



### Science Objectives

- Students will explore a simulation of white light falling on a plate attached to a thermometer. As students change the color of the plate, the simulation will record different temperatures as the light energy is transformed into thermal energy – based on the selected wavelength of light chosen.
- Students will observe the colors of light that are absorbed and reflected and connect these to the rate of the temperature increase of the plate.
- Students will vary the color of the plate and note differences in the rate of heating, while exploring the ranks of the colors from the fastest to the slowest heaters.
- Students will quantify the temperature increase over time for the primary and secondary colors as well as white, gray, and black.
- Students will determine how the secondary colors are formed from a combination of the primary colors.
- Students will rank the colors based on the collected data and connect to real world situations.

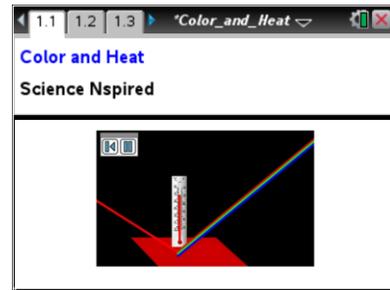
### Vocabulary

- |                          |                            |
|--------------------------|----------------------------|
| • temperature            | • color                    |
| • reflection             | • absorption               |
| • primary colors – RGB   | • color mixing             |
| • secondary colors – CYM | • electromagnetic spectrum |
| • light energy           | • thermal energy           |

### About the Lesson

This investigation involves a constant light source falling on a plate of varying color. The plate can be colored with the primary (red, green, blue) and the secondary (cyan, yellow, magenta) colors as well as black, gray, and white. As the plate heats, data will be collected in a spreadsheet and displayed on a graph for examination. The students will first explore the simulation and predict the rank of heating for the colors from their past experiences and intuition. They will then examine the data from the heating of the plate of different colors over time, and then rank them again using what they discovered. Students will also explore and verify the combinations of primary colors that form the secondary colors.

The students will explore the ways that different plate colors absorb and reflect energy over time.



### Tech Tips:

- This activity includes class captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at <http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials>

### Lesson Materials:

#### Student Activity

- Color\_and\_Heat\_Student.doc
- Color\_and\_Heat\_Student.pdf

#### TI-Nspire document

- Color\_and\_Heat.tns



As a result the students will:

- develop the relationship between color and thermal energy.
- connect the color of a plate and the colors from white light that are reflected.
- understand that the secondary colors are formed from combinations of the primary colors.
- apply their knowledge of the heating rates of different colors to real world applications.



#### TI-Nspire™ Navigator™

- Send out the *Color\_and\_Heat.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.
- Quick Poll the class for Formative Assessment.
- Add questions from the student document to the tns file and collect to the Portfolio.

#### Activity Materials

- Compatible TI Technologies:  TI-Nspire™ CX Handhelds,  TI-Nspire™ Apps for iPad®,  TI-Nspire™ Software

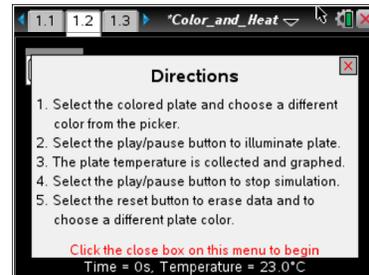


### Discussion Points and Possible Answers

Have students read the background information stated on their activity sheet.

#### Part 1: Exploring the System

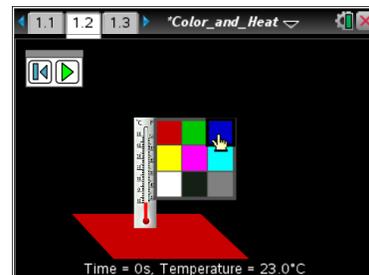
1. Students will read the directions explaining how to use the simulation. They can close the box by selecting  when you are finished.



 **Tech Tip:** Press `menu` if you need to view the directions again.

 **iPad Tip:** Select  **Tools > Directions** to view the directions again.

2. Students should select the color plate and choose a color to use. They can start the simulation by selecting the play button , and then observe the data displayed at the bottom of the page. Students should see that the colors being absorbed and reflected are represented with colored lines directed towards and away from the plate. To pause the simulation, select . To reset, select .



- Q1. For the color you selected, what do you happens in the simulation? Write a description and share this with a neighbor and the class as requested.

**Answer:** If students chose a color in the top two rows, the light will fall on the plate, but only some colors are reflected. If students chose white or gray, all colors are reflected. If students chose black, none of the colors are reflected. Students should observe the temperature increasing for all colors.



3. Have students test the simulation for all of the colors. They should note any patterns or relationships between the temperatures and the color of light that is absorbed and reflected.

Q2. Rank the colors from hottest to coolest based on what you saw in the simulation.

