



Interactions with Electromagnetic Waves

NC Standard
PS.6.2.1 &
PS.6.3.4

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Activity Description & Estimated Class Time

This lesson consists of five 50-minute sessions that investigate the interactions of light and matter. In the first two sessions, students measure changes in temperatures of differently colored cards placed in direct sunlight. In the third and fourth sessions, students measure the amount of light the cards reflect. Students are challenged to compare data sets from the first and second sessions to find a pattern in the reflectance and heating data. In the fifth session, students experiment with colored transparent plastic to gain understanding of materials that let some colors of light pass through while absorbing others. The lesson culminates with a challenge to write a secret message that can only be read when viewed through a piece of colored plastic.

Correlations to NC Science Standards

PS.6.2.1 Use models to compare the directional transfer of heat energy of matter through convection, radiation, and conduction.

PS.6.3.4 Use models to explain the various waves (seismic, sound, electromagnetic, including visible light) are reflected, absorbed or transmitted through various materials.

Learning Target

Students will develop an understanding that light is a form of energy, some of which we see, and some of which we do not. Students will demonstrate knowledge and understanding by:

- using materials to measurably absorb light;
- using materials to measurably reflect light;
- comparing absorption and reflection in the same materials; and
- using materials to manipulate light to change colors.

Brief Science Background

Electromagnetic waves are comprised of both electricity and magnetism. Like all waves, they can vibrate at different rates, and their characteristics depend on how quickly or slowly they vibrate. They do not look like waves on water or a string, and in fact, most do not look like anything at all because they vibrate too fast or too slow to interact with our eyes. Even though we can't see them, we know they exist because they interact with matter. When they do, both the electromagnetic waves and the matter are affected. Depending on the type of matter, electromagnetic waves may be reflected, absorbed, scattered, refracted (as with a prism), or they might simply pass through. Light waves are examples of one type of electromagnetic wave. When they are absorbed, they may heat the matter that absorbs them, or cause a chemical reaction, such as when light strikes a green leaf and causes the reactions that support plant life (photosynthesis). Other types of electromagnetic waves create an electrical current in conductors. These are examples of ways that electromagnetic waves transfer energy.

Common Preconceptions

Many children ages 10-14 conceive of light as either a source such as a light bulb, an effect such as a patch of light on the ground, or a state such as brightness or dimness. Students tend to think of light as traveling in long, thin, flashing rays. Many also think of light as a medium that transports colors. Students rarely imagine that when they see a non-luminous object such as a piece of paper, they are seeing the light reflected from it. When asked how a lamp brightens a room, about $\frac{3}{4}$ of children can give no mechan-



**Common
Preconceptions
cont.**

ism for this. Similarly, although many understand that light bounces off of mirrors, they do not conceive of it bouncing off of other objects. Even those who accept that light bounces off of opaque objects do not relate this to how we see. Very few children (or adults) grasp the pure abstraction that light is electromagnetic waves with different colors at different frequencies. Instead, colors are seen as discrete things unto themselves, and often as a property of objects rather than as a property of light

Part 1 — Soaking Up Some Rays – Two 50-minute Sessions

Materials

Materials for the whole class

- 16 digital thermometers
- several rolls transparent tape
- 16 envelopes
- class set of color sample cards (orange, brown, white, light green, yellow, red, and blue) to be cut into 1" x 3" strips.
- Soaking Up Some Rays Student Activity Sheet (SD 2), 16 copies
- some means of timing in 30-second intervals (provided by teacher)
- graph paper
- optional if no shade: umbrellas (provided by teacher and students)

Materials for pairs of students

- 1 digital thermometer
- transparent tape
- an envelope containing orange, brown, white, light green, yellow, red, and blue 1" x 3" color sample strips
- 1 copy of Soaking Up Some Rays Student Activity Sheet (SD 2)
- 2 sheets of graph paper
- 2 student science notebooks (provided by teacher)

Preparation allow for approx. 30 min.

1. This activity requires an outdoor location, a sunny day, relatively still air, and nearby shade. If there is no convenient shade, provide umbrellas for shade.
2. Cut the color sample cards to make as many 1" x 3" strips as you can from each card. Students will fold the 1" x 3" strips in half lengthwise and tape the sides as shown in SD 1. When folded in this way, a sleeve fits over the thermometer and in the reflectance meter sample holder. Place 7 different color strips (folded and taped or not) in envelopes, one envelope per team.
3. Have thermometers, tape, color sample sets, and envelopes arranged so that students can pick these up.



Procedure

1. Start by asking, “When light hits a surface, what can happen to the light, and what can happen to the surface it hits?” **No direct teaching here. Accept all answers.** After brief discussion, explain that the class will try to find some things out about this.
2. Give out the envelopes with color samples. Ask a student from each pair to take an orange, a black, and a white color sample from their envelope.
3. Say, “We will go outside to investigate how light and these color samples interact. Before we go out, I will show you what each team will do.” Give a volunteer team a copy of SD 2 and project SD 2 for the class. Walk the volunteer pair through the following for the class:
 - a. Say “We will start outdoors in the shade. When we are outdoors, keep everything in the shade until we start timing and put everything back in the shade when we finish timing.”
 - b. Ask the volunteer team (in the shade) to set a thermometer to ° F, place the orange sleeve on the thermometer, and call out the temperature when the reading stops changing. Ask them to record this temperature on SD 2 under the “**Starting Temp**” column for the orange color.
 - c. Say to the whole class, “When I say ‘START,’ move into the sun. I will begin timing and call time after 3 minutes. When I call time, record the temperature in the “**Final Temp**” column of SD 2 and turn off your thermometer. Then, calculate the change in temperature. When we go outdoors, we will do this three times with three different colors.”
4. When all teams have their materials, go outside to a shady location. Remind students to stay in the shade while they prepare thermometers, put the orange sleeves over the thermometer tips and record their starting temperatures. When ready, call “start” and follow the procedure above.
5. Have students return to the shade and remove the orange sleeves from their thermometers. Ask each team to pick the color they think will get *hotter* than the orange sample when held in the sun and record it on the top part SD 2. Follow the above procedure with the new color.
Be sure students turn the thermometers off and on before testing the new colors. The thermometers time out after a few minutes and this resets them.
6. Ask each team to pick a color they think will stay *cooler* than the orange sample when held in the sun, and record it on the top part of SD 2. Repeat the above procedure.
7. Bring the class inside. Ask, “What happened to the temperature of the orange sample when it was in the sun? What are some possible explanations for what happened?” After they share ideas, explain that when light strikes an object such as a piece of paper or a rock, some light energy is “absorbed” in the surface. The absorbed light becomes heat. Therefore, the amount of light absorbed is closely related to the increase in temperature.
8. In shade (or indoors), remind students that they tested colors they thought would either get warmer or stay cooler than the orange sample. Show the four new color samples and list them. Ask students to think about what they discovered regarding temperatures of the orange, black, and white samples, and then, in the bottom chart

**Procedure cont.**

on the SD 2 data sheet, predict the order of all seven colors, from highest temperature gain to lowest temperature gain. Wait for all teams to record their predictions before going on.

