Andrews University
PHYSICS ENTERPRISES

Ice Melting Blocks

Experiment Manual

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Designed by

TRANSPARENT DEVICES LLC
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PHYSICS ENTERPRISES

Introduction

Description

This set explores the concept of heat transfer and thermal conductivity. This is demonstrated visually using blocks of different materials to show how their properties affect a block of ice.

This set may be used at many different levels, from elementary grades through high school. Rather than present “canned” lessons, we have simply “talked through” the science, in the belief that you will find age appropriate ways to use the materials with your students, and perhaps use some of our language to communicate the ideas.

Included Equipment

- 1 square block of aluminum
- 1 square block of foam plastic
- 2 large O-rings
- 1 paper 10 x 10 grid

Safety

Please teach and expect safe behavior in your classroom and lab. Safety considerations call for supervision of students at all times: safety eyewear, no horseplay, immediate reporting to the instructor of accidents or breakage, among others.

This set contains small objects and thus is not suitable for use with young children. This product is not a toy. It is for educational and laboratory use only. It is not intended for use by students age 12 years and under without competent adult supervision.

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Heat Conduction

Overview

This set consists of two blocks that appear very similar. However, they are composed of very different materials. Students should NOT be told that the blocks are different, but instead discover it by observation.

Place the two blocks on a level table. First, allow the students to touch the blocks and make predictions. Then place an ice cube on each block and watch them melt.

Note: The melting ice cube may move on its puddle of water. If the block is not absolutely level, the ice cube may fall of the edge of the block. The included O-rings may be placed on the blocks to restrict the movement of ice cubes.

Observation & Prediction

Ask the students to touch the blocks and record their observations. They should NOT move the blocks or pick them up, but merely touch them and record what they observe.

Students should immediately notice that one of the blocks feels cold while the other feels warmer. At this point, they may be asked to predict how much longer it would take an ice cube to melt when placed on the colder feeling block, as compared to the warmer feeling one.

In fact, this is a misleading question. The “cold” block and the “warm” block are both the same temperature (room temperature). The ice cube on the “cold” block actually melts very rapidly – probably less than 4 minutes. In the same time, the ice cube on the “warm” block will only just start to melt.

Ice cubes after melting
10-15 seconds

Thermal Conductivity

There are two discrepant events here. 1) Objects at the same temperature can feel as though they are at different temperatures. 2) Ice on the “cold” block melts much faster than on the “warm” block. Both of these events have the same explanation: the two blocks are made of different materials with vastly different heat conductivities.

As noted earlier, both blocks start at the same temperature, that of the room around them. In both cases, a person’s hands are significantly warmer than either block (or the room). Heat energy moves from high temperatures to low temperatures. Therefore, heat will flow from the hand (≈37°C) to the block (≈20°C) in both cases, but the rates at which this happens are not equal. The rate of heat transfer is what our skin detects, leading to the incorrect conclusion that one block is warmer than the other.

The “cold” block is composed of aluminum, which has one of the highest heat conductivities of common materials. It feels cold because it conducts heat away from your hand much faster than the “warm” feeling block. This fast rate of heat loss leads you to believe that the block itself is cold, when in reality it is at room temperature.

The “warm” block is made of rigid plastic foam. Plastic is a poor conductor of heat, and the gas bubbles in this sample make it especially so. Heat is still conducted away from your hand when you touch it, but the process is so slow that your brain incorrectly tells you that the block is warm.

An ice cube on the verge of melting is at 0°C. Transferring heat to the ice cube is necessary to melt it. Given that both of the blocks are at room temperature to start with – much warmer than 0°C – they will both conduct heat to the ice. However, the high heat conductivity of the aluminum allows it to conduct heat to the ice very quickly, resulting in rapid melting. In contrast, the low conductivity of the plastic melts the ice slowly.

Hot Water Demonstration

The difference in thermal conductivities of the two blocks can also be shown by heating them above body temperature. Both blocks can be safely heated by immersing them in hot tap water (max. 60°C) for several minutes . (Caution: Do NOT heat the blocks with a flame or electric heat.)

When handled, the aluminum block will feel hot to the touch, while the plastic much less so. This is again due to the higher thermal conductivity of aluminum. This is despite the fact that both have been heated to the same temperature.

Additional Activities

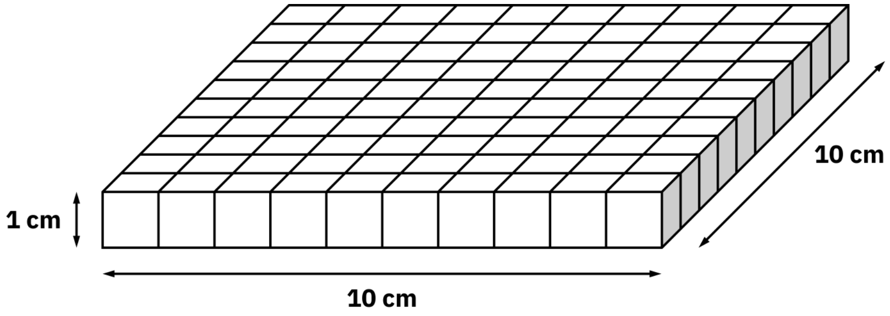
Physical Properties

This set can also be used to help visualize ideas such as metric measurement, density, and the mole concept.

Volume

The length and width of the aluminum block are approximately 10 cm, and the height (thickness) is approximately 1 cm. If we had an extremely sharp, strong, and infinitely thin blade, we could imagine cutting the block into small cubes with dimensions of 1 cm x 1 cm x 1 cm. It would be dangerous to try this, but it is good to imagine the process.

To help visualize this, a 10 by 10 paper grid may be placed on top of the aluminum block. We can then count 100 squares, corresponding to 100 small cubes, each with a height of 1 cm (the thickness of the block). Each of these cubes is one “cubic centimeter”.



What we have found is called the “volume” of the block, measured in cubic centimeters. Volume is a measure of how much three dimensional space an object occupies.

We used reasoning, rather than an explicit formula, but we could instead say that,

Volume = length x width x height.

It is informative to use the volume formula carefully and methodically:

Volume = length x width x height
= 10 cm x 10 cm x 1 cm
= 100 cm x cm x cm
= 100 cm^3

Although centimeters (cm) are not numbers, if we treat them like numbers in our calculations,
we get the common abbreviation for cubic centimeters (cm^3).

Ten of these blocks would have a volume of 1,000 cubic centimeters, which is also equal to 1 liter.
Thus, 1 milliliter is the same volume as 1 cubic centimeter.

Note: The actual dimensions of the block are not exactly 10 cm x 10 cm x 1 cm. They are close enough to visualize the concept, but if accuracy is required, students may use a ruler or calipers to find the actual length, width, and height and calculate the volume as described above.

Density

Given that the aluminum block is a rectangular solid, it makes an excellent sample to use when discussing density.

With the addition of a simple classroom balance and metric ruler, students can easily find the block’s density (2.7 g/cm^3 for the aluminum alloy and 0.54 g/cm^3 for the foamed plastic). These densities can then be compared to that of water (1 g/cm^3) by placing both blocks in a container of water to show that the aluminum block sinks while the plastic block floats.

Note: To find accurate densities, students should measure the dimensions of each block with a metric ruler or calipers, rather than relying on the approximation of 10 cm x 10 cm x 1 cm.

Mole Concept

The concept of a “mole” is important in the study of chemistry. As it happens, a block of aluminum with dimensions 10 cm x 10 cm x 1 cm contains almost exactly 10 moles of aluminum (10.007 mol). While the block in this set is not exactly these dimensions, it serves as an excellent visual when talking about moles.

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