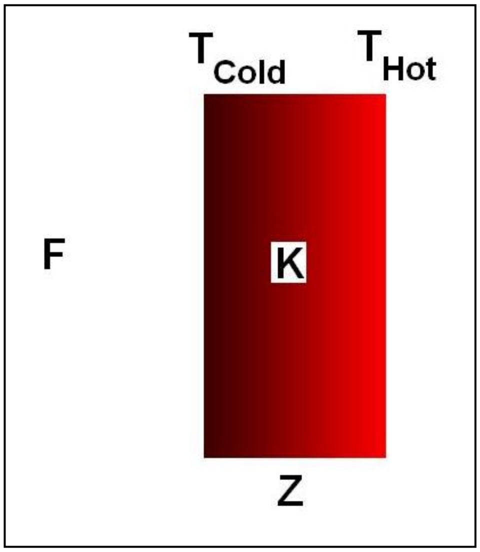

Every time you put on clothing to go outside in the winter you are experimenting with heat flow and insulation. Your body is at a temperature of 98.6^{o}F (37^{o}C) and emits about 100 watts of heat. By putting on a layer of clothing, you are preventing this 100 watts from quickly leaking out into the cold air, and this keeps you nice and warm.

The type (K value) of the insulation you wear (cotton versus down) will determine how rapidly this 100 watts leaks out, and how cold you will feel.

Another factor involved in keeping warm is the temperature difference given by DT= (T_{hot} - T_{cold}) between your body and the surrounding air. If there is a big temperature difference, the heat will flow more rapidly and you will cool off more quickly. Also, a thin insulation (Z small) will make you feel cooler than a thick insulation (Z large) and allow more heat to escape more quickly. Scientists can create a formula that follows all of these relationships.

Problem 1 - Convert the following statement into a mathematical formula using P = heat flux in watts/m^2, K = heat diffusion coefficient of the insulation, z = thickness of insulator in meters and DT = temperature difference in Celsius:

The amount of heat flux in watts per square meter is proportional to the temperature difference in degrees Celsius and inversely proportional to the thickness of the insulator in meters. The constant of proportionality is given by K.

Problem 2 - A cook is using an aluminum pot (K=250) and a stainless steal pot (K=16) to boil water. If the pots have a thickness of 2 millimeters and the temperature difference between the hot plats and the inside of the pot is 200^{o}C, which pot will boil the water the fastest?

Problem 3 - On the surface of Mars, the heat flux is measured to be 20 milliWatts/m^2. The temperature gradient DT/Z = 5^{o}C/20 meters. What is the heat diffusion coefficient K for the martian soil?

Problem 1 - Convert this statement into a mathematical formula using P = heat flux in watts/m^2, K = heat diffusion coefficient of insulation, z = thickness of insulator in meters and DT = temperature difference in Celsius: *The amount of heat power per square meter is proportional to the temperature difference and inversely proportional to the thickness of the insulator. The constant of proportionality is given by K*.

Answer: $$F = K\frac{DT}{Z}$$

Problem 2 - A cook is using an aluminum pot (K=250) and a stainless steal pot (K=16) to boil water. If the pots have a thickness of 2 millimeters and the temperature difference between the hot plate and the inside of the pot is 200^{o}C, which pot will boil water the fastest?

Answer: Aluminum: F = 250 x (200/0.002) = 25,000,000 watts/m^2
Stainless Steal: F = 16 x (200/.002) = 1,600,000 watts m^2

There is 16 times more heat entering the aluminum pot so water will boil faster in an aluminum pot that a stainless steel pot.

Problem 3 - On the surface of Mars, the heat flux is measured to be 20 milliWatts/m^2. The temperature gradient DT/Z = 5^{o}C/20 meters. What is the heat diffusion coefficient K for the martian soil?

Answer: 20 miliWatts/m^2 = 0.020 Watts/m^2. From the formula we have

0.020 watts/m^2 = K x (5^{o}C/20meters) so

K = 0.020 x 20 meters/5^{o}C and so

K = 0.08 watts/meter ^{o}C

Note: Solid granite has a value of K = 3.0
Volcanic pumice rock has K = 0.5
Lunar soil has K between 0.1 and 0.01

So the martian surface is similar as an insulator to lunar soil which has been produced by numerous asteroid bombardments and has lots of space between the soil particles.