Activity 1

1 Visualizing Conduction

Watch as heat travels along a piece of metal.

Caution: Be careful when handling hot water!

Materials

Liquid crystal paper

Piece of metal

Styrofoam cup

Hot water

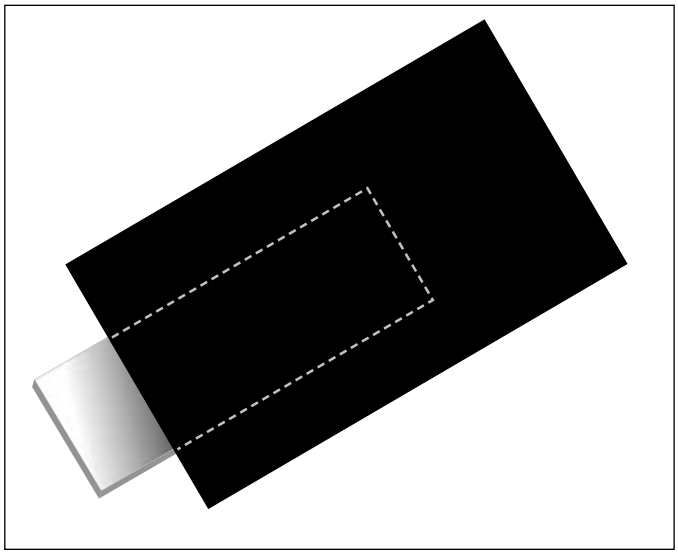
Scissors

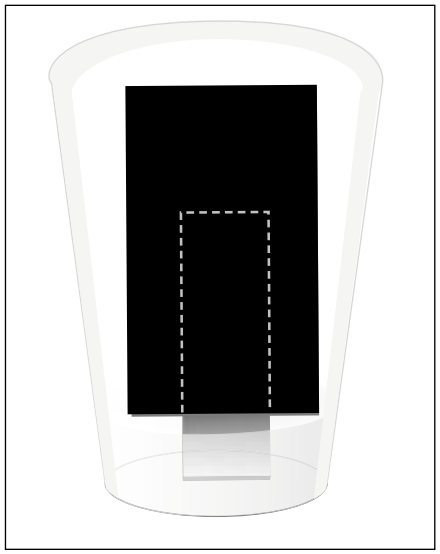
Ruler

Tape or glue

Instructions

1. Cut a piece of liquid crystal paper about 2" x 4".
2. Touch the liquid crystal thermometer with your fingers. What happens? If nothing happens, rub your hands together for a few seconds and try again.
3. Tape or glue the piece of liquid crystal paper to one end of the metal, as shown in the picture. Make sure some of the metal is left uncovered.
4. Fill the cup with very warm water until the water is about an inch deep.
5. Put your apparatus in the cup, metal end first. Be careful not to let the water touch the liquid crystal paper.
6. Watch what happens to the liquid crystal paper. Write down the colors changes that you see.





Discussion Questions

What do you think the different colors mean? What causes the colors to change?

Look for a specific shape or pattern that the colors made on the thermometer. Repeat the experiment until you are sure you have seen it!

Try replacing the metal with a different type of metal or another type of material. What can you learn about a material from this experiment?

Activity 1

1 FOR THE TEACHER
Visualizing Conduction

Discussion

Liquid crystals are a unique type of material — they flow like a liquid but are orderly arranged like the crystals. They are used in displays and as thermometers because they reflect different colors of light depending on their temperature.

When hot water comes in contact with the aluminum, thermal energy begins making its way up the metal — and an observer can see this happen in real time through the changing colors. Under close inspection you can see that the heat starts at a point at the bottom of the piece of liquid crystal and, as the energy travels upward, takes the shape of a flame. Eventually the temperature evens out across the metal and the colors all change together.

Most metals are good heat conductors, meaning that heat can pass through them easily. Insulators are the exact opposite of conductors; they keep heat from passing through. Insulators like foam, felt, and cotton are used to shield houses and people from cold temperatures because they keep the heat inside (or near the body). A metal jacket would not keep you very warm in the winter!

