ME109 – Heat Transfer

Midterm 2- Fall'06

Instructor: Prof. A. Majumdar

Nov. 17, 2006; 12:15 am - 1:15 pm; Maximum Points = 30

NOTE: This is an open book, open notes exam.

1. Consider a counter flow heat exchanger with the following conditions:

	Hot Stream	Cold Stream
Mass Flow Rate (kg/s)	3	1
Heat Capacity (kJ/kg-K)	1	3
Inlet (^{o}C)	500	
Outlet (^{o}C)		250

   The overall heat transfer coefficient is U = 3000 W/m^2-K and the heat exchanger surface area is A = 1 m^2. Determine the temperature of the hot stream outlet and the cold stream inlet. (10)

2. Air at atmospheric pressure and 100 ^{o}C enters a 4 cm diameter tube that is 2 m long. The mean velocity of the air entering is 0.5 m/s. A 1 kW heater is wound on the outer surface of the tube such that it provides a uniform heat flux on the tube. Assuming hydrodynamically and thermally fully developed flow, find: (i) mass flow rate; (ii) Reynolds number; (iii) mean outlet temperature of the air; (iv) wall temperature at the outlet. Use the following properties of air are: density = 1 kg/m^3; heat capacity = 1 kJ/kg-K; thermal conductivity = 0.03 W/m-K; kinematic viscosity = 2 x 10^{-5} m^2/s. (10)

3. Air at atmospheric pressure, velocity of 10 m/s and 60 ^{o}C flows parallel to and on both sides of a flat plat that is 20 cm square. If the plate is maintained at a temperature of 20 ^{o}C, calculate the rate of heat transfer to the plate. Note that laminar-to-turbulent flow transition over a flat plate occurs at Re_x = 3 x 10^5. Use the following properties of air are: density = 1 kg/m^3; heat capacity = 1 kJ/kg-K; thermal conductivity = 0.03 W/m-K; kinematic viscosity = 2 x 10^{-5} m^2/s. (10)

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Makeup Midterm 2- Fall'06

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1. Consider a counter flow heat exchanger with the following conditions:

	Hot Stream	Cold Stream
Mass Flow Rate (kg/s)	3	1
Heat Capacity (kJ/kg-K)	1	3
Inlet (^{o}C)		200
Outlet (^{o}C)	300	

   The overall heat transfer coefficient is U = 3000 W/m^2-K and the heat exchanger surface area is A = 1 m^2. Determine the temperature of the hot stream inlet and the cold stream outlet. (10)

2. Ethylene glycol at 0 ^{o}C enters a 2 cm diameter tube with a velocity of 4.5 m/s. The tube wall is maintained at a temperature 80 ^{o}C. Calculate the length of the tube if the exit temperature is 40 ^{o}C. The properties of ethylene glycol are as follows: density = 1100 kg/m^3; heat capacity = 2.4 kJ/kg-K; thermal conductivity = 0.25 W/m-K; kinematic viscosity = 2 x 10^{-5} m^2/s.(10)

3. Consider a flat plat at temperature T_s over which a fluid at temperature T_∞ and velocity U_∞ flows. If the Prandtl number is very small, the momentum boundary layer can be assumed to be negligible in thickness compared to the thermal boundary layer. Hence, it is safe to assume that throughout the thermal boundary layer the velocity is U_∞. With this assumption and using integral method, find the relationship between the Nusselt number, $Nu_x = hx/k_f$, and Reynolds number, $\mathrm{Re}_x = U_\infty x/\nu$. (10)