Heat Transfer Homework Due Thursday, September 22

1. A piece of insulation has a thermal resistance of 4.0 (°F ft² hr)/(Btu in) – that is, it has an R-value of 4.0 per inch of thickness. The insulation is 2” thick. The temperature on the left side of the insulation is 60°F and the temperature on the right side of the insulation is 10°F
   a. Which direction does the heat flow – left to right or right to left?
   b. What is the heat flux (rate of heat transfer per unit area) through the insulation in units of Btu/(hr ft²)?

2. Consider an air space in a horizontal ceiling. The air space is 1.5” thick and does not include any highly reflective materials. The lower surface is at a temperature of 60°F and the upper surface is at 40°F.
   a. Which direction does the heat flow – up or down?
   b. What is the thermal resistance (R-value) of the air space?
   c. What is the heat flux through the air space?

3. On a very clear day, the sun is shining in Boulder with a solar flux of 300 Btu/(hr ft²). This solar flux strikes a 4’ by 6’ window at an incidence angle of 50 degrees. The window has a transmissivity of 60%.
   a. What is the radiation flux on the plane of the window?
   b. What is the total radiation transmitted through the window, in units of Btu/hr?

4. A structural insulated panel (SIP) is a sandwich of insulation between two pieces of sheathing. Consider a SIP comprised of 3.5” of molded-bead, expanded polystyrene with a density of 1.5 lb/ft³ and half-inch plywood sheathing. The temperature on one surface of the SIP is 60°F and the temperature on the other surface is 10°F. Note that these are surface temperatures and not air temperatures – do not consider the effect of surface resistances (also known as air films).
   a. What is the overall R-value of the wall, not including surface resistances?
   b. What is the heat flux through the SIP?

5. A SIP is comprised of 3.5” of molded-bead, expanded polystyrene with a density of 1.5 lb/ft³ and half-inch plywood sheathing. It is used in an exterior wall of a house with an area of 240 ft². The inside of the SIP is finished with ½” gypsum. The outside surface has hardboard siding. The inside air temperature is 70°F and the outside air temperature is 0°F.
   a. What is the overall R-value of the wall, including surface resistances?
   b. What is the heat transfer rate through the wall in units of Btu/hr?
   c. What is the temperature at the surface between the gypsum and the SIP sheathing?