Materials

Liquid crystal sheet (Postcard Size)
You can purchase liquid crystal sheets at most science supply stores, such as Educational Innovations, http://www.teachersource.com, part number LC-3035A. $22.95 for a 12-inch square.

Piece of metal approximately 1" by 4"
Aluminum flashing works well for this and is available in the hardware store in the roofing section. Approximate cost: $10 - $15 for a 14" x 10' roll. Smaller sections may be available upon request.

Styrofoam cup

Very warm water

Scissors

Ruler

Tape

Note: You may wish to provide other materials such as plastic, glass, or wood so that students can compare how the experiment proceeds with materials of different thermal conductivities (discussion question 3).

Suggested Resources

Liquid Crystal Thermometer:
http://en.wikipedia.org/wiki/Liquid_crystal_thermometer

Heat:
http://en.wikipedia.org/wiki/Heat_%28thermodynamics%29

Heat Conduction:
http://en.wikipedia.org/wiki/Heat_conduction

Bibliography

Liquid Crystal Thermometers:
http://www.exo.net/~pauld/activities/liquidcrystal/liquidcrystal.html

Activity 1

2 Visualizing Convection

Observe a temperature change through color using liquid crystal thermometers.

Safety: Be careful when handling the hot water and when using the lamp.

Materials

Liquid crystal thermometer

Ice cube

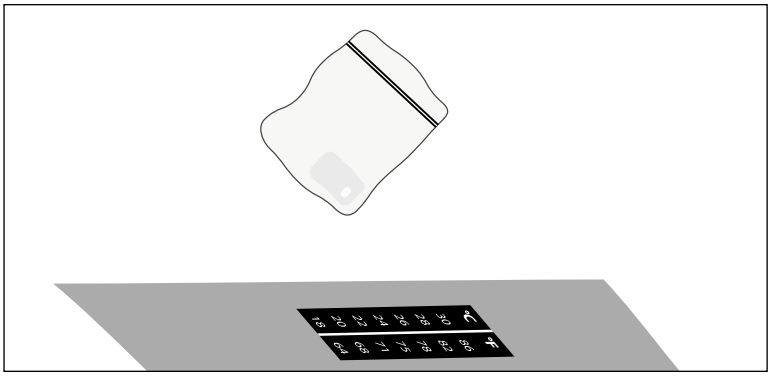
Small plastic bag

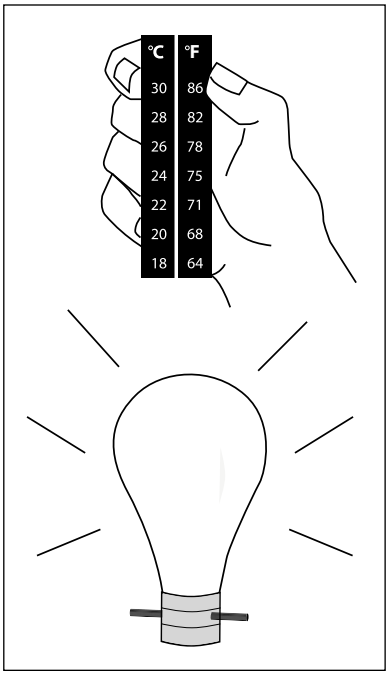
Lamp with working light bulb

Pencil and paper

Instructions

1. Observe and record the temperature shown on the liquid crystal thermometer. Make sure no one has touched it for at least a minute before you write down the temperature.
2. Turn on the lamp.
3. Hold the liquid crystal thermometer by its edges about 1cm above the light bulb. The lampshade may need to be removed.
4. For at least 30 seconds, observe how the temperature indicated by the thermometer changes. On your paper, record how the temperature changed.
5. Turn off the lamp and move the thermometer away from the lamp. Set the thermometer on a desk or table until it returns to the temperature you recorded at the beginning of the experiment.
6. Place the ice cube in the plastic bag and hold it above the thermometer.
7. Observe what happens to the thermometer and describe any changes on your paper.





Discussion Questions

What is causing the liquid crystal thermometer to change colors when it is not touching the light bulb?

