Birzeit University
Mechanical & Mechatronics Engineering Department
Heat Transfer ME 431
Homework # 1 introduction
Instructor: Dr. Afif Hasan

1.6 The heat flux through a wood slab 50 mm thick, whose inner and outer surface temperatures are 40 and 20 C, respectively, has been determined to be 40 W/m^2. What is the thermal conductivity of the wood?

1.12 An inexpensive food and beverage container is fabricated from 25-mm-thick polystyrene (*k* = 0.023 W/m.K) and has interior dimensions of 0.8 m X 0.6 m X 0.6 m. Under conditions for which an inner surface temperature of approximately 2^oC is maintained by an ice-water mixture and an outer surface temperature of 20^oC is maintained by the ambient, what is the heat flux through the container wall? Assuming negligible heat gain through the 0.8 m X 0.6 m base of the cooler, what is the total heat load for the prescribed conditions?

1.18 You've experienced convection cooling if you've ever extended your hand out the window of a moving vehicle or into a flowing water stream. With the surface of your hand at a temperature of 30^oC, determine the convection heat flux for (a) a vehicle speed of 35 km/h in air at 5^oC with a convection coefficient of 40 W/m^2 .K and (b) a velocity of 0.2 m/s in a water stream at 10^oC with a convection coefficient of 900 W/m^2.K. Which condition would *feel* colder? Contrast these results with a heat loss of approximately 30 W/m^2 under normal room conditions.

1.21 An electric resistance heater is embedded in a long cylinder of diameter 30 mm. When water with a temperature of 25^oC and velocity of 1 m/s flows crosswise over the cylinder, the power per unit length required to maintain the surface at a uniform temperature of 90^oC is 28 kW/m. When air, also at 25^oC, but with a velocity of 10 m/s is flowing, the power per unit length required to maintain the same surface temperature is 400 W/m. Calculate and compare the convection coefficients for the flows of water and air.

1.29 Under conditions for which the same room temperature is maintained by a heating or cooling system, it is not uncommon for a person to feel chilled in the winter but comfortable in the summer. Provide a plausible explanation for this situation (with supporting calculations) by considering a room whose air temperature is maintained at 20^oC throughout the year, while the walls of the room are nominally at 27^oC and 14^oC in the summer and winter, respectively. The exposed surface of a person in the room may be assumed to be at a temperature of 32^oC throughout the year and to have an emissivity of 0.90. The coefficient associated with heat transfer by natural convection between the person and the room air is approximately 2 W/m^2. K.

1.85 A solar flux of 700 W/m^2 is incident on a flat-plate solar collector used to heat water. The area of the collector is 3 m^2, and 90% of the solar radiation passes through the cover glass and is absorbed by the absorber plate. The remaining 10% is reflected away from the collector. Water flows through the tube passages on the back side of the absorber plate and is heated from an inlet temperature *Ti* to an outlet temperature *To*. The cover glass, operating at a temperature of 30^oC, has an emissivity of 0.94 and experiences radiation exchange with the sky at 10°C. The convection coefficient between the cover glass and the ambient air at 25°C is 10 W/m^2. K.

(a) Perform an overall energy balance on the collector to obtain an expression for the rate at which useful heat is collected per unit area of the collector, q_u. Determine the value of q_u.

(b) Calculate the temperature rise of the water, $T_o - T_i$, if the flow rate is 0.01 kg/s. Assume the specific heat of the water to be 4179 J/kg . K.

(c) The collector efficiency η is defined as the ratio of the useful heat collected to the rate at which solar energy is incident on the collector. What is the value of η?