<u>Rank</u>	<u>Color</u>	<u>Reflected Colors</u>
1 <sup>st</sup> (Hottest)		
2 <sup>nd</sup>		
3 <sup>rd</sup>		
4 <sup>th</sup>		
5 <sup>th</sup>		
6 <sup>th</sup>		
7 <sup>th</sup>		
8 <sup>th</sup>		
9 <sup>th</sup> (Coolest)		

**Answers:** Most students will not get this correct yet.

<u>Rank</u>	<u>Color</u>	<u>Reflected Colors</u>
1 <sup>st</sup> Hottest	Black	none
2 <sup>nd</sup>	Red	red
3 <sup>rd</sup>	Yellow	red and green
4 <sup>th</sup>	Green	green
5 <sup>th</sup>	Gray	some of all
6 <sup>th</sup>	Magenta	red and blue
7 <sup>th</sup>	Cyan	blue and green
8 <sup>th</sup>	Blue	blue
9 <sup>th</sup> Coolest	White	all



### TI-Nspire Navigator Opportunities

Quick Poll the class for the hottest and coolest and compare two colors. (Which is hotter—green or yellow?)

4. Have the class compare their rankings.



Q3. Describe a situation in which you would pick a color based on what you have learned about how different colors absorb light and heat up. Include the color you would pick and why.

**Answer:** Answers will vary, but one answer might be that on a hot day I would choose to sit on a blue car rather than a yellow one since blue heats at a slower rate.

**Teacher Tip:** Share these scenarios with the class to help clarify the concepts as needed.

### Part 2: A Closer Look

Move to pages 1.3 – 1.4.

5. Now students need to quantify the way each color heats over time. Looking at the spreadsheet on page 1.3 and the graph on page 1.4, have them answer the following questions.

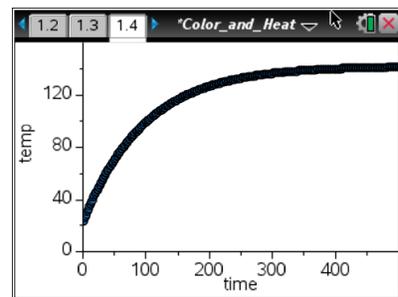
A	time	B	temp	C	D
1	0.		23.		
2	1.		24.2138		
3	2.		25.4152		
4	3.		26.6044		
5	4.		27.7814		

Q4. Which colors heat the fastest? Why?

**Answer:** Black and red. Reasons will vary, but some may cite the temperatures at certain times or speak to the energy levels of light from the Electromagnetic Spectrum.

Q5. Which colors heat the slowest? Why?

**Answer:** White and blue. Reasons will vary, but some may cite the temperatures at certain times or speak to the energy levels of light from the Electromagnetic Spectrum.



**Teacher Tip:** This might be a good time to discuss the E/M spectrum and the range of energies from low (red) to high (blue).

6. Now you will assign groups or individual students a time at which they will collect the temperature for each of the nine colored plates. Have them record their assigned time below.

My assigned time \_\_\_\_\_

**Teacher Tip:** Pick from 20 seconds up to 140 seconds by 20 second intervals (options shown on page 1.5 of .tns file), and make sure at least two students have the same assigned times. Note: The simulation may not stop precisely at the indicated time for students. The temperature data will vary slightly for students who have the same assigned time.



TI-Nspire Navigator Opportunities Note

You may set up a question from the spreadsheet to collect and aggregate data from the class.

Move to page 1.5.

Q6. Fill in the temperature readings for your assigned time in the data table below. Add this data to the spreadsheet on page 1.4 as well. Next, rank these colors with 1 being the hottest and 9 being the coolest.

	Red	Green	Blue	Yellow	Magenta	Cyan	White	Black	Gray
Temp									
Rank									

Answers:

	A times	B red	C green	D blue	E yellow	F magenta	G cyan	H white	I black	J gray
1	20	61.1125	56.1691	45.0616	58.8023	50.8414	48.3531	26.1363	73.8364	54.224
2	40	87.6968	80.5367	63.0331	84.4316	72.3808	68.4804	29.1165	104.162	77.5217
3	60	106.24	98.4383	77.6729	102.778	89.0448	84.459	31.9484	122.253	94.9051
4	80	119.174	111.59	89.5986	115.912	101.937	97.144	34.6393	133.044	107.876
5	100	128.196	121.251	99.3134	125.314	111.911	107.214	37.1962	139.482	117.554
6	120	134.489	128.349	107.227	132.044	119.627	115.209	39.6258	143.322	124.775
7	140	138.878	133.564	113.674	136.862	125.596	121.556	41.9344	145.613	130.163
8		0.7	0.6	0.4	0.65	0.5	0.45	0.1	1	0.57
9										

Q7. How well does this new ranking match with others in the class? Compare your data with at least one other student that had the same time as yours. Also, compare with others that had larger or smaller assigned times.

Answer: The same times would give all the same values. All students should have the same ranking.

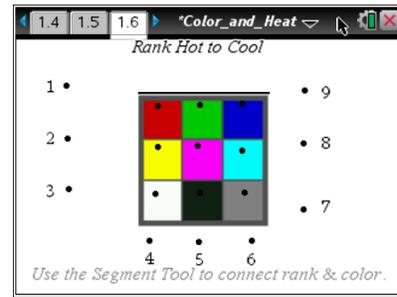
Q8. How well does this new ranking match with what you stated in question 2 from Part 1?

Answer: Answers will vary depending upon the how they ranked the colors in question 2 Part 1.

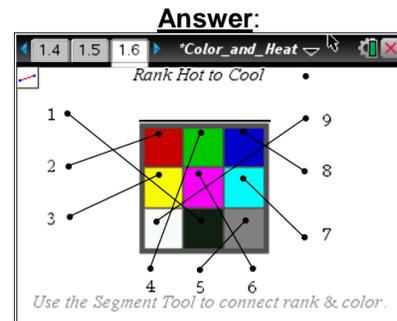


Move to page 1.5.

- 7. After students compare their ranking with other students, they can make any adjustments to the rankings as needed. They will now connect the dots to create a visual display of their rankings.



- Q9. Connect the rank with the color. To do this, use the Segment tool. Click on the point next to the rank and then draw the segment to the point in the center of the color.



**Tech Tip:** Select **Menu > Points & Lines > Segment.**

**iPad Tip:** Select **Tools > Points & Lines > Segment.**

**TI-Nspire Navigator Opportunities**

Use class capture to check students answers on this page or to help them use the Segment tool.

**Tech Tip:** Press **ctrl Z** to undo and press **ctrl Y** to redo.

**iPad Tip:** Use to undo and long tap to redo.

- Q10. Given what you have learned, assume that you are in the Arctic and you can bring two blankets. Which two colors would you select and why?

**Answer:** You want to get two colors that rank high for heating, so black and red would be best.

- Q11. Your aunt has invited you to spend the summer in the Sahara Desert with her. She said that she would buy two sand buggies to play with and wants to know what colors you want. Pick two and explain your rationale for choosing those colors.

**Answer:** You want the coolest temperatures so white and blue would be the best.



Q12. Given what you now know about the heating capacity of these colors, give a situation during which you would pick cyan over yellow. Explain your reasoning.

**Answer:** Answers will vary but students should explain a situation that makes sense based upon the fact that cyan is cooler than yellow.

### Part 3: Primary vs. Secondary Colors

8. Now students will explore the relationship between the primary and secondary colors.

Q13. Of the six given colors on page 1.2, list the primary colors.

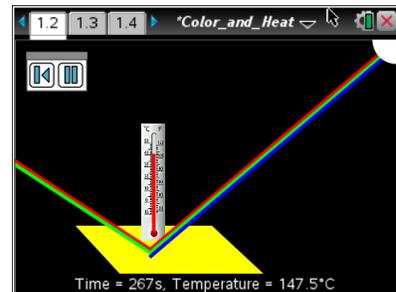
**Answer:** Red, green, and blue

Q14. Of the six given colors on page 1.2, list the secondary colors.

**Answer:** Cyan, magenta, and yellow

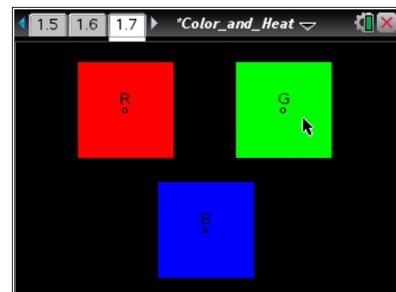
Q15. Return to page 1.2 and set the color to one of the secondary colors. What colors do you see being reflected? Repeat this for all three secondary colors.

**Answer:** Yellow reflects red and green.  
Magenta reflects red and blue.  
Cyan reflects blue and green.



### Move to page 1.7.

9. Now have students test what they have learned using the colors on page 1.7. They are to grab the open circle in the center of the square to select a color and move it over another.



Q16. What do you notice about the resulting color when you overlap two colors?

**Answer:** The resulting color is the same as the color that reflects the two colors overlapping each other. For example, overlapping red and green produces yellow and yellow reflects red and green.



#### TI-Nspire Navigator Opportunities

Use class capture to confirm the color mixing for all three combinations.

### Wrap Up

When students are finished with the activity, collect .tns files using TI-Nspire Navigator or Connect-to-Class. If you used Quick Poll or if you added Questions into the tns file you can save grades to the Portfolio. Discuss the students answers to questions using the Review and look at individual files as a class.

### Extensions

The Center for Communicating Science conducted the Flame Challenge and the winner's animation would be a nice "next step" in the study of light and heat.

<http://sciencefriday.com/video/06/08/2012/what-is-a-flame.html>

<http://flamechallenge.org/>