Absorption

Daily Required Materials

- Teacher/students' HP Stream & projector
- BasicBoard
- Student notebooks

Lesson 1 Starter Experiment	*Additional Materials*
• Follow directions to assemble a simple BasicBoard system that will investigate how light absorbed by different materials is converted into heat • Understand how Logo collects and displays measurements from the absorption system. • Describe any patterns you see in the initial data from the absorption system. • Describe how the different components of the absorption system work together.	• Wire as needed • 2 leashed temperature sensors • Black construction paper • White construction paper • Piece of foam • Tape • Lamp with a light bulb
Lesson 2 Models and Questions	***Additional Materials***
• Propose a model to explain how matter and energy flow at both macroscopic and microscopic levels within this absorption system. • Generate a testable scientific question that will refine, expand, confirm, or refute your current model of absorption.	• Worksheet: Models and Questions • Starter experiment
Lesson 3 Investigation Plan	***Additional Materials***
• Describe what evidence is needed to answer your scientific question. • Design an investigation and explain how this investigation will generate relevant patterns of evidence to answer the scientific question. • After peer review of the scientific question and the investigation plan, revise the plan to increase relevance to your question and to generate data that is more accurate and more precise.	• Worksheet: Investigation Plan • Starter experiment
Lesson 4 Evidence and Interpretation	***Additional Materials***
• Organize, represent, and analyze data from the investigation. • Assess whether or not the data collected is sufficient evidence to answer the scientific question. • Revise your absorption model and explain how this new model is a better fit for available evidence.	• Worksheet: Evidence and Interpretation • Starter experiment
Lesson 5 Presentation	***Additional Materials***
• Create an evidence based account of the investigation process and answer to the scientific question. The format is selected by the instructor and may be a laboratory report, presentation, poster, video, model, etc.	• Refer to daily required materials

Disciplinary Core Ideas	Lesson				
	1	2	3	4	5
PS3.A Definitions of Energy	✓	✓	✓	✓	
PS3.B Conservation of Energy and Energy Transfer	✓	✓	✓	✓	
PS4.A Wave Properties		✓	✓		
PS4.B Electromagnetic Radiation			✓	✓	
ETS1 Engineering Design	✓		✓	✓	✓
Science and Engineering Practices	**Lesson**				
	1	2	3	4	5
Asking questions and defining problems	✓	✓	✓	✓	
Developing and using models		✓	✓	✓	
Planning and carrying out investigations			✓	✓	
Analyzing and interpreting data	✓	✓	✓	✓	✓
Using mathematical and computational thinking		✓	✓	✓	
Constructing explanations and designing solutions	✓		✓	✓	
Engaging in argument from evidence		✓	✓	✓	✓
Obtaining, evaluating, and communicating information	✓	✓	✓	✓	✓
Crosscutting Concepts	**Lesson**				
	1	2	3	4	5
Patterns	✓	✓	✓	✓	
Cause and effect	✓	✓	✓	✓	
Scale, proportion, and quantity	✓	✓	✓	✓	
Systems and system models	✓	✓	✓	✓	
Energy and matter		✓	✓	✓	
Structure and function	✓	✓	✓	✓	
Stability and change		✓	✓	✓	

Absorption 1: Starter Experiment

Getting Started

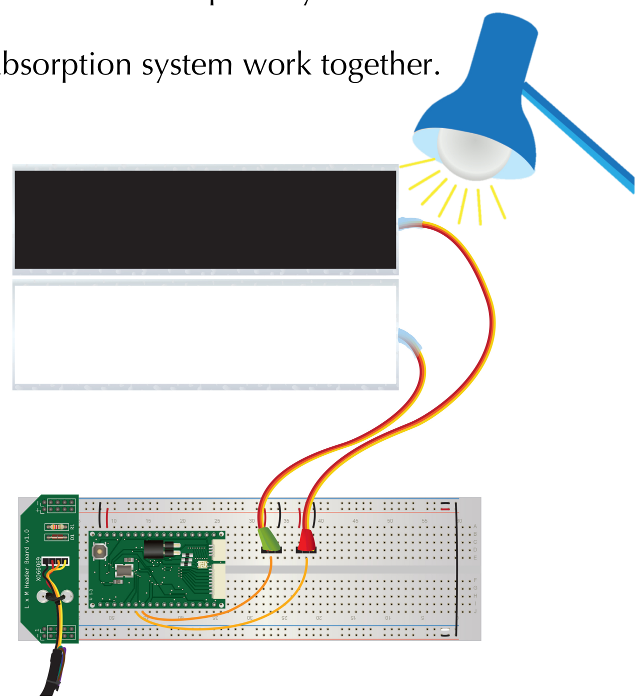
Why do you think people prefer to wear light-colored clothes in the summer?

In this experiment, we will investigate what happens when light shines on different colors of paper.

