Name:_____.

Final Exam

CM 3110

17 December 2008

Note:
Significant figures count.
Please box your final answers.
Please be neat.

1. (20 points)
   a. When a single heat shield is inserted between a radiation source and an object, the heat flux from the radiation source goes down. For this case, fill in the blank:
      (energy flux hitting the object) = (source radiation flux)* _____.
   b. What is the radiation flux that is emitted from a black body at 110^{o}C?

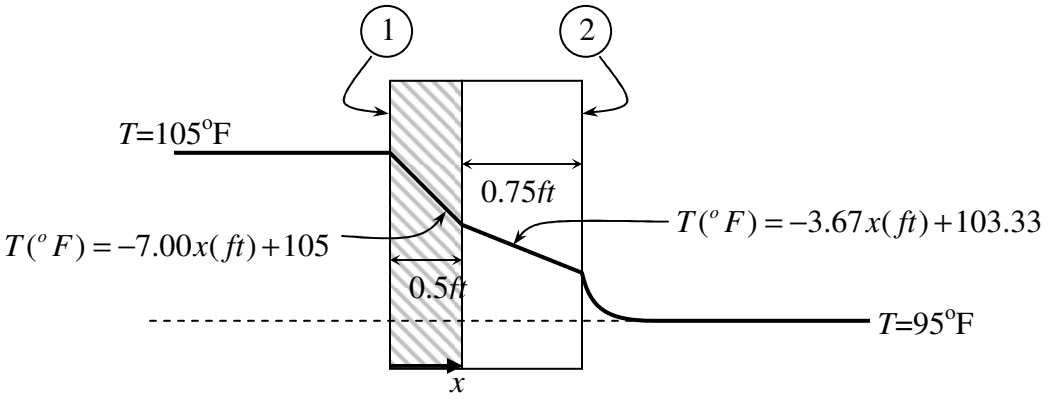
      Give your answer in W/m^2: _____.
   c. What is the friction factor for water flowing in a pipe at

      Re=100.0? _____.
   d. What is the drag coefficient for air flowing past a sphere at

      Re=0.0100? _____ .
2. (20 points) SuperTransfer heat-transfer fluid enters the inside of an existing double-pipe heat exchanger at a flow rate of 5.20 kg/s (thermal conductivity = 0.15 W/mK, heat capacity =11.92 kJ/(kg K), Prandtl number = 12.8). The temperature of the stream at the inlet is 400.0K. The flow on the outside of the heat exchanger is water flowing in a counter-current direction. The water enters at 321 K (under pressure) and flows at a rate of 0.920 kg/s (thermal conductivity = 0.628 W/m K, heat capacity = 4.183kJ/(kg K), Prandtl number = 4.51). The overall heat-transfer coefficient is 1250 W/(m^2 K), and the heat transfer area is 10.3 m^2. Calculate the heat-transfer rate in kW.

3. (20 points) A complex pilot plant at the Fatuous Chemical Company has a need for a heat exchanger that operates on a cold stream that heats from 71.67^{o}C to 81.00^{o}C and a hot stream that flows counter-currently and cools from 95.00^{o}C to 81.00^{o}C. For the following devices operating with these temperatures, what is the driving force for heat transfer?
   a. A double-pipe heat exchanger
   b. A 1-2 shell-and-tube heat exchanger
   c. A 2-4 shell-and-tube heat exchanger
   d. Is it better for the driving force to be higher or lower? Why? (no points without the *why*)

4. (20 points) The temperature profile through a thick insulated wall is measured to be that shown in the sketch below. The heat flux through the wall is 1040 BTU/hr ft^2.
    a. What is the value of the heat-transfer coefficient at surface 1? Explain your answer.
    b. What is the value of the thermal conductivity of material 1? Explain your answer.



5. (20 points) A very long rod (circular cross section) initially at 100°C is suddenly immersed in a fluid at temperature 25°C. The radius of the rod is R.
    a. What is the differential equation that we need to solve to get the radial temperature profile in the rod as a function of time? Indicate all of your assumptions.
    b. What are the appropriate boundary and initial conditions? Be sure to give enough conditions to be able to fully solve the differential equation.

6. (10 points bonus) A piece of process equipment uses a Venturi meter (shown below) to measure flow rate of water in turbulent flow. The diameter of the throat (point 2) is 6.0 in. The pressure at the throat P_2 is measured to be 1400 psia and the pressure at the upstream tap P_1 is 3400 psia. The ratio of the upstream diameter to throat diameter is 2:1 (to 2 significant figures). What is the volumetric flow rate in the stream? Give your answer in ft^3/s. You may neglect friction.