

Module 1: Shadows

5th Grade

About the Instructions:

This document is intended for use by classroom teachers, SciTrek leads, and SciTrek volunteers. The document has been composed with input from teachers, leads, volunteers, and SciTrek staff to provide suggestions for future teachers/leads/volunteers. The instructions are not intended to be used as a direct script, but were written to provide teachers/leads/volunteers with a guideline to present the information that has worked in the past. Teachers/leads/volunteers should feel free to deviate from the instructions to help students reach the learning objectives of the module. Places in which you can be creative and mold the program to meet your individual teaching style, or to meet the needs of students in the class are: during class discussions, managing the groups/class, generating alternative examples, and asking students leading questions. However, while running the module make sure to cover all the material each day within the scheduled 60 minutes. In addition, no changes should be made to the academic language surrounding conclusions or the conclusion activity.

Activity Schedule:

There are no scheduling restrictions for this module.

Day 1: Technique/Observations/Variables (60 minutes)

Day 2: Question/Materials Page/Experimental Set-Up/Procedure (60 minutes)

Day 3: Results Table/Experiment/Graph/Conclusion Activity (60 minutes)

Day 4: Conclusion Activity/Conclusion/Question/Materials Page/Experimental Set-Up/Procedure (60 minutes)

Day 5: Results Table/Experiment/Graph/Conclusion (60 minutes)

Day 6: Conclusion/Poster Making (60 minutes)

Day 7: Poster Presentations (60 minutes)

Day 8: Conclusion Assessment/Tie to Standards (60 minutes)

*This schedule assumes the teacher has given the conclusion assessment before SciTrek comes on Day 1 of the module.

The exact module dates and times are posted on the SciTrek website (scitrek.chem.ucsb.edu/elementary) under the school/teacher. The times on the website include transportation time to and from the outside of Chem 1204. Thirty minutes are allotted for transportation before and after the module. Therefore, if a module was running from 10:00-11:00, then the module times on the website would be from 9:30-11:30.

Student Groups:

For the initial observation (Day 1), students work in three groups of approximately ten students each. After Day 1, the groups of approximately ten students are further subdivided into three subgroups, approximately four students each, for the rest of the module. One volunteer is assigned to help each group (which is made up of three subgroups). We find groups/subgroups work best when they are mixed levels and mixed language abilities.

NGSS Performance Expectation Addressed:

5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Learning Objectives:

1. Students will know shadow sizes are affected by the size of an object (height, width, and length) as well as the location of the light source (light distance, light height, and light angle).
2. Students will be able to determine the relative shadow size of two objects when there is one difference in either the object size, placement, or the location of the light source.
3. Students will know a conclusion is a claim supported by data.
4. Students will be able to classify a statement as claim, data, or opinion.
5. Students will be able to identify appropriate claims and data for a given data set.
6. Students will know they must only have one changing variable in order to draw a conclusion.
7. Students, in small groups, will be able to select a question and make experiment decision that allows them to answer their question and present their findings to the class.
8. Students will be able to list at least two ways they behaved like scientists.

Classroom Teacher Responsibilities:

In order for SciTrek to be sustainable, the program needs to work with teachers on developing their abilities to run student-centered, inquiry-based science lessons on their own in their classrooms. As teachers take over the role of SciTrek lead, SciTrek will expand to additional classrooms. Even when teachers lead the modules in their own classrooms, SciTrek will continue to provide volunteers, and all of the materials needed to run the module. Below is a sample timeline for teachers to take over the role as the SciTrek lead.

*Groups are made up of approximately ten students and are subdivided into three subgroups (approximately four students each) after Day 1 of the module.

1. Year 1
 - a. Classroom teacher leads a group (Role: Group Lead; this is referred to as a volunteer in these instructions)
2. Year 2
 - a. Classroom teacher co-leads the modules with a SciTrek staff member (Role: Co-Lead)
 - i. Classroom teacher will be responsible for leading entire class discussions (Ex: conclusion activity).
 - ii. Classroom teacher will be responsible for time management.
 - iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups who are struggling.
 - iv. Classroom teacher will be responsible for all above activities. The SciTrek co-lead will only step in for emergencies.
 - v. The SciTrek co-lead will run the tie to standards activity.
3. Year 3 and beyond
 - a. Classroom teacher leads the modules (Role: Lead)
 - i. Classroom teacher will be responsible for leading entire class discussions (Ex: conclusion activity).
 - ii. Classroom teacher will be responsible for time management.
 - iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups who are struggling.
 - iv. For year 3 a SciTrek staff member will co-lead the tie to standards activity with the classroom teacher, for subsequent years they will run the tie to standards independently.