Learning Goals

- ✓ Follow directions to assemble a simple BasicBoard system that will investigate how light absorbed by different materials is converted into heat.
- ✓ Understand how Logo collects and displays measurements from the absorption system.
- ✓ Describe any patterns you see in the initial data from the absorption system.
- ✓ Describe how the different components of the absorption system work together.

Instructions



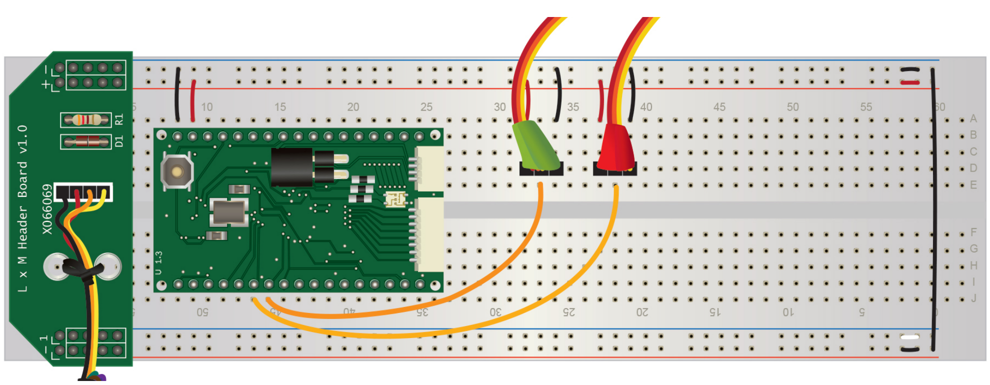
1. Gather the following materials:
   - ☐ BasicBoard and HP Stream
   - ☐ Wire as needed
   - ☐ 2 leashed temperature sensors

     (Calibration numbers must be known)
   - ☐ Black construction paper
   - ☐ White construction paper
   - ☐ Piece of foam
   - ☐ Colored tape
   - ☐ Lamp with a light bulb

2. Connect one leashed temperature sensor to ADC 4 and another to ADC 5 on the AppBoard.

3. Connect power and ground for the leashed temperature sensors.

   Note: if these are connected backwards, the sensor will overheat and fail.



Learning by Making

4. Use colored tape to mark the leashes for quick identification. Use **green** tape for the sensor on **ADC 5** and **red** tape for the sensor on **ADC 6**.

5. Each piece of foam should already have small cavities carved out. Insert the sensors into each cavity.

6. Cut pieces of black and white paper that are large enough to cover the sensors and foam.

7. Place the white sheet over the sensor attached to ADC 5 marked with green tape. Place the black sheet over the sensor attached to ADC 6 marked with red tape. Secure with tape around the edges.

8. Plug in the lamp and place it above both paper samples. Do not turn on the lamp.

9. Plug the FTDI cable into your HP Stream.

10. Create your own working copy of the experiment called **`Absorption`** by following these steps. If done correctly, a new black terminal window should pop up that says **`Welcome to Logo`**.
    - Answer **`y`** to create a new experiment
    - Select **`BasicBoard.tar`**
    - Give your experiment a descriptive name. **Record this name in your notebook.**
    - Select the version **`Absorption`**

11. Compile and download the code to the AppBoard with **`.compile`** and **`.download`**.

12. Run the program with **`.run-once`** and turn on the lamp.

13. Allow this experiment to run for at least 20 minutes while you complete the Starter Experiment challenges.

Challenges

	Credit	Task
1	◆	Draw a simple diagram of your experimental setup. Make sure to indicate the pin on the BasicBoard to which the sensors are attached. Label each component, interaction, and mechanism of this starter experiment.
2	◆	Identify the independent (manipulated) and dependent (respondent) variables in this experiment. What can be changed or controlled? What can be tested?
3	◆◆	Examine the `jLogo` and `uLogo` files for this experiment. Based on what you find in the code, explain what is being printed to the terminal window and what is being displayed on the graph.
4	◆◆	In your notebook, describe any patterns you see in the packets or the graph. How does temperature change over time? How does the rate of change in temperature vary over time?

Helpful Hints

If you need to start over, hold down the **`ctrl`** key and **`c`** at the same time. Next, type the command **`start`** and hit the **`enter`** key.
If you already created the absorption experiment, answer **`y`** for **`Would you like to load an existing experiment?`**
If you see **`chip not found`**, call the teacher over.
If you see _____ **`undefined`**, you are trying to run a uLogo word on the AppBoard that it doesn't understand.
If you see **`I don't know how to`** _______, you are trying to run a jLogo word on the HP Stream that it doesn't understand.
If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.
Watch the FTDI cable <u>during</u> download. If it blinks fast, the AppBoard is working.
Watch the FTDI cable <u>after</u> download. If it slowly blinks red and green, the AppBoard is working.

Going Further

Extra Credit	Task
◆	Recalibrate your temperature sensors. This may increase the accuracy of absorption experiment measurements.
◆◆	Adjust the height of the lamp and rerun the experiment. Repeat at least 4 times for different heights. Create a graph that displays temperature change as a function of lamp height.

