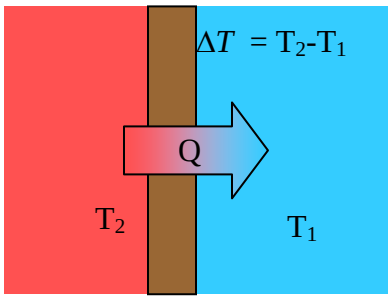
Keep The Heat

In this activity we will compare how well materials insulate between temperature differences. Let's first look at the heat flow equation

$$Q = \frac{A \bullet \Delta T}{R_{total}}$$



Where Q is the flow of heat energy (flow means amount per unit time, i.e., Joules of energy per second, or BTU of energy per second), ΔT is the temperature difference across a boundary of some material, A is the surface area of the boundary and R is a measurement of how well the material hinders the flow of heat.

1. Under what conditions will Q be equal to zero?

2. Under what conditions will Q be very large?

Materials:

- Small cardboard box
- Light bulb
- insulation material of choice
- Light bulb socket with switch
- Graph paper
- tape
- Hot glue gun
- scissors or utility knife
- thermometer
- Ruler

Complete the following procedures and answer the questions as you go along.

Procedures:

1. Cut a small hole in bottom of box that is big enough to all electrical wiring of light bulb socket to pass through the box. Insert light bulb into socket. Tape socket into box so that the light bulb is approximately in the middle of the box.

a. What is the wattage of your light bulb?

b. What does wattage mean? What are the units of a watt?

2. Cut a small hole in the top of box and insert thermometer into hole. Make sure that bottom of thermometer is approximately in the center of the box but **NOT** touching the light bulb.
3. Close up box (you may use tape if necessary) and turn on the light bulb
    a. Draw a diagram of your box with all dimensions accurately labeled. You will need to know the total surface area of your box.

4. Record the temperature in the box every 30 seconds until it stops increasing and reaches a "steady state" temperature.

Time (min:sec)	Temperature (°F)	Time	temperature
0:00		5:00	
0:30		5:30	
1:00		6:00	
1:30		6:30	
2:00		7:00	
2:30		7:30	
3:00		8:00	
3:30		8:30	
4:00		9:00	
4:30		9:30	

a. What is the temperature of the room (outside of box)?

b. What is the equilibrium temperature of your box?

5. Now repeat the experiment, but surround the inside walls of you box with an insulation material of your choice. Make sure to cover the walls uniformly.

a. What insulation did you use?

b. How thick is it?

Analysis:

Please Show all calculations and work

1. Approximately 95% of the energy in an incandescent light bulb goes to thermal energy or heat.
   a. What happens to the remaining 5% of the energy?

   b. What is the purpose of a light bulb? Is the light bulb very efficient? Why/why not?

   c. How many watts of your light bulb are converted to thermal energy?

   d. How many BTU/hrs is this (1 Watt = 3.41 BTU/hr)? This value is Q in the heat equation.

2. At equilibrium, what is ΔT for your box? How long does it take your box to become steady state?
   a. Un-insulated, $\Delta T_{u\text{-}insulated}$? Time to steady state?

   b. Insulated, $\Delta T_{insulated}$? Time to steady state?

   c. From your experience with this lab, what does the term "steady state" mean?

3. What is the surface area, A of your box?

4. Using the heat flow equation in units of BTU/hrs, calculate the R-value of the un-insulated cardboard box, $R_{un\text{-}insulated}$.

5. Using the heat flow equation in units of BTU/hrs, calculate the combined R-value of the insulated cardboard box, R_{total}.

6. What does this tell you about the R value of the insulation material, $R_{insulation}$?

7. For your lab write up, follow the directions from you engineering notebook on page 127. In addition to these requirements, you must also do all of the following.
    a. Graph the temperature of the insulated and un-insulated box vs. time.
    b. Why does the surface area of the box matter?
        1. What would happen if the box was bigger?
        2. Smaller?
    c. Talk with another group and get information about their insulated box.
        1. How did it perform?
        2. What was the steady state temperature?
        3. R value of the insulation?
        4. What are some advantages/disadvantages of your material in comparison to the other groups?

The write is an *individual* grade and each group member is expected to do his/her own.