SciTrek staff is counting on teacher involvement. Teachers should notify the SciTrek staff if they will not be present on any day(s) of the module. Additional steps can be taken to become a SciTrek lead faster than the proposed schedule above. Contact scitrekelementary@chem.ucsb.edu to learn more.

In addition, teachers are required to come to UCSB for the module orientation, approximately one week prior to the start of the module. Contact scitrekelementary@chem.ucsb.edu for exact times and dates, or see our website at scitrek.chem.ucsb.edu/elementary under your class's module times. At the orientation, teachers will go over module content, learn their responsibilities during the module, and meet the volunteers who will be helping in their classroom. If you are not able to come to the orientation at UCSB, you must complete an online orientation. Failure to complete an orientation for the module will result in loss of priority registration for the following year.

Prior to the Module (at least 1 week):

1. Come to the SciTrek module orientation at UCSB.

Notes for Teachers During the Module:

Note: We **highly recommend** you give the initial conclusion assessment prior to **Day 1** of the module.

If possible, have a document camera available to the SciTrek lead every day of the module. If you do not have a document camera, please tell a SciTrek staff member at orientation.

Day 1:

Have three floor spaces available for students to perform the initial observation. Each group will need a 2 ft x 4 ft floor space for the experimental set-up, as well as additional space for approximately ten students to sit. The desks/tables do not need to be moved into groups.

Day 2 - 6:

Have students' desks/tables moved into nine groups and cleared off.

Day 3 - 5:

Have nine floor spaces available for students to perform experiments. Each subgroup will need a 2 ft x 4 ft floor space for the experimental set-up, as well as additional space for approximately three students to sit.

Day 7 - 8:

Have students' desks/tables cleared off. The desks/tables do not need to be moved into groups.

Scheduling Alternatives:

Some teachers have expressed interest in giving the students more time to work with the volunteers throughout the module. Below are options that will allow the students more time to work with the volunteers. If you plan to do any of the following options, please inform the SciTrek staff no later than your orientation date (approximately one week before your module, exact orientation times are found at: scitrek.chem.ucsb.edu/elementary). This will allow the SciTrek staff to provide you with all needed materials.

Day 1:

If you would like to have more time for your students to make observations and generate variables, you can do one or both of the following activities with your class, **before** SciTrek arrives:

- 1) Conclusion assessment (**highly recommended**)
- 2) Technique activity

Day 2:

If you would like to have more time for your students to design their experiments, you can do the example question/experimental set-up, outlined in the Introduction with your class, **before** SciTrek arrives.

Day 3:

If you would like to have more time for your students to perform their experiments, you can do one or both of the following activities with your class:

- 1) Example graph outlined in the Introduction, **before** SciTrek arrives.
- 2) Conclusion activity, **after** SciTrek leaves.

Day 4:

If you would like to have more time for your students to redesign their experiments, you can finish the conclusion activity with your class, **before** SciTrek arrives.

Day 5:

If you would like to have more time for your students to perform their experiments and write conclusions, you can do the example conclusion with your class, **before** SciTrek arrives.

Day 7:

If you would like to have more time for your students to discuss their experiments during poster presentations, you may take more time for each presentation and finish the presentations with your class, **after** SciTrek leaves.