Absorption

Absorption 2: Models and Questions

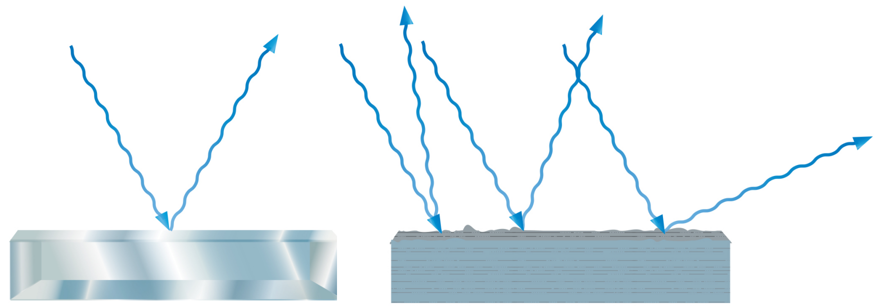
Getting Started

There are several ways to illustrate the way light interacts with objects. One useful model is that of a **wave** traveling through space. When light waves hit **matter**, several things can happen.

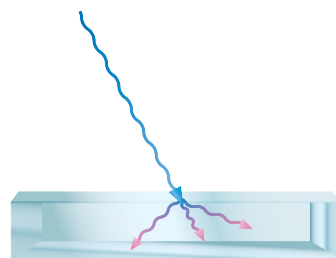
- Light can bounce right off
- Light can penetrate and absorb
- Light can pass right through

or any combination of these three!

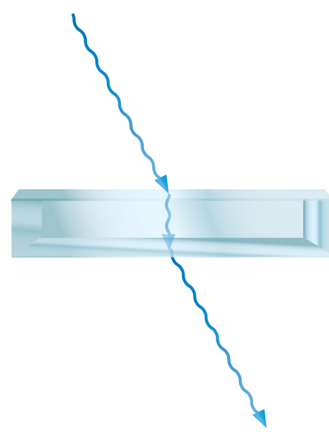
<u>*Reflection*</u>
Light bounces back after it hits the surface of a material. Reflections can be *specular*; crisp and clear. Reflections can be *diffuse*; scattered and blurry.



<u>*Absorption*</u>
Light penetrates the surface of the material and transfers energy to the atoms and molecules within. This transfer is often in the form of light energy to thermal energy.



<u>*Transmission*</u>
Light passes right through the material with little or no interaction with the atoms and molecules making up the material.



What are examples of specular and diffuse reflective materials?
What things get hot when left out in the Sun?
What are examples of materials that allow light to pass through?

Learning Goals

- ✓ Propose a model to explain how matter and energy flow at both macroscopic and microscopic levels within this absorption system.
- ✓ Generate a testable scientific question that will refine, expand, confirm, or refute your current model of absorption.

Instructions

1. Gather the following materials:
   - ☐ Worksheet: Experiment Plan - Models and Questions
   - ☐ Assembled evaporation experiment
   - ☐ *Optional* additional paper, whiteboard space, or poster paper

2. In the **Experiment Description** box of your Experiment Plan worksheet, write 1-2 sentences to describe the absorption experiment. What process does it explore?

3. In the **My Model** box, draw a model of your current understanding about the process of light interacting with atoms in matter during the process of absorption. Draw what you might see if you had microscopic eyes. *You may use an additional piece of paper, whiteboard, or poster paper.*

   Your model must depict the following:
   - Experiment components (paper, sensor, light, etc.)
   - How energy flows within the system

4. In your notebook, write 3-5 sentences to describe your model.

5. Complete the Models and Questions Challenges.

Challenges

	Credit	Task
1	◆◆	• Swap your Experiment Plan worksheet with that of another group. If you drew your model on something else, attach this worksheet to your model. • Without talking to the other group, fill out the **Peer Feedback** box on their worksheet. Write at least <u>two</u> statements for each prompt. • Once you are finished, return the worksheet and model to the other group.
2	◆◆	As a group, reflect on the feedback that you received. What questions do you still have about the process of light interacting with matter? What was unclear in your model? • In the **Scientific Question** box, write a 2-3 sentence reflection.
3	◆◆◆	The best scientific questions are driven by curiosity and the desire to know more. All scientific questions must include certain characteristics. Scientific questions are: ✓ **Answerable**. There is a real answer, often yes or no. ✓ **Testable**. You can design an experiment to find the answer. ✓ **Specific**. The question is focused and unambiguous. The question is not too broad. • As a group, generate a scientific question that will refine, expand, confirm, or refute your current model of light absorption. Write this question in the **Scientific Question** box on your worksheet. • In your notebook, write 2-5 sentences to explain how your question is answerable, testable, and specific.

