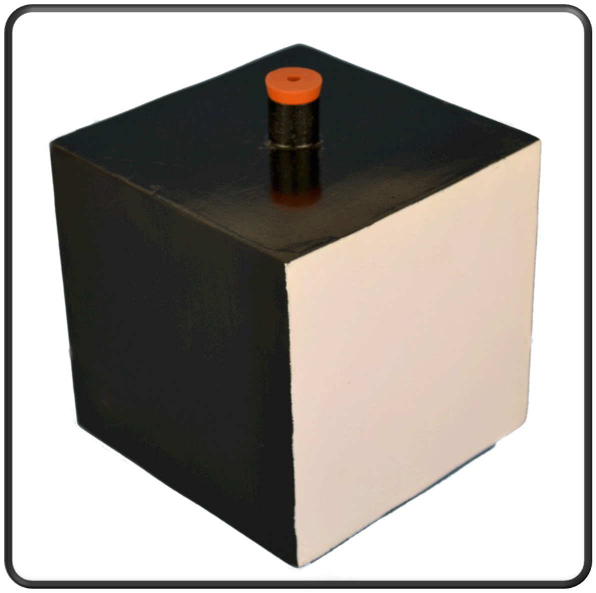
Leslie's Cube

PH0411A

Instruction Manual

Moving Science Ahead

Leslie’s Cube



Introduction:

The primary purpose of the apparatus is to measure thermal properties as function of surface color and texture. The four vertical faces of the cube each have a different surface: dull black, polished black, white and bright tin. A hole on the top face allows the cube to be filled with water.

Instructions for Heat Absorption Activity:

Required Materials: water, heat source (e.g. lamp), thermometer (or temperature logger sensor), timer.

1. Carefully fill the Leslie Cube with water.
2. Insert rubber stopper into top face of cube.
3. Insert thermometer (or temperature logger sensor) into rubber stopper to measure water temperature.
4. Position an already warm lamp such that it points directly at one of the vertical faces of the cube. Lamp should be placed 10 – 20 cm from cube. Record this distance.
5. Start timer and record the temperature of the water as the cube is heated by the lamp. Record temperature increase in increments of one degree Celsius. Take data for an increase of several degrees.
6. Repeat step 5 for each of the vertical faces of the cube (dull black, polished black, white, and polished tin). Make sure the distance from the cube face to the lamp remains constant.

To compare the rate of heat absorption of each of the faces of the cube, students may graph the increase in temperature as a function of time. The slope of a best fit line for each cube face ($\Delta T / \Delta t$) correlates to the heat absorption for the cube face surface type.

Note: Be sure cube is completely dry at end of activity to avoid rusting of inner surface.

Instructions for Emissivity Activity:

All objects with temperature above absolute zero radiate energy. The power radiated by an object is given by the Stefan-Boltzmann law:

$$I(T) = \varepsilon\sigma T^4$$

where ε is the emissivity of the object, σ is the Stefan-Boltzmann constant (5.6703 x 10^{-8} W m^{-2} K^{-4}), and T is the temperature of the object. Emissivities vary between 0 and 1, with a perfect blackbody has an emissivity of 1 (perfect emitter).

This activity will probe the radiated energy by measuring the temperature of the Leslie cube using an infrared thermometer.

Required Materials: hot water, thermometer (or temperature logger sensor), timer, infrared thermometer logger sensor.

1. Very carefully fill the Leslie Cube with very hot water (~80 deg. Celsius).
2. Insert rubber stopper into top face of cube.
3. Insert thermometer (or temperature logger sensor) into rubber stopper to measure water temperature.
4. Wait several minutes to allow cube to come to equilibrium.
5. Point infrared thermometer logger sensor 10 cm from cube
6. Record the temperature each of the vertical faces of the cube (dull black, polished black, white, and polished tin) using the infrared thermometer. Make sure to keep the IR thermometer the same distance from the cube face for each recording. Monitor the water temperature to ensure the water temperature remains constant.

The different temperatures of each cube face reveals the fact that the surfaces do not all share the same coefficient of emissivity. Though the surface temperature of each face is equivalent (they are in thermal equilibrium with the water), the measured temperature using the infrared thermometer will yield a lower temperature.

Students should find that two black sides and the white side are relatively close to an ideal ‘blackbody’ radiator, while the polished tin has a much lower temperature and hence lower coefficient of emissivity. This is due to the fact that the polished tin is a good reflector, and the infrared sensor is in fact mostly measuring the temperature of the reflected object in the mirror like surface.

Note: Be sure cube is completely dry at end of activity to avoid rusting of inner surface.