Day 8:

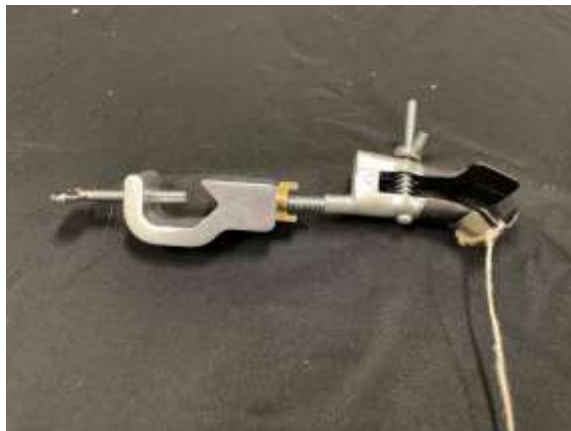
If you would like more time for the tie to standards activity, you may give the conclusion assessment to your class, **before** SciTrek arrives.

Materials Used for this Module:

1. Maglite Mini AAA LED Flashlight (Walmart Part Number: 551779062)
2. Colored light filters (Sammy's Camera part number: orange (Lee Filters 105 (S105)), green (Lee Filters 139 (S139)), blue (Lee Filters 075 (S075)) cut to fit inside flashlight.
3. 152 cm/60 in flexible measuring tape (ETA hand2mind Part number: IN524)
4. Ruler (Office Depot Part Number: 2125472)
5. Masking Tape
6. Plastic Blocks (height: 2 cm, 3 cm, 4 cm, 5 cm, 6 cm, 7 cm, 8 cm, 9 cm, 10 cm; all blocks have widths of 7 cm and depths of 3 cm). (Spracher Engineering fabricates these blocks)
7. Support Stand with Rod (Spectrum Chemicals and Laboratory Products Part Number: 141-77765-E1)
Rods (below; left) have masking tape marked with the height (every 5 cm, up to 60 cm). Bases (below; right) have masking tape marked with the direction of the flashlight beam and clamp. Bases also cite specifications for initial observation.



8. White Oil Cloth (Amazon sold by Fabric.com) cut into 20 in x 30 in pieces. (store flat)
9. Clamp (Fisher Scientific Part number: S99452) Clamps have been modified by tying a string (~70 cm of string length hanging down). The string is tied to the front of the clamp and secured in this position with masking tape. This allows students to determine the distance from the flashlight to the block.



10. Swing Arm Protractor (EAI Education: 502762)
11. Clipboard (OfficeMax Part Number: 21678980)

All printed materials used by SciTrek (notebooks, materials page, picture packet, poster parts, instructions, and nametags) can be made available for use and/or editing by emailing scitrekelementary@chem.ucsb.edu.

Types of Documents:

Notebook:

One given to every student and is filled out by the student. The lead will use a notebook to write in as an example for students. The notebook the lead uses is referred to as the class notebook in these instructions.

Notepad:

One given to every group and is filled out by the volunteer. In these instructions, the examples are narrower and taller than the notebook pages.

Picture Packet:

One per class that, if needed, the lead fills out. In these instructions, the examples are the same size as the notebook pages, but they are labeled.

In these instructions, all other example documents are labeled.

Day 1: Technique/Observations/Variables

Note: We **highly recommend** teachers give the conclusion assessment prior to Day 1 of the module. The suggested times in the lesson plan below are assuming students completed the conclusion assessment prior to SciTrek's arrival.

Schedule:

Times if teacher gave assessment prior to SciTrek:

Introduction (SciTrek Lead) – 2 minutes
 Module Introduction (SciTrek Lead) – 3 minutes
 Technique (SciTrek Lead) – 7 minutes
 Observation Discussion (SciTrek Lead) – 4 minutes
 Observations (SciTrek Volunteers) – 25 minutes
 Variable Discussion (SciTrek Lead) – 5 minutes
 Variables (SciTrek Volunteers) – 12 minutes
 Wrap-Up (SciTrek Lead) – 2 minutes

Times if SciTrek must give assessment:

Introduction (SciTrek Lead) – 2 minutes
 Conclusion Assessment (SciTrek Lead) – 10 minutes
 Module Introduction (SciTrek Lead) – 3 minutes
 Technique (SciTrek Lead) – 5 minutes
 Observation Discussion (SciTrek Lead) – 4 minutes
 Observations (SciTrek Volunteers) – 20 minutes
 Variable Discussion (SciTrek Lead) – 5 minutes
 Variables (SciTrek Volunteers) – 9 minutes
 Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