Helpful Hints

Drawing a model may take many iterations. Use an erasable surface to sketch out your ideas.
Show time passing in models by using three panels: before, during, and after.
Use symbols to represent objects that are either too complicated to draw (like a circuit board) or don't have a known form (like an unknown microbe). Label or explain any symbols in your drawings. As a class, you may decide on standard symbols for certain objects.

Going Further

Extra Credit	Task
◆	Consider the following list of questions. Which of these qualify as good scientific questions? Which of these are scientific questions, but need improvement? Which of these are not scientific questions? ▪ Rank these questions from best to worst. Write 2-5 sentences explaining your ranking.
◆◆	Consider the following list of questions. Some are examples of scientific questions and some are examples of non-scientific questions. ▪ Improve the quality of two scientific questions in this list. ▪ Rewrite two non-scientific questions in this list to make them scientific.
◆◆	The words ***who***, ***what***, ***where***, ***when***, **why**, and ***how*** are the 6 most common ways to start a question. ▪ For each of these words, write two scientific questions. ▪ Which of these 6 words was the easiest to use in a scientific question? Which of these 6 words was the hardest to use? Write 2-5 sentences explaining your reasoning.

Example Questions

A. What is the relationship between temperature and altitude in the atmosphere?
B. Why do people get colds?
C. Who decided to remove Pluto as a planet?
D. What is the best way to cook an egg?
E. How long can people live?
F. Do people with green eyes have better vision than people with brown eyes?
G. Who is your favorite singer?
H. How long does it take to heat a liter of water from room temperature to boiling in a microwave?
I. Where is the bathroom?
J. When should you plant peppers?

Models and Questions

Experiment Description

Briefly describe this starter experiment.

My Model

Propose a model to describe what happened.

Peer Feedback

Reviewed by:

This model shows:

I do not understand or/and have questions about:

Scientific Question

What questions do you still have about the process that you modeled?
Generate a testable scientific question.

Name:

Experiment:

Models and Questions

Experiment Description

Briefly describe this starter experiment.

My Model

Propose a model to describe what happened.

Peer Feedback

Reviewed by:

This model shows:

I do not understand or/and have questions about:

Scientific Question

What questions do you still have about the process that you modeled?
Generate a testable scientific question.

Name:

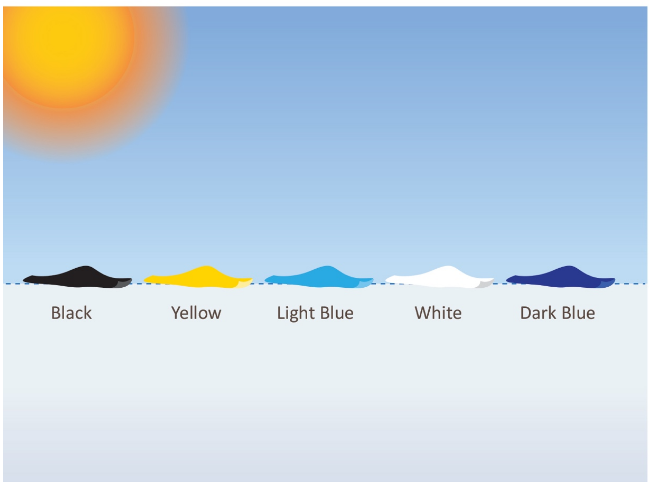
Experiment:

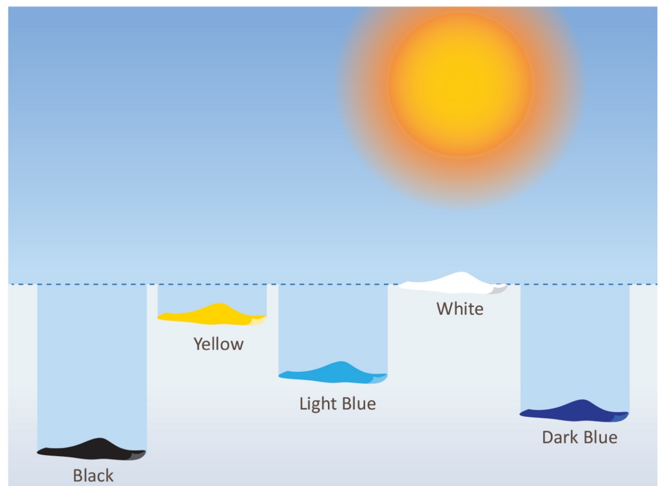
Absorption 3: Investigation Plan

Getting Started

In 1761, Benjamin Franklin wrote a letter to a friend, Miss Mary Stevenson. In this letter, he recalls an experiment of his from several decades prior – the winter of 1729.

> I took a number of little square Pieces of Broad Cloth from a Taylor's Pattern-Card, of various Colours. [...] I laid them all out upon the Snow in a bright Sunshiny Morning. In a few Hours (I cannot now be exact as to the Time), the Black, being warm'd most by the Sun, was sunk so low as to be below the Stroke of the Sun's Rays.





