ชื่อ..รหัส...................................

PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Final Examination Semester I   Academic year : 2003

Date : September 29, 2003   Time : 9.00 – 12.00 น.

Subject : 230 – 313 Heat Transfer   Room : R300

อ.กัลยา ศรีสุวรรณ

ผู้ออกข้อสอบ

1) ข้อสอบมีทั้งหมด 8 ข้อ ให้ทำทุกข้อ
2) ข้อสอบแต่ละข้อมีคะแนนเท่ากัน
3) มีข้อมูลเพิ่มเติมในหน้า 12 และ 13
4) ให้ทำด้านหลังกระดาษได้

	คะแนนเต็ม	คะแนนที่ได้
ข้อ1	10	
ข้อ2	10	
ข้อ3	10	
ข้อ4	10	
ข้อ5	10	
ข้อ6	10	
ข้อ7	10	
ข้อ8	10	
รวม	80	

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1. Mercury at 250 ^{o}C flows over a tube bank consisting of 1.25-cm-OD. 1-m-long tubes in staggered type arrangement with equal Sn/d and Sp/d of 3. The matrix has 60 rows in the direction of flow and 30 tubes in each row. The velocity of mercury before entering the matrix is u_{∞} = 0.05m/s, and the tubes are maintained at a uniform temperature of 160 ^{o}C. Determine the average heat transfer coefficient and the total heat transfer rate through the matrix.

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2. Atmospheric air at T_∞ = 24 ^{o}C flows with a velocity of u_∞ = 4 m/s along a flat plate L = 2 m long that is maintained at a uniform temperature of 130 ^{o}C

(a) Determine the thermal boundary-layer thickness δ_t and the local heat transfer coefficient h at the trailing edge (that is, L = 2 m) of the plate.

(b) Find the average heat transfer coefficient over the entire length of the plate.

(c) Calculate the heat transfer rate from the plate to the air per meter width of the plate.

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3. The steady-state energy equations for flow between two parallel plates are taken for three cases as

$$\rho c_p \left(u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} \right) = k \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right) + \mu \Phi$$

where u is the flow velocity in the axial x direction and Φ is a viscous shear force term.

Energy equations for flow between two parallel plates for three cases are simplified and presented in the following forms:

3.1 $$\rho c_p u \frac{\partial T}{\partial x} = k \frac{\partial^2 T}{\partial y^2} + \mu \left(\frac{\partial u}{\partial y} \right)^2$$

3.2 $$\rho c_p u \frac{\partial T}{\partial x} = k \frac{\partial^2 T}{\partial y^2}$$

3.3 $$\rho c_p u \frac{\partial T}{\partial x} = k \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right)$$

Discuss the assumptions made to simplify the energy equation for each case.

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4. Air-free-saturated steam at $T_S = 60\ ^{o}C$ (P = 19.94 kPa) condenses on the outer surface of 100 horizontal tubes with 2.5-cm OD and 2 m long, arranged in a 10 by 10 square array. The surface of the tubes is maintained at a uniform temperature $T_w = 40\ ^{o}C$. Calculate the average condensation heat transfer coefficient for the entire tube bundle, the total rate of heat transfer, and the rate of condensation at the surface of the tubes in the bundle.

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5. A two shell pass, four tube pass heat exchanger is to be used to heat water with oil. Water enters the tubes at a flow rate of m_c = 2 kg/s and temperature t_1 = 20 ^oC and leaves at t_2 = 80 ^oC. Oil enters the shell side at T_1 = 140 ^oC and leaves at T_2 = 90 ^oC. Calculate the heat transfer area required for an overall heat transfer coefficient of U_m = 300 W/m^2. ^oC [c_{pc} = 4180 J/kg. ^oC].

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6. A counterflow shell-and-tube exchanger of area of 20 m^2 is used to heat water with hot exhaust gases. The water with a mass flow rate of m_c = 2 kg/s [c_p = 4180 J/(kg. ^oC)] enters at $T_{c,in}$ = 25 ^oC . The exhaust gases of mass flow rate of 5 kg/s [c_p = 1030 J/(kg. ^oC)] enters the heat exchanger at $T_{h,in}$ = 175 ^oC . The overall heat transfer coefficient is U_m = 200 W/(m^2. ^oC). Calculate the heat transfer rate and the exit temperatures of hot and cold fluids.

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7. Thermal conductivity of a plane wall varies with temperature according to the relation

$$k(T) = k_o\left(1 + \beta T^2\right)$$

where k_o and β are constants.

(a) Develop an expression for the heat flow through the slab per unit area if the surfaces at x = 0 and x = L are maintained at uniform temperatures T_1 and T_2 , respectively.

(b) Develop a relation for the thermal resistance of the wall if the heat transfer surface is A.

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8. Aluminum fins of rectangular profile are attached on a plane wall with 5-mm spacing. The fins have thickness t = 1 mm, length L = 10 mm, and thermal conductivity k = 200 W/m. ^{o}C, The wall is maintained at a temperature T_0 = 200 ^{o}C , and the fins dissipate heat by convection into the ambient air at T_∞ = 40 ^{o}C with heat transfer coefficient h = 50 W/m^2. ^{o}C,

(a) Determine the fin efficiency.

(b) Determine the area-weighted fin efficiency (Fin performance).

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Table 1. Properties of Mercury(liquid)

Table 2. Properties of water.

Table 3. Properties of air at atmospheric pressure.

Table 4. Saturated steam table.