- | | | |
|---|--|---|
| <input type="checkbox"/> Student nametags | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> Flashlight without filter |
| <input type="checkbox"/> (NS + 1) Notebooks | <input type="checkbox"/> (2) Dry erase marker | <input type="checkbox"/> (13) Protractors |
| <input type="checkbox"/> Volunteer instructions | <input type="checkbox"/> Measuring tape (152 cm) | <input type="checkbox"/> Clamp with string attached |
| <input type="checkbox"/> Picture of experimental set-up | <input type="checkbox"/> (3) Rulers | <input type="checkbox"/> Ring stand base |
| <input type="checkbox"/> Volunteer lab coat | <input type="checkbox"/> Masking tape | <input type="checkbox"/> 5 cm Plastic block |
| | <input type="checkbox"/> Flashlight with colored filter (filter must be group color) | <input type="checkbox"/> White plastic surface |

Other Supplies:

- | | | |
|---------------------------------------|---|--|
| <input type="checkbox"/> (3) Notepads | <input type="checkbox"/> (3) Ring stand poles | <input type="checkbox"/> (35) Clipboards |
|---------------------------------------|---|--|

Lead Box:

- | | | |
|---|--|--|
| <input type="checkbox"/> (3) Blank nametags | <input type="checkbox"/> Time card | <input type="checkbox"/> Bag with (2) flashlights without filter, (3) colored filters (blue, orange, and green), and (4) AAA batteries |
| <input type="checkbox"/> (3) Extra notebooks | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> (5) Protractors |
| <input type="checkbox"/> Lead instructions | <input type="checkbox"/> (2) Wet erase markers | <input type="checkbox"/> Clamp with string attached |
| <input type="checkbox"/> Shadows picture packet | <input type="checkbox"/> (2) Black pens | <input type="checkbox"/> 5 cm Plastic block |
| <input type="checkbox"/> Picture of experimental set-up | <input type="checkbox"/> (3) Markers (orange, blue, green) | <input type="checkbox"/> White plastic surface |
| <input type="checkbox"/> Lead lab coat | <input type="checkbox"/> (3) Measuring tapes (152 cm) | |
| <input type="checkbox"/> Conclusion assessment (if teacher did not take assessments, then (35) assessments) | <input type="checkbox"/> (3) Rulers | |
| | <input type="checkbox"/> Masking tape | |

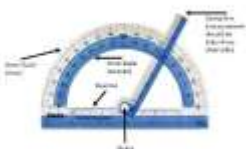
Notebook and Notepad Pages:

TECHNIQUE
Protractors

Protractors are used to measure and draw angles.


How to measure an angle using a protractor:

1. Line up the origin with the center point of the block and place the baseline parallel to the bottom of the block.
2. Move the swing arm to point to the center of the flashlight.
3. The angle is the value on the outer clear scale, on the clear side of the swing arm.



Identify the angle of the flashlight in relation to the box.


1.



+

Angle: 160°


2.



+

Angle: 90°


3.



+

Angle: 52°

4.



+

Angle: 136°

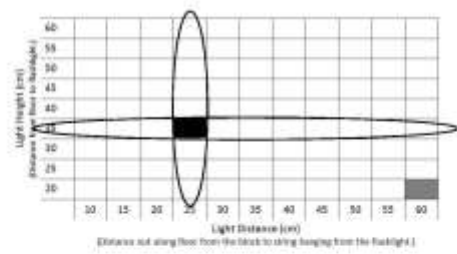
3

OBSERVATIONS

Experimental Set-Up:

- Block Height = 5 cm
- Block Width = 7 cm
- Block Length = 3 cm
- Light Angle = 60°
- Flashlight pointed at block
- Each square on the block is 1 cm x 1 cm

Circle the appropriate box:



1

OBSERVATIONS

Experimental Set-Up:

Block Height = 5 cm _____

Block Width = 7 cm _____

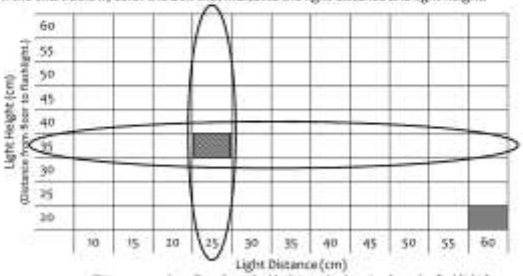
Block Length = 3 cm _____

Light Angle = 60° _____

Flashlight pointed at block _____

Each square on the block is 1 cm x 1 cm _____

On the chart below, color the box that indicates the light distance and light height.



