ACTIVITY 2_2: Measuring insulation properties of different materials

The problem:

Thermal insulation of a house is a crucial problem when we want to minimize energy losses. But, which material it is better to use to build the walls or the roof of our house? Which material properties are the most suitable? The argument we are going to study will allow us to find some answers to these questions. We start by analysing with the aid of simple experiments the different behaviour of solid materials with respect to the transfer of heat by conduction.

Material for each group:

- 2 surface temperature sensors
- Styrofoam cup
- 5 squares of thickness 1 cm of different materials (aluminium, plexiglas, wood, plasterboard and styrofoam)
- 3 aluminium squares of different thicknesses (0,1 cm, 1 cm and 3 cm)
- Masking tape

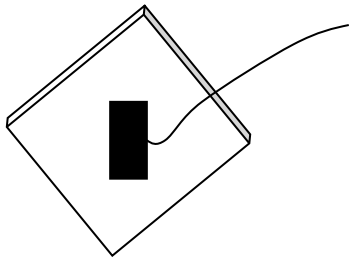
Suggestions for the experiment:

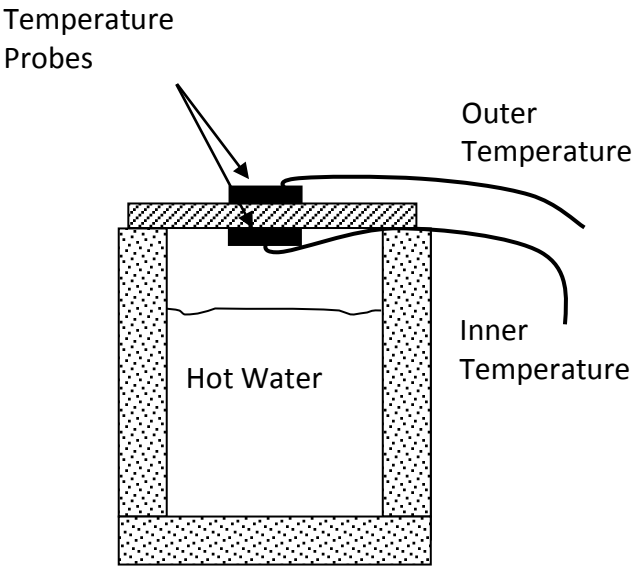
This experiment consists in measuring the difference of temperature across a square plate when there is a net heat flow. We shall use the setting shown in figure. We shall place the plate upon the cup filled with hot water and by means of temperature probes we shall measure the temperature of inner and outer faces versus time.

Pick a square of thickness 1 cm and tape a temperature sensor to each side of a piece of material. Fill the foam cup with very hot water until reaching ¾ of the height. By using a thermometer, measure the room temperature (T_{room}) and the temperature of the water (T_{water}). Write down the measurements

T_{room} = T_{water} =

Place the square on top of the cup, as shown in figure, and hold it firmly in place. Connect the two probes to the computer. Start to collect data.





Observe the graph of temperature vs. time and wait until the two curves (the inner and outer

temperatures) reach a stable value. Read these values and report them in the table below.

Repeat the previous procedure with the other squares of different materials with thickness 1 cm. At the end, complete the table with the required data.

Material	Inner Temperature	Outer Temperature	Temperature Difference (ΔT)
Wood			
Plexiglas			
Styrofoam			
Plasterboard			
Aluminium			

DISCUSSION

Why is there a difference of temperature between the faces of the squares?

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List the materials in order from highest to lowest temperature difference.

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Which material do you think is the best conductor? And the best insulator?

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Try to explain why, although water temperature and room temperature do not change, the inner temperature of the squares is different depending on the material.

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Now, we shall analyse how the thickness of the squares affects the heat conduction. To do this, repeat the previous measurements by using, this time, the three aluminium squares of thicknesses 0,1, 1 and 3 cm. Report data in the following table.

Material	Inner Temperature	Outer Temperature	Temperature Difference (ΔT)
Aluminium 0,1 cm			
Aluminium 1 cm			
Aluminium 3 cm			

DISCUSSION

How does the difference of temperature change when thickness increases?

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In order to make thermal insulation of a house more effective do you think is it better to use thicker walls or not? Explain.

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In depth analysis:

The rate of heat transfer by conduction through a layer with area *A* and thickness *d* when the temperature difference between external faces is ΔT is described by the Fourier law, which is mathematically written as:

$$\frac{\Delta Q}{\Delta t} = \frac{k}{d} A\Delta T = KA\Delta T$$

where $\Delta Q/\Delta t$ is the rate of heat transfer and *k* is the ***thermal conductivity*** of the material.

The parameter $K = k/d$ is measured in Kcal/m^2 °C and represents the heat amount transferred trough a layer with unit area (1 m^2) per hour and per unit difference of temperature.

In the table below, we have reported the parameter *K* for some materials commonly used in home-building.

External wall	26 cm air brick	1,2
Internal partition wall	12 cm air brick	1,5
Floor	Concrete and squares	1,0
Window	4 mm glass	4,3
Door	Wood	3,6

Based on the data in the table, try to estimate the heat loss by conduction across the walls, the floor, the windows and the doors of your classroom during an half-day (5 hours) lesson session in a winter day (assume a room temperature of 20 °C and an outer temperature of 5° C) . Which elements of your classroom lose the most heat by conduction?

Conclusions:

For each activity summarize what you have learned at the end of the activity and explain how you have drawn your conclusions.