Examine the relationship between snow melt and cloth color. **How much snow would melt under a red piece of cloth?**

Learning Goals

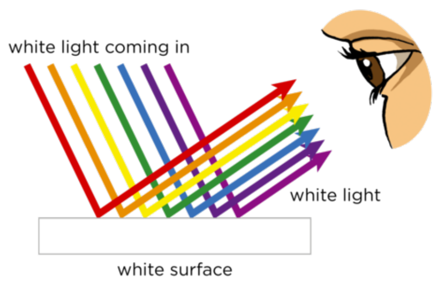
- ✓ Describe what evidence is needed to answer your scientific question.
- ✓ Design an investigation and explain how this investigation will generate relevant patterns of evidence to answer the scientific question.
- ✓ After peer review of the scientific question and the investigation plan, revise the plan to increase relevance to your question and to generate data that is more accurate and more precise.

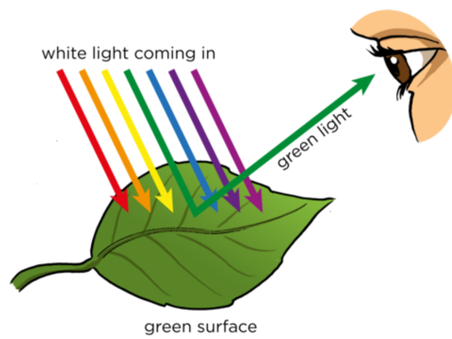
Instructions

1. Gather the following materials:
   - ☐ Worksheet: Experiment Plan – Investigation Plan
   - ☐ Assembled absorption experiment
   - ☐ *Optional* additional paper, whiteboard space, or poster paper

Absorption

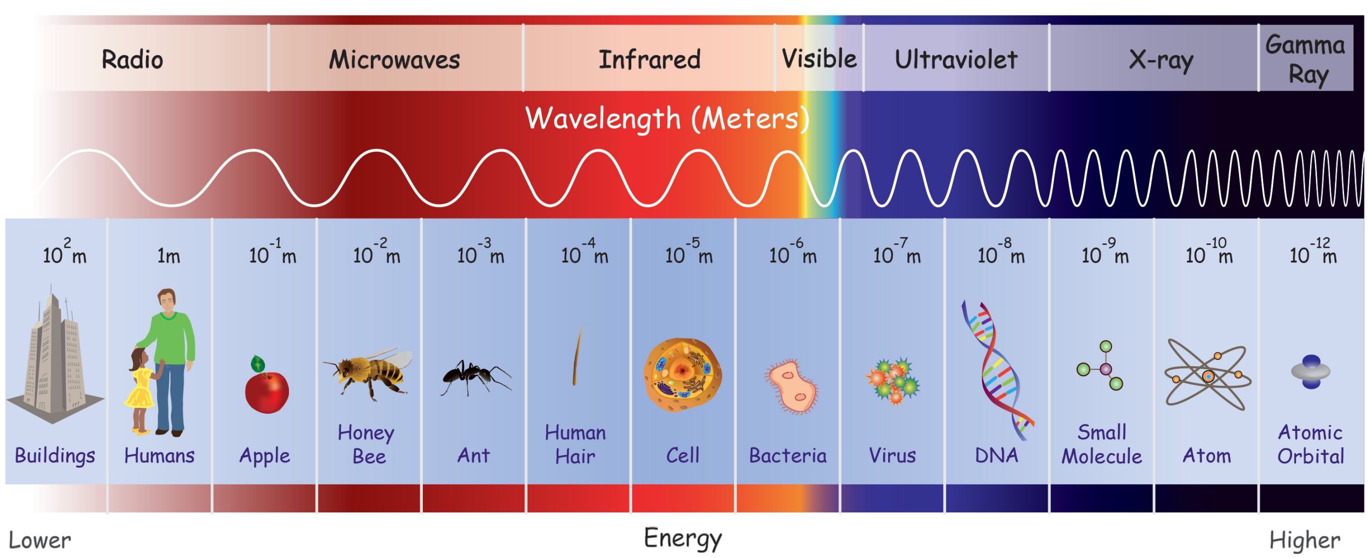
2. The Sun emits what is called **white light**. White light includes all colors of the rainbow. When white light shines on a green leaf, only green light is **reflected**. All other colors are **absorbed**. What colors are absorbed and reflected by each of the cloth pieces in Franklin's experiment?





	Absorbed Light	Reflected Light
Black		
Yellow		
Light Blue		
White		
Dark Blue		

3. **Color** corresponds to specific **wavelengths** of light. The human eye can only perceive a small range of these wavelengths – **visible light**. In your notebook, rank the color Benjamin Franklin's cloth pieces from longest wavelength to shortest wavelength.



4. Light waves carry different amounts of **energy** depending on their color. Radio waves carry the least energy. Gamma rays carry the most energy. In your notebook, answer the following question.