9. Assign each team one of the seven color samples, making sure that each color is assigned to at least one team. Have teams assigned to one of the four new colors make their corresponding thermometer sleeves.
10. Project pg. 2 of SD 2 so that students can see the information they will collect. Point out that the procedure will be the same as before, but this time, teams will record temperatures every 30 seconds for 3 minutes (at 30, 60, 90, 120, 150, and 180 seconds) as you call time.
11. Take the class outside to test their samples.
12. Bring the class inside. Ask each team to calculate the temperature change between the final and starting temperatures and record it on SD 2. Compile the class results and post or project them for all to see. (For two teams with the same color, average the results). Have students use the class data to complete the bottom section of SD 2.
13. Ask the class to examine the data for all colors. In particular, ask students to compare their predictions to the experimental results. Were they surprised by any of the results? Ask students what they notice. For example, which colors warmed most and least, whether those that warmed most had anything in common. Discuss observations.

Content Connection

1. Give the following challenge: “On SD 2, write two or three sentences that use the terms color, absorption, sunlight and heat to explain our results.” Discuss their responses.
2. Point out that even though all the colors were exposed to the same amount of light for the same amount of time, all colors did not heat up by the same amount. Ask the class what they can infer from this?
All colors did not absorb the same amount of light.
3. Ask what they think might be happening to the light that is not absorbed?
Accept all answers.

Part 2 — Reflection – Two 50-minute Sessions

Materials**Materials for the whole class**

- 10 8” x 8” x 1.5” pizza boxes, unassembled
- 10 black punch cards to make 10 sets of light baffles, solar cell stands, and sample retainers
- several staplers (supplied by the teacher)
- 10 solar cells with red and black banana plug leads
- 10 multimeters
- bag of small rubber bands
- several transparent tape dispensers



Materials cont.

- 10 flashlights
- 10 color sample sets, 7 colors each, (folded sleeves from previous lesson)
- 10 envelopes
- the ability to project SD 7
- Reflection Student Activity Sheet (SD 8), 10 copies

Materials for groups of 3 or 4 students

- 1 reflectance measuring device (see Preparation). **There is a how to video on www.ciblearning.org**
- 1 multimeter
- 1 flashlight
- 1 7-color sample set in an envelope
- 1 copy of SD 8
- student notebooks (provided by teacher)

Preparation allow for approx. 30 min.

An efficient way to prepare the reflectance measuring devices is to get 3 or 4 students to help outside of class time. If you assemble a prototype for your helpers, 5 people can make 10 boxes in about 20 minutes. Once made, these setups can be re-used for all classes.

1. Refer to **Reflective Measuring Device (SD 4)** as you assemble a prototype:
 - a. Punch out the items listed below and sort them into three stacks:
 - light baffle punch-outs
 - solar cell stand punch-outs
 - sample holder flaps
 - b. Ask your helpers to assemble the pizza boxes.
 - c. Staple in the sample holder flaps so that one of them touches but does not cover the slot used for the pizza box tab, as shown in Step 1 on SD 5. The flaps should be about $\frac{3}{4}$ inch apart. Be sure there is room to insert a folded color sample sleeve between the stapled areas of the flaps.
 - d. Fold the solar cell stand so that the triangle (base of the stand) makes a right angle with the rectangle (Step 2 on SD 5). Attach the solar cell to the upright rectangular portion of the solar cell holder with a rubber band. The solar cell goes on the side opposite the triangular base (Step 3 on SD 5).
 - e. Thread the solar cell wires through the tab slot near the corner of the box, as shown on SD 4 and Step 4 of SD 5. Once the wires are through, tape the solar cell assembly to the bottom of the box (Step 4 on SD 5) with the edges of the triangular base parallel to the sides of the box.
 - f. Tape the upright section of the light baffle (the part with the slit) to the wall of the box (SD 6). The upright portion should just touch the right edge of the right-hand sample holder flap. With that in place, tape the light baffle to the floor of the box (SD 6).
2. Put out 10 of these setups for students to pick up.
3. Set out the flashlights, multimeters, and solar cells.
4. Set out an envelope of 7 color sample sleeves for each team.
5. Be ready to show SD 7 for all to see.
6. Make 1 copy of Reflection Student Activity Sheet (SD 8) for each team.



Procedure

1. Remind students of the question asked at the end of the last class: what happens to the light that does not get absorbed? Explain that you have some measuring devices that can be used to find out a little more about this.
2. Ask students to charge the flashlights for 30 seconds, turn them on, and place them in the box so that only one LED is positioned in front of the slit to make the brightest possible circle of light between the sample holder flaps. Ask teams to leave flashlights in place and turn them off.
3. Project SD 7 and ask students to put the solar cell plugs in the multimeter as shown, matching wire color to hole color. Instruct students to set the multimeter dials to the 200m position as shown. The meter should read above zero. Ask teams to close the box and press down the lid. With the box closed and flashlights off, the reading should be zero. If not, check for light leaks. Nearly all light leaks disappear when the lid is pressed down carefully. If not, check the assembly of the box.
4. Ask teams to turn on flashlights, pick them up, shine them directly on the solar cell, and record the multimeter reading in notebooks. Ask “What does the meter measure?” **The amount of light reaching on the solar cell.**
5. Ask teams to slide the orange color sample into the sample holder flaps and put the flashlight in place with one LED shining directly through the slit to make a bright circle on the sample. Ask them to close the lids and take a reading. **It is not necessary to record the reading at this time.** Ask “How does this reading compare to when you shined the light directly on the solar cell?” Ask “What does the meter measure?” **The amount of light reaching the solar cell. It should be a lower number than when the flashlight shined directly on the solar cell.** This reading has no units such as lumens, a unit of light. The number on the multimeter is only a way to compare different amounts of light.
6. Ask students to open the pizza box lid and turn off the flashlights and multimeters. Ask them to view their setup from above and use a finger to trace the path of light from the flashlight to the solar cell.
7. Ask each team to turn on the flashlight and multimeter, close the lid, take a reading for the orange sample, and record it on SD 8. Remind them that this number represents the amount of light reaching the solar cell.
8. Remind students that in the previous lesson each team chose a color they thought would get hotter than orange. Ask each team to pick a color that got hotter than orange and write it in the appropriate place on SD 8. Ask teams to predict whether that color will give a larger or smaller reading than orange. Before testing the sample, ask them discuss their reasons.
Students will likely predict the number to be greater than the number for orange.
9. Ask students test their predictions, and write their multimeter readings on SD 8 under “Light Measurement.”
These numbers will likely be less than what they expect. The class will discuss this later.
10. Say, "In the previous lesson, you predicted a color that would heat up less than orange." Ask teams to identify that color on SD 8 and predict whether it will produce a larger or smaller light measurement than orange. Ask them to discuss their reasons.



**Procedure
cont.**

**Content
Connection**

**Guided Practice/
Formative Assessment**

11. Ask teams to test their predictions and record results on SD 8.
12. Lead a whole-class discussion about the following ideas: When light strikes the color sample, it is either absorbed or reflected. Light that bounces off of something is called “reflected” light. The box measures reflected light. The thermometers measured absorbed light. Use the information we gathered in both this lesson and the previous one to account for the light readings we just obtained. **Students should begin to understand that if a sample absorbs more light, it reflects less light, and vice-versa.** End the discussion by projecting or writing the sentences below on the board and asking students to complete them in their notebooks:

A color sample that heats up more in the sun reflects _____ light.

A color sample that heats up less in the sun reflects _____ light.

13. Say, “We now have a theory about absorbing and reflecting light. Use the theory to order the colors in the bottom part of SD 8, from those you think will reflect the most light at the top to those you think will reflect the least light at the bottom. After your team makes its predictions, use the light measuring box to test all of the colors. That way you will test the theory.” **WHEN STUDENTS FINISH, BE SURE THEY TURN OFF FLASHLIGHTS AND MULTIMETERS.** (Leaving either one on ruins the batteries).

1. Hold a class discussion comparing the class results to the theory.
2. Ask students which colors from the sample set would be best to wear on a hot summer day.
3. Say that a group of people are playing flashlight tag at night. They can wear any of the seven colors from the sample set. Which color would be best to wear to avoid getting tagged? Ask for reasons and evidence to back up student responses.
The color that reflects the least light would be best. That is the color with the lowest light reading.

Ask students to write responses in notebooks. This covers both Part 1, “Soaking Up Some Rays,” and Part 2, “Reflection.” Discuss all answers, especially “wrong” ones, and ask students to explain why they are wrong.

1. Complete the following sentence with the correct response: The amount of light that a material reflects
 - a. is less than the amount of light that is absorbed.
 - b. is a property of the material that is exposed to the light.
 - c. is based on the weight of material exposed to light.
 - d. is equal to the amount of light that is absorbed.

Provide a reason for your answer:



**Guided Practice/
Formative Assessment
cont.**

b. the amount of light that a material reflects is a property of the material.

Only the surface of an object affects how much light is reflected. The interior of the object does not matter with regard to reflection. a, c, and d are all wrong for the same reason: the amount of light reflected can be more than, less than, or equal to the amount absorbed.

2. Which of the following materials reflects more light?

- a. something that is very light colored, close to white
- b. something that is an intense, deep color, such as deep red
- c. something that is transparent, such as glass
- d. something that is very dark colored, close to black

Provide a reason for your answer:

a. something that is light colored (close to white) reflects more light.

Deep or intense colors do not necessarily reflect more. Transparent things are not very reflective because light goes through them. Dark colored materials absorb more light and reflect less.

3. Complete the following sentence with the correct response: A material that does not reflect much light

- a. appears to be very bright, even in dim light.
- b. absorbs very little light that strikes it.
- c. absorbs much of the light that strikes it.
- d. might not reflect much light now, but could reflect more light later on.

Provide a reason for your answer.

c. Materials that reflect less light absorb more of the light that strikes them.

These materials do not appear bright. They do, however, always reflect the same amount. This does not vary over time because the amount of light they reflect is a property of the material on the surface.

4. Complete the following sentence with the correct response: The light that strikes a material

- a. is all reflected.
- b. is usually both reflected and absorbed.
- c. is all absorbed.
- d. is all converted to heat.

Provide a reason for your answer.

b. The light that strikes a material is usually both reflected and absorbed.

Students saw this in their data. It is rarely all reflected or all absorbed. The absorbed light turns into heat.



5. Complete the following sentence with the correct response: When more light is reflected,
- more is absorbed.
 - none is absorbed.
 - all of the light is absorbed.
 - less is absorbed.

Provide a reason for your answer:

d. The more light that is reflected, the less is absorbed.

In the cases the class investigated, a certain amount of light struck each of the color samples. Some of that light was reflected and some was absorbed. If a color reflected more of the light, less remained that could be absorbed. Likewise, if a color reflected less of the light, it meant that more could be absorbed.

Part 3 — Secret Color Message – One 50-minute Session

Materials

Materials for the whole class

- either 16 copies of, or the ability to project
 - Secret Writing A (SD 9)
 - Secret Writing B (SD 10)
 - Secret Writing C (SD 11)
- 32 sheets of paper (provided by teacher)
- 16 sets of 6 colors of transparent plastic: red, green, blue, cyan, magenta, and yellow
- 16 sets of colored pencils

Materials for groups of 2 students

- 2 sheets of white paper
- a set of colored pencils
- 1 set of 6 transparent color filters: red, green, blue, cyan, magenta, and yellow
- 1 copy of SD 9, SD 10, and SD 11, or the ability to see it projected.

**Preparation
allow for approx. 15 min.**

Assemble envelopes containing 6 colors of transparent plastic, one for each pair of students.

Procedure

Start by asking students what they know about light so far. Remind them of previous lessons about the composition of white light, absorption, and reflection. Let them know that in this activity they will investigate another way that light interacts with different materials.

1. Pass out the sets of transparent plastic, have students look through them, and ask them to find three things that appear to change when viewed through the colored pieces. Ask them to describe what changed.
2. Project the Secret Message A (SD 9). Challenge the class to find which one of the colored plastic pieces they can look through to see the message. When most students have seen the message, ask which colored plastic pieces worked.
3. One at a time, show Secret Message B (SD 10) and Secret Message C (SD 11). Repeat the process in steps 2 and 3.



Procedure cont.

4. Project all secret messages, one at a time, and ask students for ideas about how the colored plastic makes messages readable.
 - Ask students if they know of other transparent materials that let light pass through.
Glass, Air, Water
 - What are some things that seem to color light?
Sunglasses, Colored Glass
 - Explain that the pieces of colored plastic are certain types of filters. Ask students to describe what a filter does and give some examples.
Filters allow some things to pass through them while other things get caught. Some familiar examples are coffee filters, Brita™-type water filters, oil filters in cars, and air filters in home heating systems.
 - Inform students that they are using color filters. What could they be filtering? In other words, what passes through and what gets caught?
Some colors of light pass through but other colors do not. They seem to be caught by the filter, so they are absorbed.
5. Make sure each student has a sheet of white paper and each pair of students has some colored pencils and/or markers. Ask students to make three marks on their paper, using a different color for each mark. Then ask, “How does a colored mark interact with light? **Where there is a colored mark, the place that is marked reflects only that color and absorbs all the other colors.** Next, ask the class, “If a colored mark reflects that color, where is all of the other light going?” **It is absorbed by the mark.**
6. Challenge each individual student to use markers and colored pencils to design a hidden message on the paper, which can only be read by looking at it through a color filter.
7. When students are finished, have each pair trade papers with another pair and try to read the message in white light (without a color filter or using only the uncolored filter). Then have them use the colored filters until they find one that works. **The message works only if it can be read through a filter, but can't be read without a filter.** Advise students to be prepared to explain how they designed their messages.

Content Connection

Project SD 12 and explain that the four people in the cartoon are looking at a red mark through blue plastic, and they see the red line as black. However, each one explains what they see differently. Ask each student to pick someone they agree with and someone they disagree with, and come up with arguments for and against. Find students with opposing views and assign them to make their points to each other in small groups.

- White light has all colors and a red mark reflects everything but red. The blue filter takes out all of the blue light, making the mark look black. **The red mark reflects only red, not everything but. The blue filter lets all of the blue light pass through.**
- It looks black because no light, including white light, goes through the blue filter. **Blue light does go through the blue filter. If no light went through, everything would look black.**
- A colored marker reflects the color that we see and absorbs the rest. White light contains all of the colors. A color filter allows one color to pass through and



**Content
Connection
cont.**

**Guided Practice/
Formative Assessment
cont.**

absorbs all other colors.

This is true but it doesn't explain anything. It has all the pieces to address why they see a red line as black, but it doesn't put them together.

- White light is all colors. Only red light reflects off of the red marker, but a blue filter absorbs red light, so the mark looks black.

This is correct. The only color that the red mark is giving off cannot get through the blue plastic.

Pose the following questions to the class. Ask them to write the answer and their reasoning in their notebooks. Ask them to identify the wrong answers and explain why they are wrong.

Choose the response that most correctly completes the following sentences:

1. The colored plastic pieces...
 - a. ...allow all colors to pass through.
 - b. ...reflect most colors.
 - c. ...let all colors pass through except the color of the plastic.
 - d. ...let only the color of the plastic pass through, and block the rest.

The colored plastic pieces (d) let only the color of the plastic pass through and block the rest.

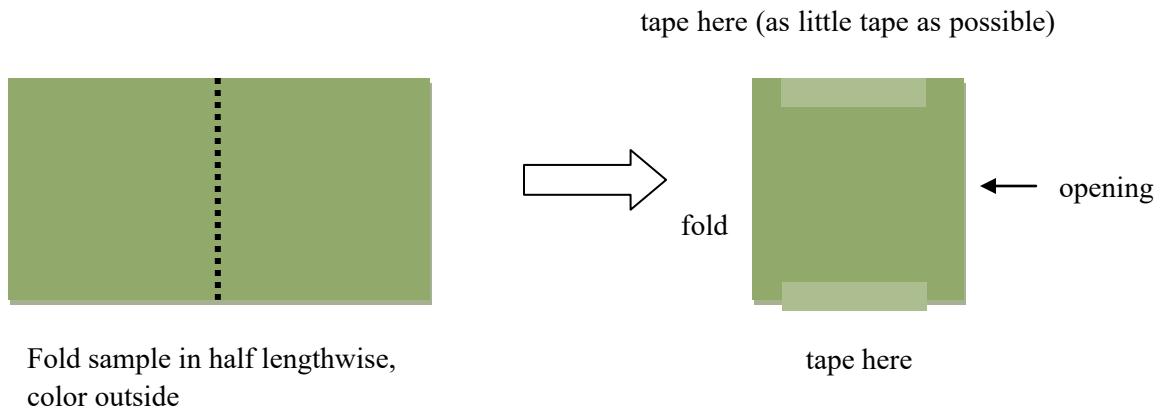
- a. is wrong because the colored plastic pieces let only their own colors pass through.
- b. is wrong because the colored plastic pieces reflect only their own colors, not most colors.
- Answer c. is the opposite of what they do. If they let all colors pass through except the color of the plastic, white objects seen through them would look like every other color combined minus the color of the plastic, which would probably be some shade of brown.

2. A red mark looks black through the blue filter because
 - a. ...the red mark absorbs all the red light and the blue filter absorbs all of the blue light, so no light from the red mark remains to reach your eye.
 - b. ...the red mark reflects only red light and the blue filter does not let red light through, so no light from the red mark remains to reach your eye.
 - c. ... the red mark reflects blue light and the blue filter absorbs blue light, so light from the red mark is able to reach your eyes.
 - d. ...the red mark reflects all colors and the blue filter lets the red light pass through, so light from the red mark is able to reach your eyes.

The red mark looks black through a blue filter because (b) the red mark reflects only red light and the blue filter does not let red light through, so no light from the red mark remains to reach your eye. If students ask how they see a mark if no light from it reaches their eyes, explain that light reaches their eyes from all around the mark - everywhere there is a color that the filter lets pass. The mark is visible the same way a shadow is visible.

- a. is wrong because the red mark does not absorb all the red light, and instead reflects it.
- c. is wrong because the red mark reflects red, not blue, and the filter lets blue pass, not red.
- d. is wrong because the red mark reflects only red, not all colors, and the blue filter does not let red light pass through.

SD 1



SD 2
pg. 1 of 2

Soaking Up Some Rays Student Activity Sheet

NAMES _____ Date _____

| Color | starting temp °F | final temp °F | change in temp °F |
|--|------------------|---------------|-------------------|
| orange | | | |
| Color Predicted to Warm More: _____ | | | |
| Color Predicted to Warm Less: _____ | | | |

| | Rank Order: Amount of Temperature Change in °F <i>Our Prediction</i> | Amount of Temperature Change in °F <i>From Class Results</i> |
|---------------|---|---|
| 1 heats most | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 heats least | | |

SD 2
pg. 2 of 2

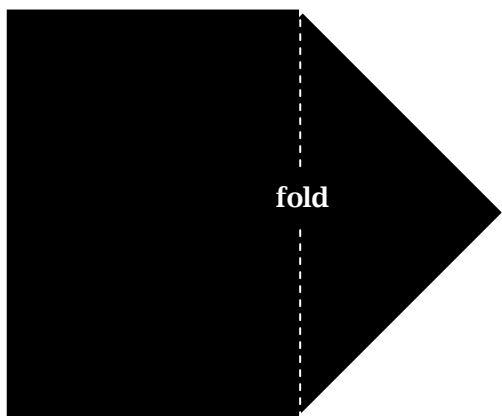
Soaking Up Some Rays Student Activity Sheet

NAMES: _____ DATE: _____

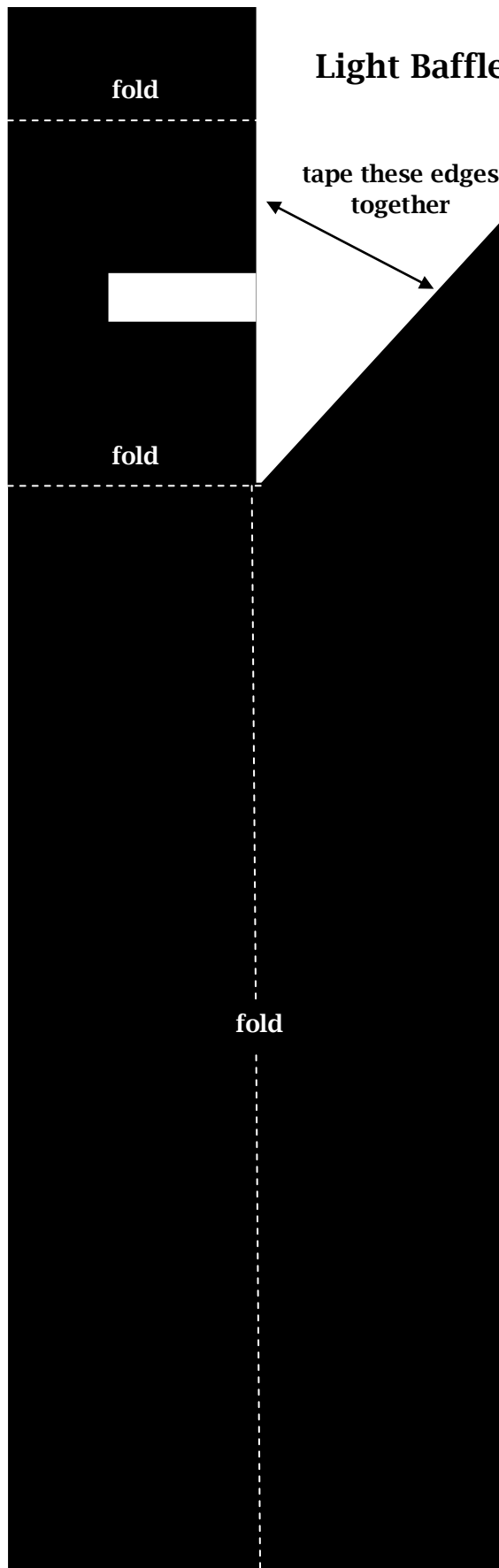
| Your Assigned Color _____ | | | | | | | | |
|---------------------------|----------------------|--------|--------|--------|---------|---------|---------|-----------------------------|
| | Starting Temperature | 30 sec | 60 sec | 90 sec | 120 sec | 150 sec | 180 sec | Final Change in Temperature |
| Temperature °F | | | | | | | | |

SD 3

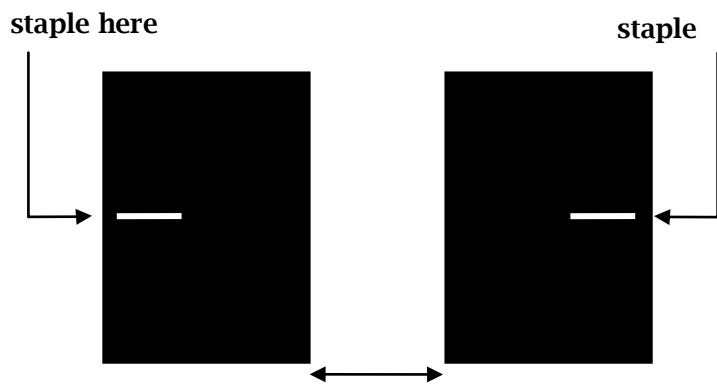
Solar Cell Stand



Light Baffle



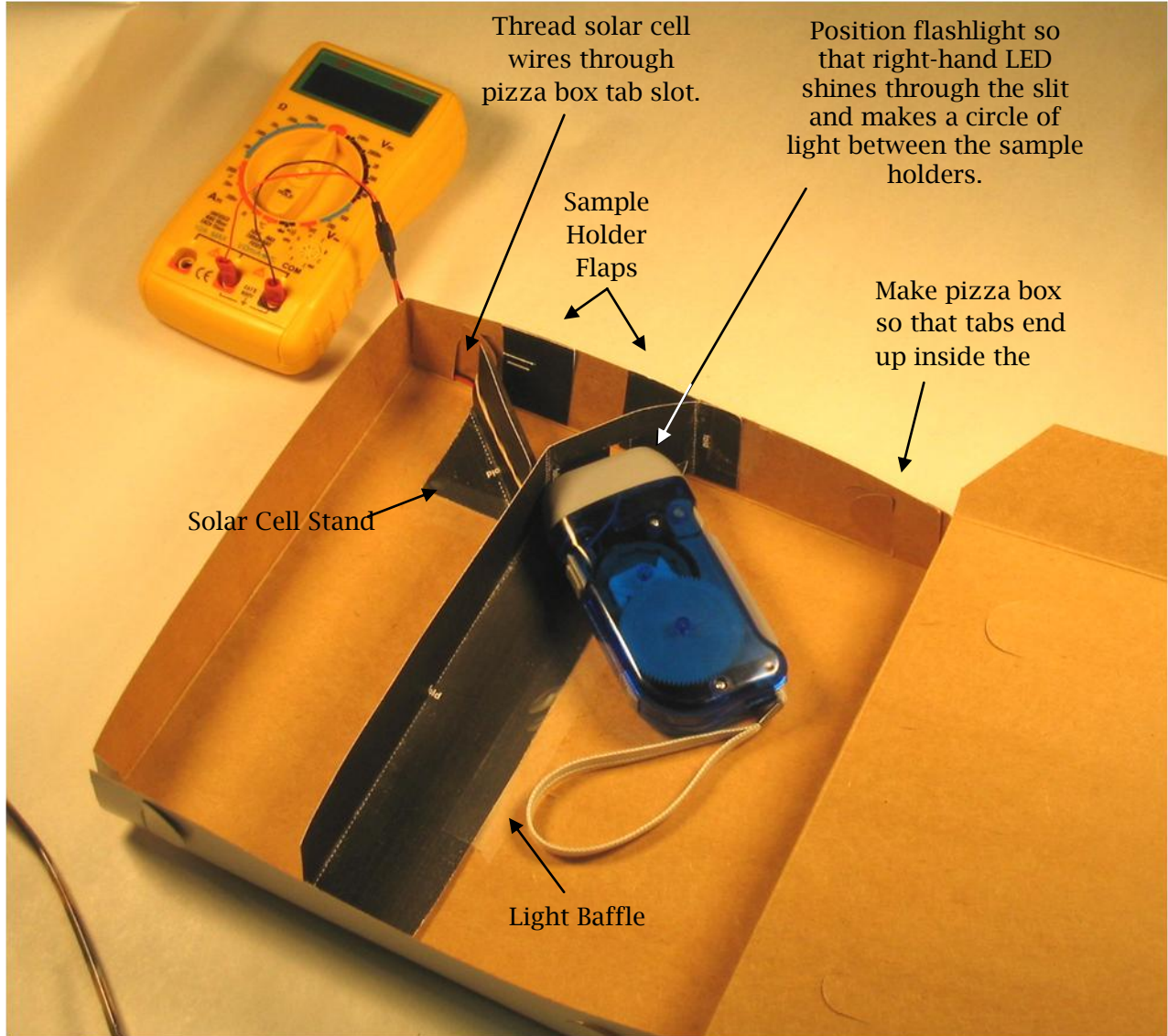
Sample Flaps



staple to wall of box about this far apart (1/4 inch)

SD 4

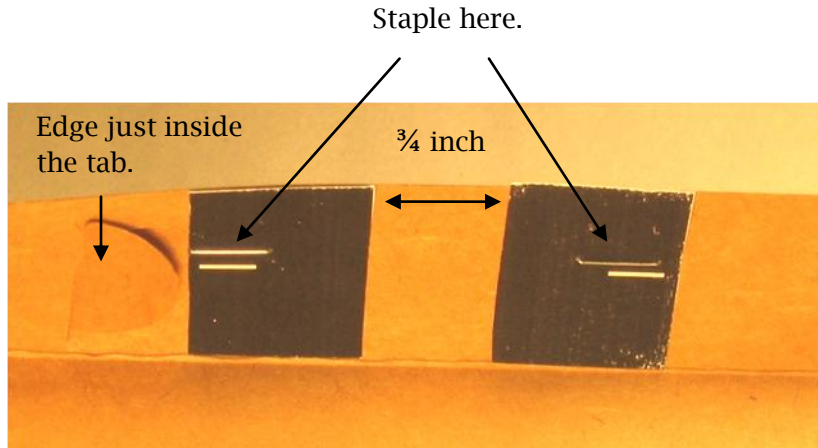
Reflectance Measuring Device



SD 5

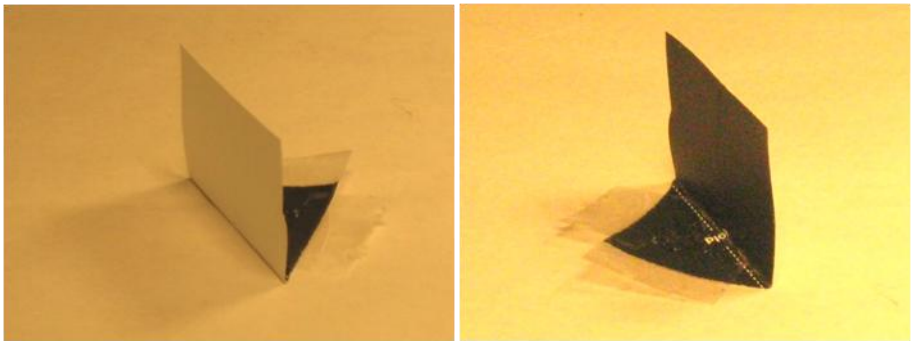
Step 1

Placing the sample holders



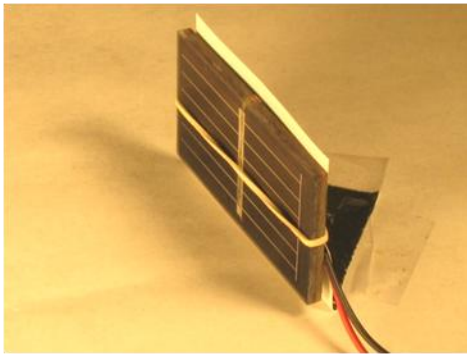
Step 2

Fold the solar cell stand at a right angle (2 views).