Why is the liquid crystal thermometer held underneath the ice cube, and on top of the light bulb?

Activity 2

FOR THE TEACHER

Visualizing Convection

Discussion

Convection is when heat moves because of the movement of hot or cold fluids, such as air or water. The fluid motion can be caused by an external source such as gravity, which is known as natural convection or free convection. Forced convection is the circulation of fluids by a fan or a pump.

When the lamp is turned on, it begins to warm the air next to the light bulb through conduction. The warm air molecules move more quickly, which forces them to spread out. This causes the air to become less dense, so the warmer air rises. When the warm air reaches the liquid crystal thermometer the thermometer starts to change color because it detects the change in temperature. This process is convection because the heat is transported by the movement of the air.

When the ice is placed above the liquid crystal thermometer, it begins to cool the air around it. The cold air does not expand like warm air and instead becomes more dense than the surrounding air. The dense cold air flows downward, cooling the liquid crystal thermometer and causing it to change color again.

Materials

Liquid Crystal Thermometer *(included in your PhysicsQuest kit)*

Ice cube

Small plastic bag *(snack or sandwich size works well)*

Lamp with working incandescent *(not fluorescent)* **light bulb**

Pencil and paper

Note: If you have enough thermometers, it is more time-efficient to give each group two thermometers. This eliminates the wait-time while the thermometer returns to room temperature after being heated by the light bulb.

Suggested Resources

Heat:
http://en.wikipedia.org/wiki/Heat_%28thermodynamics%29

Convection:
http://en.wikipedia.org/wiki/Convection

Forced Convection:
http://www.answers.com/topic/forced-convection?cat=technology

Natural Convection:
http://www.answers.com/topic/natural-convection?cat=technology

Bibliography

Liquid Crystal Thermometers:
http://www.exo.net/~pauld/activities/liquidcrystal/liquidcrystal.html

Activity 1

3 Visualizing Sun Radiation

Watch as radiation from the Sun warms a thermometer.

Safety: Be careful when handling the hot water and when using the lamp.

Materials

Liquid Crystal Thermometer

Bright sunlight

Instructions

1. Place the liquid thermometer in the sunlight. Do not touch the thermometer once you have finished putting it down.

2. Observe how the indicated temperature changes over a period of about five minutes. You may wish to record the changes in order to track the temperature more accurately.

3. Remove the thermometer from the sunlight until it returns to its original temperature.

4. Repeat steps 1-3 tilting the thermometer at different angles or putting it in different locations. You may also want to try shading part or the entire thermometer to see what happens.

Discussion Questions

Why did the temperature reading of the thermometer change when it was placed in the sunlight?

Did you observe any differences in the way the temperature changed when you tilted the thermometer at different angles? What could have caused these differences?

What happened to the thermometer when it was kept in the shade? Use these results to predict how the high temperature on a cloudy and a clear summer day might differ.

Activity 1

3 FOR THE TEACHER Visualizing Sun Radiation

Discussion

Radiation is a form of heat transfer that does not require any medium, such as air, for a means of travel. Radiation can come from many different sources such as the sun, an incandescent light bulb, or a radiator. Thermal radiation involves the motion of atoms and molecules. Proton and electrons are charged particles that make up atoms and molecules. Electromagnetic radiation is emitted when the charged particles move around. This is a wave that carries the thermal energy away from the surface.

