16226 Thermal Radiation Class Kit

Purpose:
To investigate the transfer of thermal energy by radiation.
PLACE THERMOMETER NO CLOSER TO BULB THAN 10CM

Required Accessories:

Soil
Water
Metric Ruler
Black container sets
Transparent containers
Assembly:

Using the spring clamp attached to the socket, attach the light to the lampstand. Screw the bulb into the socket. Mount a thermometer in each lid using one of the slots. Set the lids on the top of the cans. Adjust as necessary.

Heat Energy:

Energy can be transferred in a number of ways from one object to another. Heat is one form of energy that will be investigated in this exercise. We will use temperature as a measure of an objects heat energy. Heat moves readily from place to place and always flows from hot to cold. It can move within objects by a method called conduction, or it can move between objects by a method called radiation. Heat can also be carried by fluids such as air or water in a process called convection. The heat transferred to and absorbed by an object depends upon the strength of the heat source, the distance between the heat source, and the material from which the object is made.

Heat Transfer:

The source of energy for these experiments is an ordinary incandescent light bulb. It provides both heat and light energy. Measure 10 cm to one side of the bulb. Place the shiny container here. Measure 10 cm from the bulb in the opposite direction. Place the black container here. Each container is the same distance from the bulb and will receive the same amount of energy. Allow enough time for the two thermometers to reach the same temperature. Then turn the light on. Record the temperature from each container every minute for 10 minutes then turn the light off again. Continue recording the temperature from each container every minute for 10 more minutes. Chart your data with temperature on the vertical axis and time on the horizontal axis.

Which container gained heat more rapidly?
(The black container)

Which container lost heat more rapidly?
(The black container)

Do you have any possible explanations for this?
(The hotter an object is, the more rapidly it will loose its heat. Therefore, because the black container was hotter after the 10 minute exposure to the light, it was able to radiate more heat away after the light was turned off.)
The temperature of the black container increased more rapidly because, in comparison to the shiny container, less of the energy was reflected away. Typically, light colored/shiny object reflect more heat and light energy than dark colored objects which tend to absorb more heat and light energy.
If you want to keep cool in the summer sun, what color clothing should you wear?
(light colors, they absorb less heat)

Can you trace the methods by which heat energy was transferred from the bulb to the thermometer?
(Radiation from bulb filament to the bulb glass, conduction and radiation through the bulb glass, radiation through the air, conduction through the metal, radiation through the air in the container, conduction and radiation through the thermometer bulb to the colored alcohol.)

Temperature Change and Distance:

For the next part of this experiment, you will change the distance between the light source and the containers. Screw the aluminum reflector onto the lamp socket and replace the bulb. Place the black container 10 cm from the light bulb (as you did in the first experiment) and record the temperature of the container with the light off. Turn on the light. Wait until the thermometer has stabilized and record this temperature. Record the difference between the these two temperatures. Repeat this experiment with the container placed 20 cm, 30 cm, and 40 cm. (If you have 3 additional black containers, lids, and thermometers, this experiment can be done in one setting, otherwise it must be broken down into 4 separate experiments.)

Plot your data with the temperature change on the vertical axis and the distance on the horizontal axis. This curve describes an "inverse square" relationship between the temperature change and the distance. To confirm this relationship, plot your data again placing the temperature change on the vertical axis and 1/d2 on the horizontal axis. This should produce a straight line. You can use this graph to predict either the temperature change for the container at some distance or what distance from the bulb would be required to produce a given temperature change.

From this experiment, which container position produced the largest temperature change?
(the one closest to the bulb)

Why does the temperature stop rising?
(The container radiates as much energy as it receives - it is in equilibrium)

Your graph was probably not a perfectly straight line. Can you offer some suggestions to explain why?
(error in measuring distances, heat loss to air, error in reading thermometer, etc.)

Heating of the Earth:

Weather systems are produced and fueled by temperature changes on the earth. Water and land absorb and reflect heat at different rates. You can investigate these effects by placing water and soil in two large containers or bowls. Fasten two thermometers in such a way that the bulb of one is entirely submerged in the water while the other is just above the surface of the water. Arrange two more thermometers in an identical fashion above the container with the soil; one thermometer bulb below the soil's surface and one just above. Position the lamp and reflector on a ring stand so that it is above and equally distant from each test container. Allow the thermometers to stabilize then turn on the light. Record the temperature on each thermometer at one minute intervals for 10 minutes. Turn the light out. Continue recording the temperatures for an additional 10 minutes. Plot the data for all four thermometers on one sheet of graph paper.

Does the water or the soil heat more rapidly and why?
(soil, because it is darker)

Which surface temperature was higher?
(soil, because it heats faster, it will radiate more heat back to the air)

Time Allocation:

To prepare this product for an experimental trial should take less than ten minutes. The time required for an actual experiment will vary with needs of students and the method of instruction, but any one of those described is easily concluded within one class period.

Feedback:

If you have a question, a comment, or a suggestion that would improve this product, you may call our toll free number.