Hot Box

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Topic

Heat conduction and energy conservation

Time

2 hours

Safety

Please click on the safety icon to view the safety precautions. Be very careful when cutting the box. Always cut away from yourself. Remember that the lightbulb will get very hot. Let it cool down before touching it.

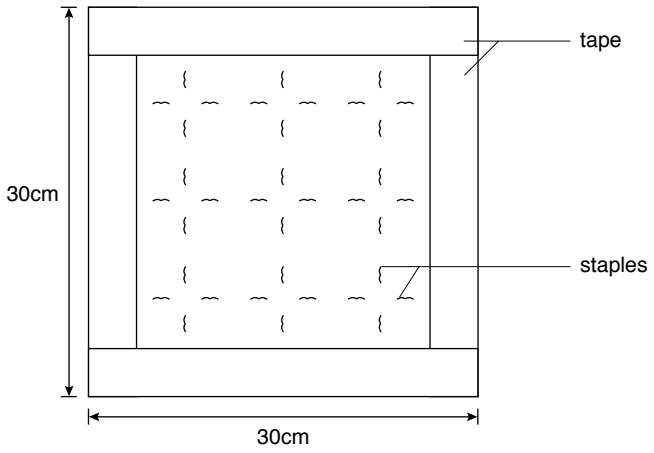
Materials

Cardboard box, 40 cm 2 40 cm 2 30 cm (Cereals are shipped to grocery stores in boxes this size, or you can cut down a larger rectangular box. It is important that the box you use for the procedure have a square base.)
one ceramic light socket
100-W lightbulb
four outdoor thermometers
scissors or matte knife
clock
stapler
three different insulating materials: Choose from fiberboard, vermiculite, cellulose, polystyrene, or plywood. (Solid pieces of insulation should be about 30 cm 2 30 cm and all the same thickness. Loose materials should be adequate to fill a paper pouch the same size and thickness.)
paper in which to encase loose insulation
masking tape

Procedure

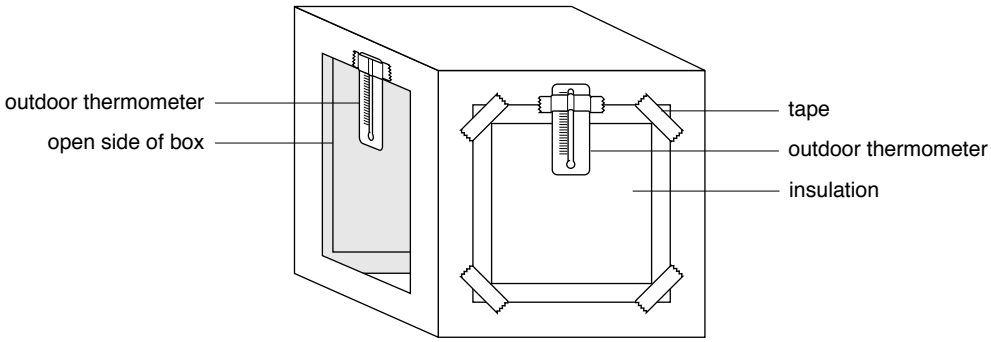
1. Cut the top flaps off the box. If you are starting with a rectangular-based box, cut it down now so that it is square, using tape to hold it in its new shape.
2. Cut four windows of equal size in the four sides of the square box.
3. Cover three of the windows with the three kinds of insulation you have decided to test. If you are using loose insulation, create a pouch for it with paper and tape. Make the filled pouch the same thickness as any solid materials you have chosen. Use the stapler to "quilt" your pouch so that the insulating material does not all fall to the bottom when you attach it to the box (see figure 1).

Figure1



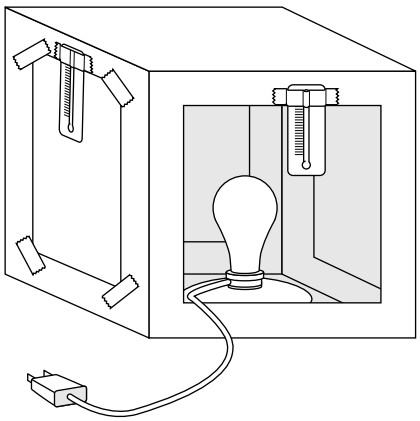
4. Tape a thermometer to the outside of each insulation sample. Make sure the bottom of the thermometer is above the bottom edge of the window. Tape one so that it hangs in the empty window opening (see figure 2).

Figure 2



5. Screw the bulb into the socket, and set it up on a table, with space for the box around it.
6. Leaving the lamp unplugged, place the box over it (see figure 3).

Figure 3



placement of lamp within box

7. Record the starting temperatures on each side on the data table, and note the time.
8. Plug in the lamp and record the temperatures of all thermometers on the data table every 5 min for 30 min.

DATA TABLE

	Temperatures at 5-min intervals						
Insulation	Start	5 min	10 min	15 min	20 min	25 min	30 min
a. Control window							
b.							
c.							
d.							

9. Which thermometer showed the lowest temperature after 30 min?
10. Which type of insulation tested best prevented heat loss?
11. Rank the insulations tested according to effectiveness from least effective to most effective.

What's Going On

Results will vary according to the type and thickness of the insulating materials being tested. Polystyrene and loose-fill cellulose fiber are generally considered the best insulators. Fiberboard is next best, followed by vermiculite and then plywood. A ranking called an R value is assigned to the insulator as an indicator of its effectiveness. The higher the number, the better the insulator. Examples of R values for some types and thicknesses of insulator follow:

TABLE OF R VALUES

Material (thickness=1cm)	R value
Expanded polystyrene	1.5
Loose-fill cellulose fiber	1.5
Fiberglass	1.3
Fiberboard	1.0
Loose-fill vermiculite	0.9
Plywood	0.5
Gypsum board (plasterboard)	0.5

Connections

Heat moves through substances in a process called *conduction.* Not all materials are alike in their ability to conduct heat. Materials that are poor conductors are called *insulators.* Insulator materials are used in the walls of houses to prevent the escape of heat, saving energy and money. An insulated house will also stay cooler in summer, because the insulation prevents outside heat from passing through the walls and warming the air inside the house.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES