# with Robotic Data Logging

This experiment shows that heat flows from hot to cold. It also shows the amount of heat in a unit volume of water.

The data is recorded using the Lego Mindstorms computer brick and Lego data logging software. The Lego brick is used to build programmable robots. Two types of equipment can be connected to the brick, stepping motors, and sensors. The computer can control the motors in rotational increments of one degree. The sensors can measure, rotation, distance, light and color, temperature, and detect touch.

How this experiment was setup and programed.

Metal cans were used because of their excellent thermal transfer. An 8 oz can and a 4 oz can were chosen so that when the 4 oz was can placed in the 8 oz, the 8 oz can would be holding twice the amount of water of the 4 oz can. The 4 oz can was filled with ice water. The ice was removed before filling the can. The 8 oz can was filled with water close to boiling. Thermometers were placed in each can and the cold can lowered into the hot water and the computer program was started to record the temperature of both cans every 10 seconds for 30 minutes. The results are shown below.
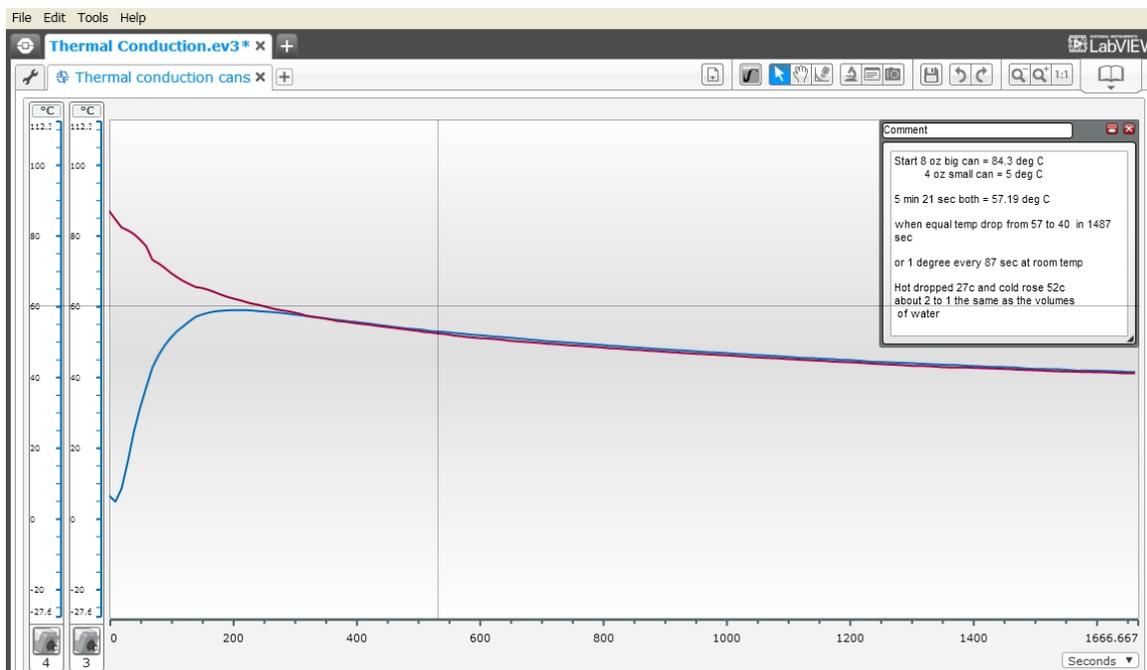
The graph shows that the cold water is rapidly loosing its heat to twice the volume of hot water and at what time and temperature they equalized. It then shows how fast it loses heat to the room temperature air.

Analyzing the Graph

The software that displays the graph has tools to analyze the data. One to analyze points along the graph and the other to analyze a section of the graph.

The first point we measured was how long and at what temperature did the volumes of water equalize. We move the point analysis tool over the line until the temperature in each can read the same.

The computer reads out the data where the line crosses the plotted line. It showed it reached equilibrium in 5 minutes and 21 seconds. The X axis is in seconds.

Point Analysis

X-Axis Position: 321.64

Name	Value
Temperature_p3_01	57.19
Temperature_p4_01	57.19
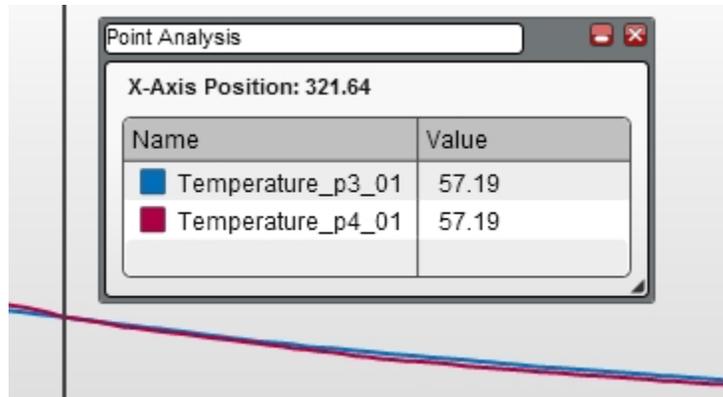
By taking a reading from equilibrium to the end we can calculate that the temperature dropped about 1 degree every 87 seconds.

Effect of the water volumes

The cold water was sitting in twice it's volume of hot water. The graph showed that the hot water dropped to 27C and the cold water rose 52 degrees. This correlates with the 2 to 1 volume of the water.

Advantage to Data logging

Using the Lego Robotic brick to record data has many advantages.

1. It takes the tedium out of recording data.
2. The accuracy of the readings are dependent on the accuracy of the sensors not the student taking the reading.
3. The experiment can be run for a long length of time. It is possible to record longer than a class session and even overnight or days.
4. Data is plotted accurately.
5. Graphing tools are available to analyze data.
6. Teaches the Cartesian Coordinate System.
7. Live measurements can be displayed on the PC monitor in real time and you can see results instantly.
8. Measurements are always taken at the right time. Unlike a human the computer will not forget to take a reading or take a reading a little bit too late.

Thermal Conduction.ev3 *

Thermal conduction cans

LabVIEW

Comment

Start 8 oz big can = 84.3 deg C
       4 oz small can = 5 deg C

5 min 21 sec both = 57.19 deg C

when equal temp drop from 57 to 40 in 1487 sec

or 1 degree every 87 sec at room temp

Hot dropped 27c and cold rose 52c
about 2 to 1 the same as the volumes
 of water