   Imagine two materials. The first material absorbs microwaves, reflects infrared light and transmits all other light. The second material absorbs ultraviolet light, reflects red visible light, and transmits all other light. Which material would feel hotter after 10 minutes? Explain your reasoning.

5. In your notebook, write down an investigation plan.
   - Describe which variable(s) you plan to change and which variable(s) you plan to measure.
   - Decide on necessary modifications to the startup experiment. Assemble a materials list.
   - Decide on measurement and data collection methods. Does this require software changes? Does this require hardware changes?
   - Identify sources of uncertainty. How will you quantify this uncertainty?
   - Explain how you will process and analyze data.

6. Use the Experiment Plan worksheet to organize the details of your initial plan.
   - In the **Variables** box, list the variables you plan to change (independent or manipulated variables) and list the variables you plan to measure (dependent or responding variables).
   - In the **Materials** box, list all materials you will need.
   - In the **Predicted Result** box, provide an example of the evidence you expect to collect.

7. Perform a test run of your experiment. Record your observations and data in the **Initial Evidence** box.

8. Complete the Investigation Plan Challenges.

Challenges

	Credit	Task
1	◆◆	Present your experimental design and initial test data to the class. For each groups' experiment, provide feedback on the following questions: • Is the evidence gathered relevant to the question posed? • Is the evidence gathered sufficient to address the question posed? • Is the evidence gathered reliable? • Are there any gaps or weaknesses in the experimental design?
2	◆◆◆	Refine your investigation plan based on peer feedback. In the **Final Investigation Plan** box, describe your revised procedure. • Explain how your plan will improve relevance to your scientific question. • Explain how your plan will improve the reliability of your data collection. Use additional paper as needed.

Helpful Hints

If you already created the absorption experiment, answer **`y`** for **`Would you like to load an existing experiment?`**
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Going Further

Extra Credit	Task
◆	It is important to track how energy flows into, out of, and within a system during an investigation. Explain why it is important to keep track of energy when studying a system, using an example from your investigation.

Investigation Plan

Your New Scientific Question

Variables

Manipulated:

Responding:

Materials

Predicted Result

Initial Evidence

Perform a test run of your investigation. Record your observations and data.

Peer Feedback

Reviewed by:

Final Investigation Plan

Revise your initial plan in your notebook. Then, explain below how your plan will improve relevance to your scientific question. Explain how your plan will improve the reliability of your data collection.

Teacher Approval:

Name:

Experiment:

Experiment Plan

Investigation Plan

Your New Scientific Question

Variables

Manipulated:

Responding:

Materials

Predicted Result

Initial Evidence

Perform a test run of your investigation. Record your observations and data.

Peer Feedback

Reviewed by:

Final Investigation Plan

Revise your initial plan in your notebook. Then, explain below how your plan will improve relevance to your scientific question. Explain how your plan will improve the reliability of your data collection.

Teacher Approval:

Name:

Experiment:

Absorption 4: Evidence and Interpretation

Getting Started

A group of three students just ran the starter experiment and are trying to figure out what their new investigation should be.

Student A: The black paper got way *hotter* than the white paper. Maybe the color of something sets how hot it can get. Would all black things reach the same temperature?

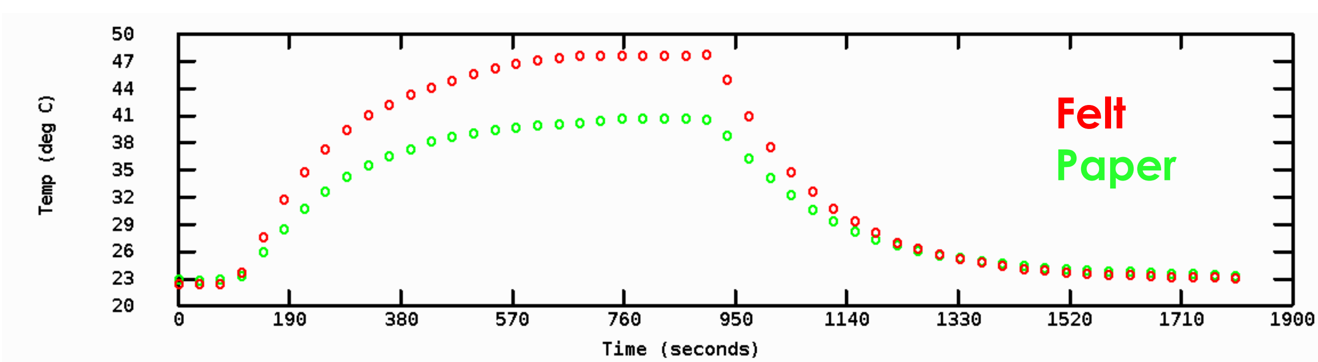
Student B: I'm not sure. The black paper also heated up *faster* than the white paper. Maybe we didn't wait long enough for the white paper to catch up.

