R-Value Worksheet

One of the most economical ways to reduce heat loss or gain in buildings is by using appropriate insulation during construction or by retrofitting afterwards. Most insulating materials are rated as to their insulating effectiveness by a unit called an R-value, which indicates a materials resistance to the flow of heat through it. 1/R is a measure of the amount of heat energy (in British Thermal Units) that would pass through a piece of material 1 square foot in area in 1 hour when the temperature is 1 degree Fahrenheit higher on one side of the material than on the other. If very little heat flowed from one area to the other, then the material between the areas would be a good insulator, for it would have a large R-value. One way to represent the relationship is:

$$\frac{1}{R} = \frac{\text{Heat(BTUs)}}{\text{Area(ft}^2\text{) } \Delta\text{t(F°) time (hour)}} \quad \text{or} \quad R = \frac{\text{Area(ft}^2\text{) } \Delta\text{t(F°) time (hour)}}{\text{Heat (BTU)}}$$

British Thermal Units are usually abbreviated to BTUs, and are equal to the amount of heat energy necessary to raise one pound of water 1 degree F (or = 252 calories = 1056 joules = 1.056 kilojoules)
Using the same formula, you can determine the amount of heat that has passed through a barrier by

$$\text{Heat (BTU)} = \frac{\text{Area(ft}^2\text{) } \Delta\text{t(F°) time (hour}}{R}$$

BTUs in various fuels
1 gallon of fuel oil: 145,000 1 gallon of gasoline: 125,000 1 cubic foot of natural gas; 1031
1 ton of coal: 25,000,000 1 cord of wood: 20,000,000 1kWh = 3413 BTU

1. An R-value measuring apparatus maintains a one degree F difference between two compartments separated by a single pane of glass measuring 2ft x 2 ft. In one hour 2.2 BTUs move across the glass. What is the R-value for this material? Show your work!

2. This apparatus is used again, but this time a $4ft^2$ piece of 1" thick styrofoam is used. Since it was lunch hour, the trial ran for two hours, during which .72 BTUs of energy moved across the styrofoam. What is the R-value for 1" thick styrofoam? Show your work!

3. Except for the small countries of Luxembourg, Bahrain, Qatar, and Oman, North America uses more energy per person than all other parts of the world. This is true because historically we have always had abundant energy in the form of wood, coal, and oil. Because we have had a large supply, there has been less interest in developing ways to use energy more efficiently. There are several categories of personal energy consumption that we all have some control over: heating and air conditions, heating water, lighting, transportation, and the purchase and use of efficient electrical appliances.

One of the major ways that energy leaves or enters buildings is through windows. A single-pane window has an R-value of 0.9.

a. An average house in the Valley has about 1,800 sq. feet of floor space, and 20 windows averaging 3 x 4 feet. If the average daytime outdoor temperature was 50 degrees F and the house thermostat was set at 70 degrees, how many BTUs would be lost through the windows during the 10 hours of daylight?

b. How many BTUs would be saved if the thermostat was set for 60 degrees?

c. In the summer season the average valley day-time temperature is 80 degrees. If the air conditioner were set for 65 degrees, how many BTUs would be drawn into the house(and need to be "removed") in one 12 hour day?

d. ...in the 100 days that average this temperature?

e. Compare to a similar house with double pane glass (R-value of 1.85). How many BTUs would be saved (in the 100 days)by installing this glass in the house?

f. How many kWh of electricity (assuming 100% efficiency)