DAY 27

1. Suppose that you fill two identical cups both at room temperature with the same amount of hot coffee. One cup contains a metal spoon, the other does not. If you wait for several minutes, which of the two contains the warmer coffee? Which energy transfer process accounts for this result?

2. Three jugs of milk are taken out of the refrigerator (T = 38°F) and left to sit on the counter (room temperature is 70°F). One jug is a gallon, one is a gallon that has a towel wrapped around it, and one is a half-gallon (all full). Which of these will cool down most rapidly? Which will cool most slowly? Explain.

3. Joe poured himself a cup of coffee at 9:00 AM (and put a snap-on lid on top the cup to help keep it warm), but then the boss called him over and he left the cup sitting on his desk, untouched. When poured, the coffee had a temperature of 190°F. By 9:10 AM the coffee had cooled to 170°F. If the coffee cools below 135°F Joe won't drink it. At what time will the coffee become too cool for Joe to drink? The room temperature at Joe's desk is 70°F.

4. Make a graph of temperature vs. time for Joe's coffee. Plot the temperature every ten minutes.

5. A cooler has walls made of 1" thick expanded polystyrene. It is sealed and lined with reflective foil (effectively halting all forms of heat transfer other than conduction). The cooler measures 20 inches long, 12 inches tall, and 12 inches deep on the inside. A 10 lb bag of ice that is just beginning to melt is thrown into the cooler. The outside temperature measures 90°F. How long will it take for the 50% of the ice to melt if the cooler is not opened?

6. **PHY 231 ONLY**
   Show that if heat transfer is occurring only due to conduction, the constant in Newton's Law of Cooling is

$$k_{cool} = \frac{k_t A}{mcL}$$

7. A homeowner discovers that it costs $60 in natural gas to keep her home at 72°F during a month when the average temperature outside is 35°F. How much could she expect to save if she turned her thermostat down to 66°F? Assume the dominant methods of heat loss are conduction and convection.

8. A wall of a house is constructed of 4" thick (on the outside) brick followed by a 3.5" air gap followed by ½" thick drywall.

The temperature inside the house is 70°F. The temperature outside is 20°F. Find the temperature at the inside surface of the brick and the outside surface of the drywall, assuming that conduction is the primary mechanism for heat transfer in this system.

9. **PHY 231 ONLY**
   A steam heat pipe has a temperature of 250°F and measures 2″ in diameter. It is wrapped in 2″ of fiberglass insulation. The temperature outside is 70°F. Find the temperature in the insulation as a function of distance from the pipe.

10.   A warning sign often seen on highways just before a bridge is "Caution--Bridge Surface Freezes Before Road Surface." Which of the three energy transfer processes is most important in causing bridge surfaces to freeze before road surfaces on very cold days?

11.   A Dewar Vessel (used in science but also found in high-quality "Thermos Bottles") consists of a bottle within a bottle. There is a vacuum between the two bottles. The interior of the bottle is silvered – very shiny. The mouth of the bottle is very small. Explain why this arrangement is very good at stopping heat loss.

12.   The Sun measures 696,000 km in radius and radiates energy at a rate of 3.827×10^{26} W (known as the solar luminosity). Space has a temperature of 2.7 K. What is the surface temperature of the sun if it is a perfect blackbody? If another star is found to have the same luminosity as the Sun but only 70% its surface temperature, what must its radius be?
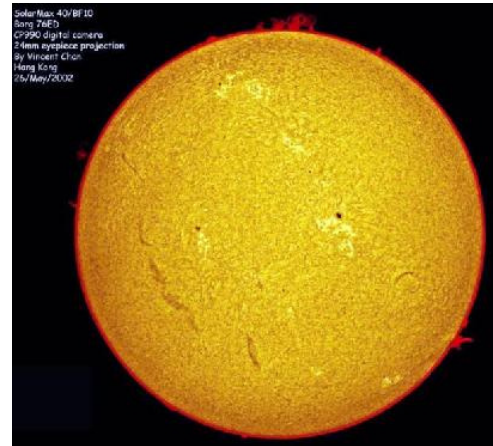

13.   A plate of steaming hot food is placed on the table, but some family members are still washing up for dinner! What is the best way to stop the food from losing heat via evaporative cooling? Explain.

14.   Based on what we've learned about heat transfer via radiation, rank the following cars in order of how hot you expect their interiors would be if left for an hour in the sun with the windows up. All three have neutral gray interiors.

A car painted gloss white.
A car painted gloss black.
A car painted flat black.
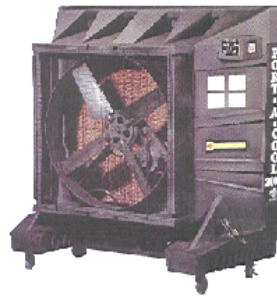
15. The company that makes "Port-a-Cools" claims that these devices, which consist of a fan that blows air through a special mat that is moistened with water, condition air for 1/10 the cost of a regular air conditioner. Explain the physics behind how a Port-a-Cool operates.

16.   In the figure is shown a black cast iron pot at various temperatures. If the pot has a surface area of 0.1 m^2 and is a near-perfect black body, calculate the heat power (in Watts) that the pot will radiate at each temperature if outdoors where the temperature is 30°F.

Same temperature as the air.

1220 Kelvin

2030 Kelvin

4400 Kelvin