Student C: Maybe the color has nothing to do with it. My fleece blanket keeps me warmer than a sheet. Let's use two different black objects – black paper and black felt.

This group came up with a list of *Scientific Questions*:

- If you shine light on different colored paper, will they all reach the same temperature if given enough time?
- Do black objects always warm up faster than white objects when absorbing light?
- Will black objects always reach the same temperature when put under a lamp?

They selected one of these questions and ran the experiment. Here are the results:



Which question did they select? Are these data enough to answer their question? What should be their next analysis step? <u>What would you do?</u>

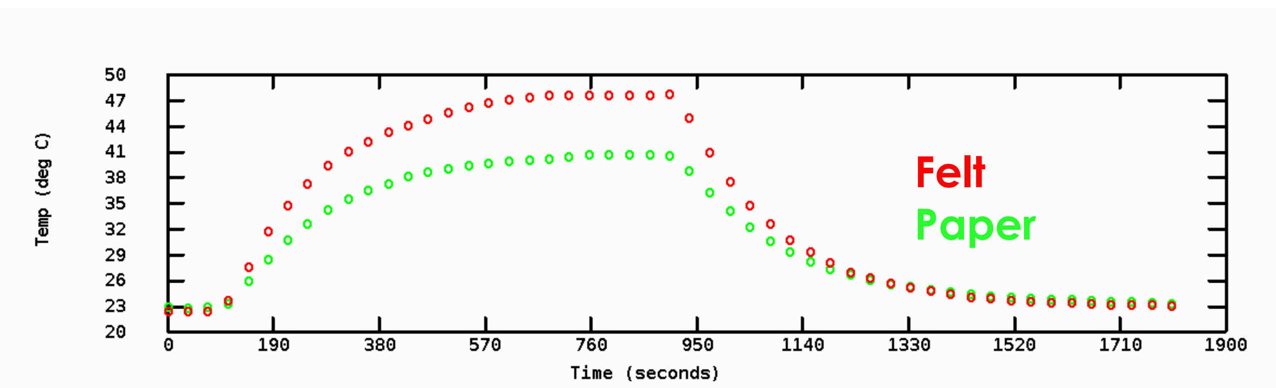
Learning Goals

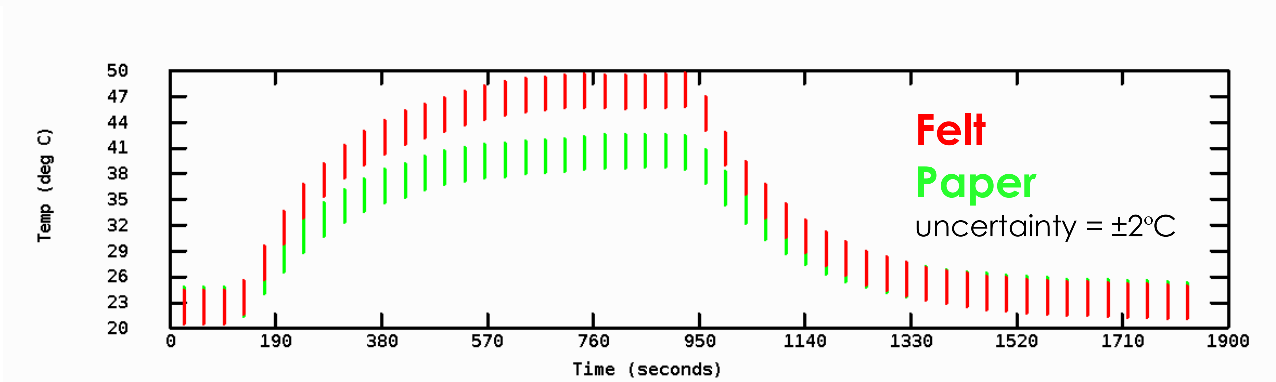
- ✓ Organize, represent, and analyze data from the investigation.
- ✓ Assess whether or not the data collected is sufficient evidence to answer the scientific question.
- ✓ Revise your light absorption model and explain how this new model is a better fit for available evidence.

Instructions

1. Gather the following materials:
   - ☐ Worksheet: Experiment Plan – Evidence and Interpretation
   - ☐ Assembled absorption experiment
   - ☐ *Optional* additional paper, whiteboard space, or poster paper

2. Your temperature sensors can be off by ± 2 degrees Celsius for any single measurement. Examine each of these graphs. They both show the same experiment, but one of the graphs includes error bars of ± 2 degrees Celsius.





Use these graphs to fill out a data table like this in your notebook:

	Peak Temperature	Time to reach Peak Temperature
Black Paper	__________°C ± __________°C	__________s ± __________s
Black Felt	__________°C ± __________°C	__________s ± __________s

3. In your notebook, explain how you used each graph to determine the results and error estimates in your table.

4. If you have not already done so, carry out your final investigation plan.

5. If you ran your experiment during the previous class period, you can reload your data using the `jLogo` **playback** feature.

