ME 331 Homework Assignment #5
Due Wednesday May 3, by 5 pm in MEB main office

1. A journal bearing can be idealized as a stationary flat plate and a moving flat plate that moves parallel to it. Consider such a bearing in which the stationary and moving plates are at 10°C and 20°C, respectively, the distance between them is 3.0 mm, the speed of the moving plate is 5.0 m/s, and there is engine oil between the plates. Calculate the heat flux to the upper and lower plates. Determine the maximum temperature of the oil.

2. The wing of an airplane has a polished aluminum skin. At an altitude of 1500 meters it absorbs 100 W / m^2 by solar radiation. Assuming that the interior surface of the wing's skin is well insulated and the wing has a chord of 6.0 m length, estimate the equilibrium temperature of the wing at a flight speed of 150 m/s at distances of 0.10 m, 1.0 m, and 5.0 m from the leading edge.

3. A spherical water droplet of 1.5 mm diameter is freely falling in atmospheric air. Calculate the average convection heat transfer coefficient when the droplet has reached its terminal velocity. Assume that the water is at 50°C and the air is at 20°C. Neglect mass transfer and radiation.

4. Neglecting radiation, consider a convective heat loss of 100 W from your body if you are standing on a windy hilltop with average wind velocity of 15 mph at T_∞ = 20°C. Without sufficient protective layers of clothing, the average surface temperature of your body under these conditions is estimated at 27°C (or 10°C lower than the core body temperature of 37°C). The surface area of a typical adult human is approximately 1.7 m^2. If the wind dies down (quiescent air), the convective heat loss from your body decreases to 80 W, and your average surface temperature increases to 30°C. Compare the heat transfer coefficients for these two cases.

   Now, compare the two rates of heat loss in air (for forced and natural convection) with the rates of heat loss that would occur in water at T_∞ = 20°C. For the natural convection case, consider standing in a lap pool with the water depth equal to your body height. Determine the rate of heat loss in quiescent water, assuming your average surface temperature is 30°C (the same as in natural convection of air).

   Next, if the water flow is turned on with an average water velocity of 15 mph, and you remain standing in the lap pool, what is the rate of heat loss, assuming your average surface temperature is 27°C (the same as in forced convection of air)?

5. Consider a heat exchanger consisting of 12.5 mm OD copper tubes in a staggered arrangement with transverse spacing of 25 mm and longitudinal spacing of 30 mm with 9 tubes in the longitudinal direction. Condensing steam at 150°C flows inside the tubes. The heat exchanger is used to heat a stream of air flowing at 5.0 m/s from 20°C to 32°C. What are the average heat transfer coefficient and pressure drop for the tube bank?