3

OBSERVATIONS

Light Color:	<u>Blue</u> Light	White Light
Shadow Color:	<u>Black</u>	<u>Black</u>
Shadow Length: (Length of longest part of the shadow)	<u>6.5 cm</u>	<u>6.5 cm</u>
Shadow Width: (Width of widest part of the shadow)	<u>10 cm</u>	<u>10 cm</u>

Describe what happened during the experiment:

2

Light Color:	<u>Blue</u> Light	White Light
Shadow Color:	<u>Black</u>	<u>Black</u>
Shadow Length: (Length of longest part of the shadow)	<u>6.5 cm</u>	<u>6.5 cm</u>
Shadow Width: (Width of the widest part of the shadow)	<u>10 cm</u>	<u>10 cm</u>

Describe what happened during the experiment:

Changing the light color does not change the shadow length or width, but the white light shadow is easier to see than the blue light shadow.

4

VARIABLES

Variable	How will changing this variable affect the shadows?
Block Height	The taller the block, the shadow length will _____, and the width will _____.
Light Distance	The farther the light distance, the shadow length will _____, and the width will _____.
Light Angle	The closer the angle is to _____, the _____ the shadow length and the _____ the width.
	Choose your own!

3

VARIABLES

Variable	How will changing this variable affect the shadows?
Block Height	The taller the block, the shadow length will be longer, and the width will stay the same.
Light Distance	The farther the light distance, the shadow length will be longer and the width will be wider.
Light Angle	The closer the angle is to 90°, the shorter the shadow length and the narrower the width.
Light Height	The higher the light height, the shadow length will be shorter and the width will be narrower.
Block Width	The wider the block, the shadow length will stay the same and the width will be wider.

5

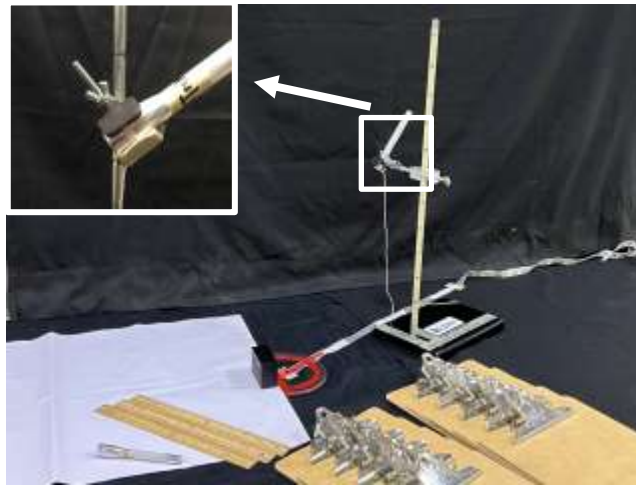
Preparation:

SciTrek Lead:

1. Get the conclusion assessments and put them in the lead box.
2. Make sure volunteers are writing their name and group color on the whiteboard.
3. Make sure volunteers are passing out nametags.
4. Make sure volunteers are setting up for the initial observation.
5. Set up the document camera for the class question (notebook, front cover), technique activity (notebook, page 2), and block measurement pictures (picture packet, page 1 and 2).

SciTrek Volunteers:

