_\infty)/2 = 300$ K, 1 atm): $\rho = 1.16$ kg/m^3, $c_p = 1007$ J/kg·K, $k = 0.0263$ W/m·K, $\nu = 15.94 \times 10^{-6}$ m^2/s, $\alpha = 2.257 \times 10^{-5}$ m^2/s, *Table A.6*, Water $(T_s = 20°\text{C} = 293$ K): $\rho_{A,s} = 1/v_g = 1/59.04 = 0.0169$ kg/m^3, $h_{fg} = 2454$ kJ/K; *Table A.8*, Water-air $(T_f = 300$ K): $D_{AB} = 0.26 \times 10^{-4}$ m^2/s.

$Nu_x = 0.0296 Re_x^{4/5} Pr^{1/3}$	(7.36)	Flat plate	Turbulent, local, T_f, $Re_x \lesssim 10^8$, $0.6 \lesssim Pr \lesssim 60$
$\overline{C}_{f,L} = 0.074 Re_L^{-1/5} - 1742 Re_L^{-1}$	(7.40)	Flat plate	Mixed, average, T_f, $Re_{x,c} = 5 \times 10^5$, $Re_L \lesssim 10^8$
$\overline{Nu}_L = (0.037 Re_L^{4/5} - 871) Pr^{1/3}$	(7.38)	Flat plate	Mixed, average, T_f, $Re_{x,c} = 5 \times 10^5$, $Re_L \lesssim 10^8$, $0.6 \lesssim Pr \lesssim 60$

Q6	An electronic device dissipating 50 W is attached to the inner surface of an isothermal cubical container that is 120 mm on a side. The container is located in the much large service bay of the space shuttle, which is evacuated and whose walls are at 150K. If the outer surface of the container has an emissivity of 0.8 and the thermal resistance between the surface and the device is 0.1 K/W, what are the temperatures of the surface and the device? All surfaces of the container may be assumed to exchange radiation with the service bay, and heat transfer through the container resistant may be neglected.	10
Q7	A liquid is flowing through a vertical tube 0.3 m long and 2.5 mm (inner diameter). The density of the liquid is 1260 kg/m^{-3} and the mass flow rate is 3.8 x 10^{-5} kg/s. Using shell balance, develop an expression for velocity distribution. What is the viscosity in N s/ m^{-2}.	10

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