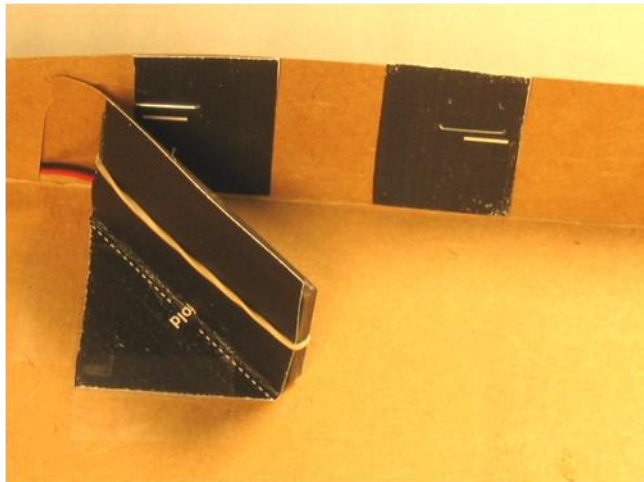
Step 3

Attach the solar cell to the white side of the stand with a rubber band.



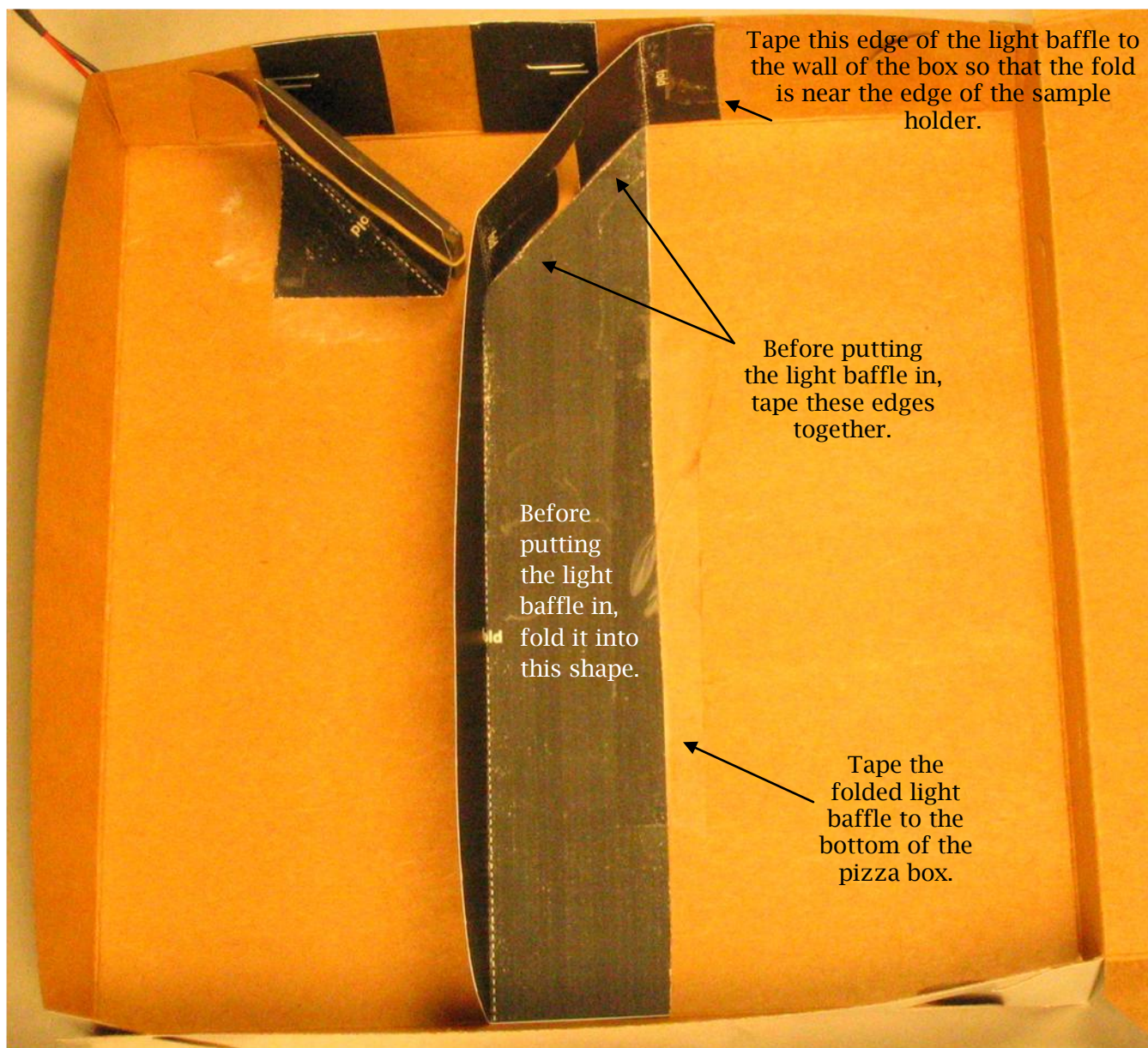
Step 4

Tape the triangular solar cell stand base to the floor of the pizza box so that the edges of the base are parallel to the walls of the box. The edge of the solar cell should be near the box tab, as shown.