1. On the front whiteboard in the classroom, write your name and the color of the group (orange, blue, or green) you will be working with.
2. Pass out nametags.
 - a. You may need to do this during the Introduction. Quietly set each student's nametag on their desk without talking to them. If names are not written on their desk, ask the classroom teacher or lead to help you when they are not talking with the class.
3. Have notebooks and protractors available to pass out.
4. Assemble the experimental set-up (shown in picture below as well as in color in the experimental set-up picture in your group box) on a spot on the floor where approximately ten students can sit.
 - a. Attach the pole to the ring stand base by screwing them together.
 - b. Attach the clamp to the ring stand pole at a height of 35 cm.
 - c. Attach the flashlight with the colored filter to the clamp. Each group will have a filter that is the same color as their group. For example, the blue group will have a blue filter. Make sure the front of the clamp and the head of the flashlight are touching (see enlargement in picture below).
 - d. Make sure the clamp and flashlight are pointing the correct way as indicated by the labels on the ring stand base and the string is hanging down from the front of the clamp.
 - e. Place the white plastic mat on the floor so one of the short sides of the plastic is closest to the ring stand.
 - f. Place the 5 cm block on the short side of the white plastic in the center.
 - g. Place the protractor against the block on the non-plastic side with the swing arm pointed at 60° . Place the measuring tape under the swing arm of the protractor so that the zero mark of the measuring tape is touching the block. Use the masking tape to tape down the measuring tape. Make sure to not cover up the 25 cm mark on the measuring tape. The protractor will be laying on top of the measuring tape and the swing arm will be tracing the measuring tape.
 - h. Use the measuring tape as a guide to position the ring stand so the string connected to the clamp is hanging over the 25 cm mark of the measuring tape.
 - i. Make sure the flashlight is in line with the protractor.
 - j. Turn on the flashlight and adjust the clamp until the flashlight is pointed directly at the center of the block. When adjusting the flashlight, turn the head of the flashlight until the light forms the tightest possible circle on the center of the block. Then, turn off the light until the students have completed their observations of the experimental set-up.
 - k. Place the three rulers on the white plastic.
 - l. Place the flashlight without a filter and ten clipboards next to the experimental set-up.



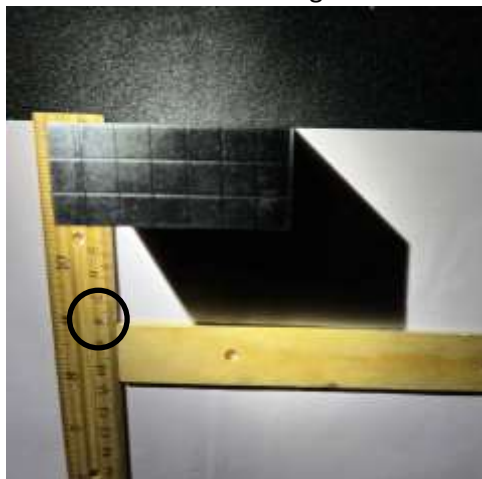
How to Measure Shadow Lengths (left image below)

1. Line up the 0 cm mark of a ruler with the front of the block (edge of the white plastic).
2. Place another ruler (numbers side down) at the edge of the shadow. This will result in the rulers making an “L.”
3. The shadow length will be the measurement from the front of the block to the beginning of the upside-down ruler. This point is indicated with a circle in the image below (8 cm).

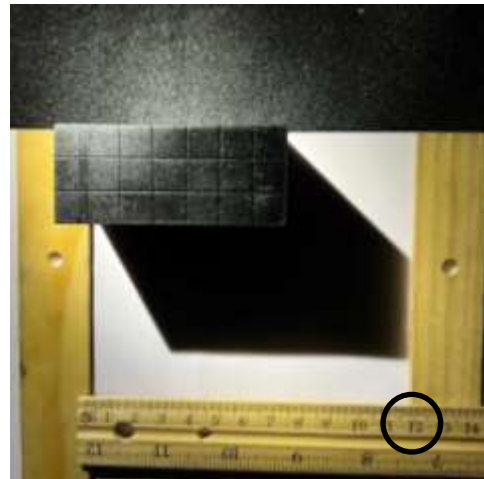
How to Measure Shadow Widths (right image below)

1. Place two rulers (numbers side down) perpendicular to the short side of white plastic on either side of the shadow.
2. Line the 0 cm mark of a third ruler with the inside edge of one of the upside-down rulers. This will result in the rulers making an “H.”
3. The shadow width will be the measurement between the two number-side-down rulers. This point is indicated with a circle in this image below (12 cm).

Shadow Length



Shadow Width



Introduction:

(2 minutes – Full Class – SciTrek Lead)

For UCSB Lead:

“Hi, we are scientists from UCSB and we want to show you what we do as scientists. We will show you an experiment and then you can make observations, come up with a class question, and design your own experiment to help answer the class question. We want to show you that you can do science and have fun.”