- ☐ Compile and download your code to the AppBoard
- ☐ Enter **`.run-playback`** in the terminal window instead of entering `.run-once`.

This will load all of your previously gathered data and redisplay all of your graphs.

6. Organize experimental data using tables and/or graphs. Describe any patterns or relationships that you can infer from these data.

7. You can add **error bars** to any graph by adding a line in your `jLogo` plotting code. Here is a sample snippet of code from within a plotting word. The number tell `jLogo` how far to draw the error bar above and below the data point.

```
     xdata "|Time (sec)| :time-list
     ydata "|Temperature (deg_C)| :temp1-list
     points
     errorbars 2
     display-plot tile 1 2 1 1
end
```

8. Use the `jLogo` words **`x-data`**, **`y-data`**, **`analyze`**, **`quick-plot`**, and **`display-quick`** to create new graphs. Refer to Lesson 3.7 for a reminder on the function of these words.

9. Identify features of the dataset that should be analyzed in order to answer your scientific question. Use statistical analysis to identify and quantify sources of error or uncertainty.

10. Complete the Evidence and Interpretation Challenges.

Challenges

	Credit	Task
1	◆	Data **tables** provide an organized way of viewing information. **Graphs** are visual representations of information from a data table. Organize data from your experiment into tables or graphs. Gather evidence by describing patterns and relationships between variables. • Fill out the **Data** box of the Experiment Plan worksheet. Include a table, graph, or written summary of your results. Recall, graphs must include the following features: ☐ A descriptive title ☐ x-axis label with units ☐ y-axis label with unites ☐ Numbered Axes ☐ Data
2	◆◆	Draw conclusions based on your gathered evidence. Is this the only way to interpret the results of your analysis? How do you know that your interpretation is appropriate? How confident are you that your group's claim is valid? • Answer your scientific question using the three parts within the **Interpretation** box. • In your notebook, write a 2-5 sentence reflection on the questions listed above
3	◆◆◆	On a piece of paper, whiteboard, or poster, draw a revised model about the process of light absorption. Your model must depict the following: • Experiment components (lamp, sensors, paper, etc.) • How light interacts with matter within the system • How energy flows within the system In the **Revised Model** box, briefly sketch your new model and explain why this model is a better fit for the evidence that you gathered.

Helpful Hints

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Going Further

Extra Credit	Task
◆	Scientists often have to define the boundaries of physical systems and use them to create models to test ideas. Explain why defining systems and models is important in science, using an example from your investigation.
◆◆	Do you agree with the following statements? Write a 1-2 paragraph reflection. "In science, there is no difference between data and evidence." "Observations are facts. Inferences are just guesses."

Evidence and Interpretation

Data

Organize, represent and analyze data from investigations in your notebook.
Then, describe below sources of error or uncertainty.

Interpretation

Claim	Evidence	Justification
Answer your scientific question	Provide evidence to support your claim	Explain why your evidence is relevant and important

Revised Model

Revise your initial model based on these investigation results.

Name:

Experiment:

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Absorption 5: Presentation

Getting Started

Your absorption experiment results have many practical implications outside of the classroom.

How could you apply your discoveries to help builders design energy efficient homes?
How could you apply this knowledge to help a family choose a tent for a winter camping trip?
How could engineers use light absorption to generate electricity?
What colors should an outdoor architect use for her new playground?

What impact will your absorption experiment have on the world?

Learning Goals

- ✓ Create an evidence-based account of the investigation process and the answer to the scientific question.

Instructions

1. Create a group presentation for your experiment. As you write your presentation, remember to do the following:
    - State the explanation you are trying to support.
    - Include genuine evidence (data + analysis + interpretation).
    - Explain why the evidence is important and relevant.
    - Organize your argument in a way that enhances readability.
    - Use a broad range of words including vocabulary that you have learned.
    - Use proper grammar, punctuation, and spelling.

2. Complete the Presentation Challenge.

Challenge

	Credit	Task
1	◆	Present your Absorption Experiment to the class. • Connect your HP Stream to the projector and demonstrate your final investigation to the class using the `jLogo` playback feature. • Share your presentation with the class. • Answer questions from the class about your project.

Helpful Hints

If you need to start over, hold down the **`ctrl`** key and **`c`** at the same time. Next, type the command **`start`** and hit the **`enter`** key.
Make sure your HP Stream is set to mirror your screen to the projector.
If you see **`I don't know how to ______`**, you are trying to run a jLogo word on the HP Stream that it doesn't understand.
If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.

Going Further

Extra Credit	Task
◆	Science is an ongoing process. What new questions should be investigated to build on your research? What future data should be collected to answer your questions?
◆◆	Communicating scientific results to peers is a valuable part of doing science. Scientists share results with the media, publish scientific papers, give presentations, and attend conferences. Locate a recent example of any of these items on the topic of evaporation. Write a 1-2 page summary and reflection.