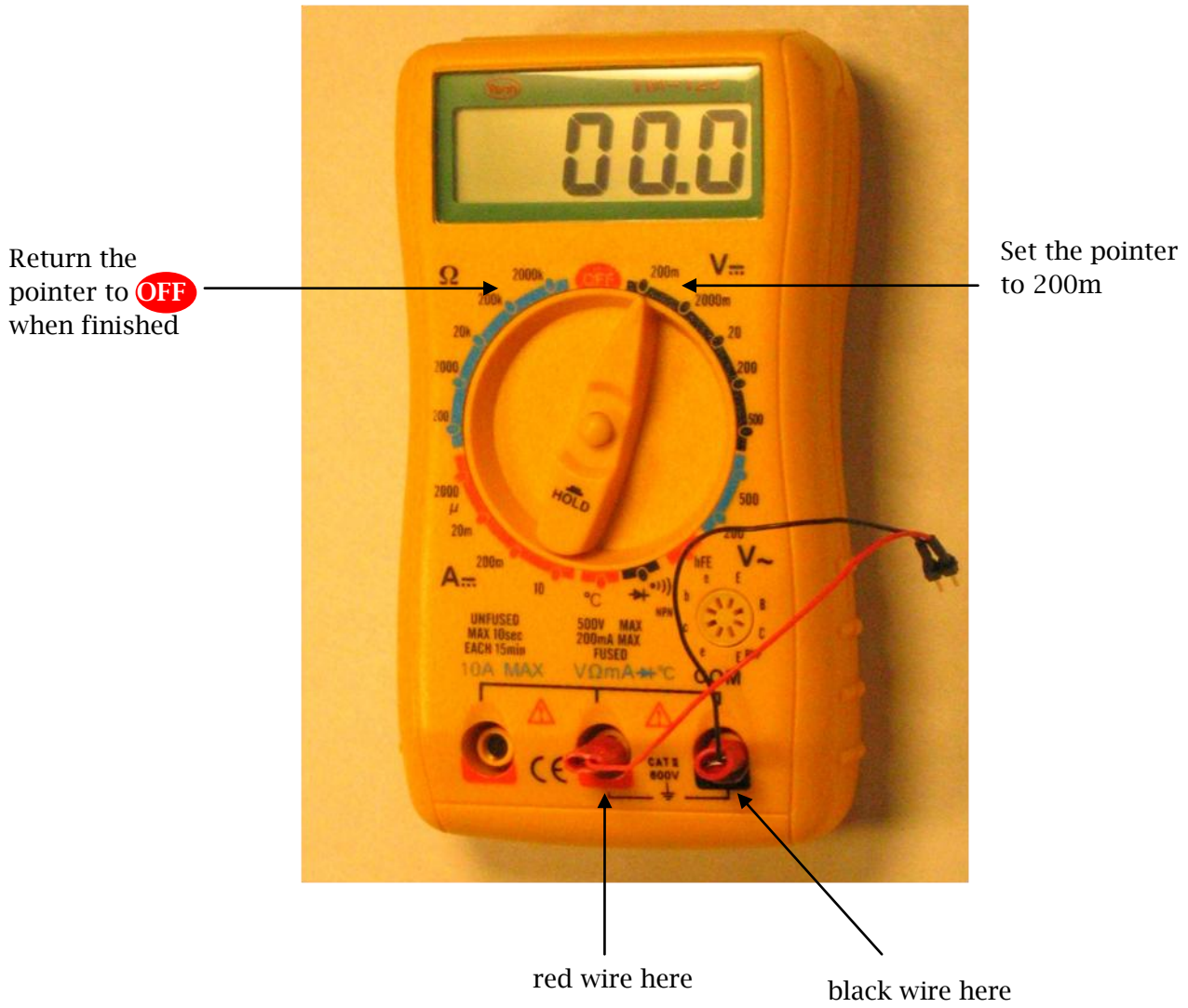
SD 6

Light Box Setup



The box should be able to close completely with the top flaps outside of the box. Closed “completely” means no light gets in.

SD 7



SD 8
pg. 1 of 2

Reflection Student Activity Sheet

Name:

1. Compare the multimeter reading of shining directly on the solar cell and shining it on the orange sample in the box with the lid closed.

Why do you think there are differences?

2. What does the meter measure?
3. Fill in the chart below with data from your meter and the box.

| Color | Light Measurement |
|--|--------------------------|
| Orange | |
| Color that got hotter than orange in sunlight | |
| Color that stayed cooler than orange in sunlight | |

4. What did you notice about the measurements you collected?

SD 8
pg. 2 of 2

Reflection Student Activity Sheet

5. Fill in the chart below with data from your meter and the box.

| | Color that you think will reflect most light | Light Measurement |
|----------------------------|---|--------------------------|
| 1 Reflects most | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 Reflects least | | |

6. Why do you think different colors have different measurements?

7. In these activities, what does the box measure? What does the thermometer measure?(Think in terms of light.)

8. When the light measurement was high in the box, what was the temperature reading of the color? What does this tell you about light?

SD 9

Secret Writing Example A



SD 10

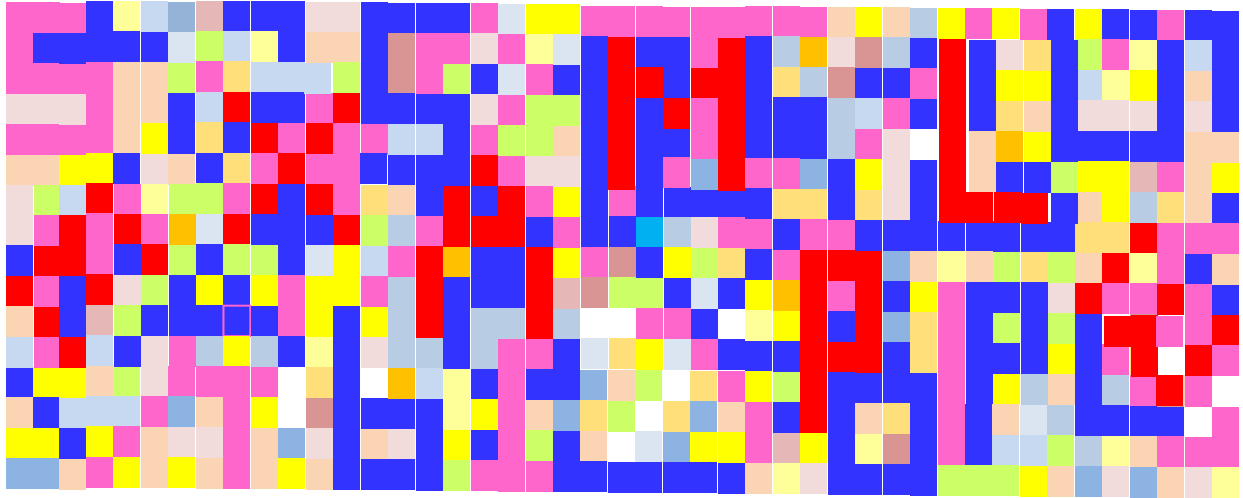
Secret Writing Example B



SEIQBCNROLEPZITMR

SD 11

Secret Writing Example C



SD 12

Students are looking at a red mark through a blue colored plastic filter. They all see the line as black. Each one has an explanation for why they see it that way. Explain why you agree or disagree with each of them .

White light has all colors and a red mark reflects everything but red. The blue filter takes out all of the blue light, making the mark look black.

It looks black because no light goes through the blue filter.

A colored marker reflects the color that we see and absorbs the rest. White light contains all of the colors. A color filter allows one color to pass through and absorbs all other colors.

White light is all colors. Only red light reflects off of the red marker, but a blue filter absorbs red light, so the mark looks black.