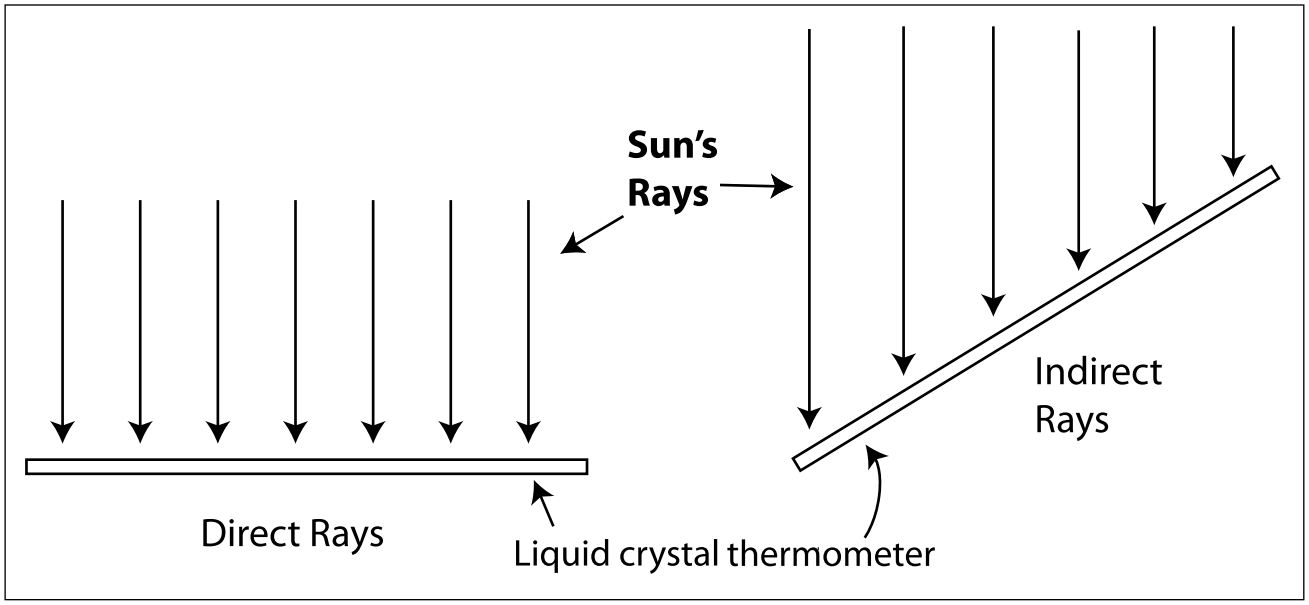
The Sun radiates light, heat, and energy. The Sun is about 93 million miles away from the Earth, so the Sun's thermal radiation must travel through space to reach the Earth. About half of the radiation reaching the Earth from the Sun is in the visible part of the electromagnetic spectrum, meaning that it has a wavelength between 400 nanometers and 700 nanometers. Most of the rest has a slightly longer wavelength and is in the near infrared portion of the spectrum. We sense this type of radiation as heat. A smaller amount has a shorter wavelength within the ultraviolet portion of the spectrum. This is the radiation that is mostly absorbed in the atmosphere, and causes sunburn from prolonged exposure.

Materials

Liquid Crystal Thermometer
(included in your PhysicsQuest kit)

The temperature of the location where you plan to conduct this activity should be within the temperature range of the thermometer.

Bright sunlight



The students should notice that the sun's radiation warms up the card faster when it is perpendicular to the sun's rays (directly facing the sun) than when the card is tilted at an angle relative to the sun's rays. In the picture above, you can see that fewer of the Sun's rays hit an angled piece of liquid crystal paper than a piece directly facing the Sun. Since fewer rays hit the angled paper, it absorbs less heat and its temperature increases slower. This result can lead to a discussion of the cause of the seasons. In the northern hemisphere the Sun's rays are more direct or "straight on" in the summer, so weather is warmer than in winter, when the rays are less direct.

When the students cast shadows on the liquid crystal thermometers, they should take note that the sun's radiation does not travel through them. This could lead to a discussion of the role of clouds in blocking solar radiation and the effects this could have on weather.

Suggested Resources

Heat:
http://en.wikipedia.org/wiki/Heat

Thermal Radiation:
http://en.wikipedia.org/wiki/Thermal_radiation

Solar Radiation:
http://en.wikipedia.org/wiki/Solar_radiation

NASA, Electromagnetic Radiation:
http://www.nasa.gov/worldbook/sun_worldbook.html

Bibliography

Liquid Crystal Thermometers:
http://www.exo.net/~pauld/activities/liquidcrystal/liquidcrystal.html

Thermal Radiation:
http://en.wikipedia.org/wiki/Thermal_radiation