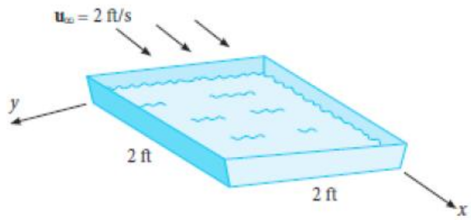
ABE 30800 Heat and Mass Transfer - Spring 2018
Homework 4– Due Thursday February 27
Total 140 marks

Question 1

A humidifier water pan shown in the figure has a surface temperature of 95^{o}F when the surrounding temperature is 80^{o}F. If the pan is 2 ft square and the air moves over the pan at 2 ft/s, estimate the convective heat transfer coefficient.

[20 marks]



Question 2

Estimate the heat loss per meter of building height due to convection from the vertical walls of a square building if air at -10^{o}C moves at 30 km/hr across the building. The surface temperature of the building is 10^{o}C.

[20 marks]

Question 3

Saturated liquid water flows through 2 cm ID stainless steel tubes at 200 g/s. The water is at 80^{o}C and the inside surface of the tubes is 200^{o}C. (a) Determine the convection heat transfer to the water per unit length of tube and (b) predict the convective heat transfer after ten years when the inside of the tubes is coated with a film so that the ID is now 1.9 cm. If scaling of the tube was creating the reduction of the tube diameter, that came accompanied with an increase in the tube wall roughness of 0.2mm, discuss if the increased tube roughness compared with the smooth tube wall will affect the heat transfer coefficient and how.

[20 marks]

Question 4

The human body is typically modelled as a vertical cylinder that is 1.8 m high and is 30cm in diameter. Calculate the average rate of heat loss from this body, which is maintained at 37°C, on a windy day when the airstream has a 5 m/s velocity and is at 35°C. To ascertain "wind chill" effects, compare this result with the heat loss that would occur in "stagnant" conditions, or when it is not windy and the heat transfer is only by natural convection. Consider a heat transfer coefficient of 3.6 W/m^2. K for natural convection. What is the wind chill effect if the wind got stronger (10 m/s) and colder (10°C)? Even though the natural convection heat transfer coefficient also changes somewhat (as discussed in Lecture 5), for this calculation consider it to remain the same. Moreover, compare the heat loss in both cases with the typical energy intake, or metabolic heat production from consumption of food, of about 1050 kcal/day. Comment upon your results.

[40 marks]

Problem 5

You need to compare the thawing times for packaged-frozen blood in two different scenarios.

(1) The bottom surface of the package is supported by Styrofoam that can be considered as an insulated side whereas the top of the package is in contact with warm air that transfers heat to thaw the material. (2) The package is supported by a wire mesh such as the same convection occurs on the top and the bottom of the package. What are the thawing times for the two conditions shown? The thickness of the package is 2.5cm and the other two dimensions of the package are much greater than the thickness so the heat transfer can be considered 1D along the thickness. The initial temperature of the blood is T_m = - 0.5^{o}C. The air temperature is 15^{o}C and the heat transfer coefficient *h* is 20 W/m^2.K. Thermal conductivity of the frozen blood is 0.6 W/m/K and its density is 950 kg/m^3. Assume that the latent heat of fusion of blood is 350 kJ/kg.

[40 marks]