For Teacher Lead:

“I have asked some scientists from UCSB to come and help us with a long-term science investigation. We will make observations, come up with a class question, and you will design your own experiment to help answer the class question.”

Allow the UCSB volunteers to introduce themselves and share their majors.

Conclusion Assessment:

(10 minutes – Full Class – Given By Classroom Teacher Prior to SciTrek)

Tell students, “Before we start with the module, we will determine how your ideas on conclusions are developing.” Have students write their name, teacher’s name, and date at the top of the assessment. Tell students, “When doing this assessment, you should work individually, so there should be no talking.” As you are giving the assessment, walk around the room and verify students have written their names on their assessments.

For page 1 (top), read questions 1 and 2 aloud and give students time to answer each before moving on to the next question.

For page 1, question 3 (bottom), read the instructions to students. Then, read each of the statements aloud and have students circle whether the statement is an example of a claim, data, or opinion.

For page 2 (top), tell students, “We will annotate or mark up the results table as a class.” Read the directions at the top of the page (*on the results table, circle the changing variable(s), underline each control, and box information about data collection*) aloud to students. Tell students, “When a variable is a changing variable, it is different for each trial and there will be a value written in each trial’s box, therefore, we will circle the variable.” Point to an example of a changing variable. “When a variable is a control, it is the same for each trial and there will be a value written in the *Trial 1* box and then an arrow through the remaining trials, therefore, we will underline the variable.” Point to an example of a control. Go through the table and for each variable and have the class say the word in parenthesis as you say the sentence. “Is the variable changing? (Yes/No) this makes the variable a (control/changing variable), therefore we should (underline/circle) it.” Then, underline or circle the variable. When you get to the data section tell students, “This is a new section of the results table and this section contains the data from the experiment so everything in this section will be boxed.” Have students box the two pieces of data. Then have them individually decide if the group could make a conclusion (question 4).

For page 2, question 5 (bottom), read step 1 of the instructions aloud to students (*Identify the following statements as either CLAIM or DATA and write a C or D on the line.*). Then, have students fill in whether they think statement *a* is a claim or data by writing a C or D on the line. Tell students, “This part is similar to question 3 of the assessment.” Read step 2 of the instructions aloud to students (*Look at the results table and circle if the statement is a correct claim, correct data, or incorrect. Statements are INCORRECT if the statement does not agree with the results table or has not been tested.*). Point to the results table and have students circle whether they think statement *a* is a correct claim, correct data, or incorrect claim or data. Once students have completed statement *a*, read statement *b* aloud and tell students, “Write a C or D on the line depending on whether you think the statement is a claim or data.” After about 15 seconds tell students, “Now, look at the results table and circle whether the statement is a correct claim, correct data, or incorrect.” Repeat the process for statements *c-e*.

For page 3, questions 6-7, repeat the process from page 2 including annotating the results table as a class.

When students are finished, collect the assessments and verify students' names are written on the top of the papers.

Module Introduction:

(3 minutes – Full Class – SciTrek Lead)

Have volunteers pass out a notebook to each student.

Have students fill out their name, teacher's name, group color (color of their name on their nametag: orange, blue, or green), and their volunteer's name (volunteers' names should be written on the board next to the group color they will be working with) on the front cover of their notebooks. Students will leave the subgroup number and class question blank. If a student does not have a nametag, only have them fill out their name and teacher's name on the cover of their notebook. They will be placed in a group when the class divides into groups for observations and can fill out their group color and volunteer at that point.

Tell the class, "We are going to investigate shadows." Ask the class, "What are shadows and what causes them?" By the end of the conversation, make sure students understand that shadows are formed when an object blocks light, causing a dark area where the light would have been if the object was not there.

Ask the class, "Can one object make different sized/shaped shadows?" By the end of the conversation make sure students understand the shadow size/shape can change depending on the light source.

Tell students, "For this module, we will be exploring shadows to learn more about what causes shadows' sizes to change. Therefore, the question that we will be exploring as a class is '**What variables affect shadows?**'" Write this question on the front page of the class notebook under the document camera and have students copy the question onto the cover of their notebooks.

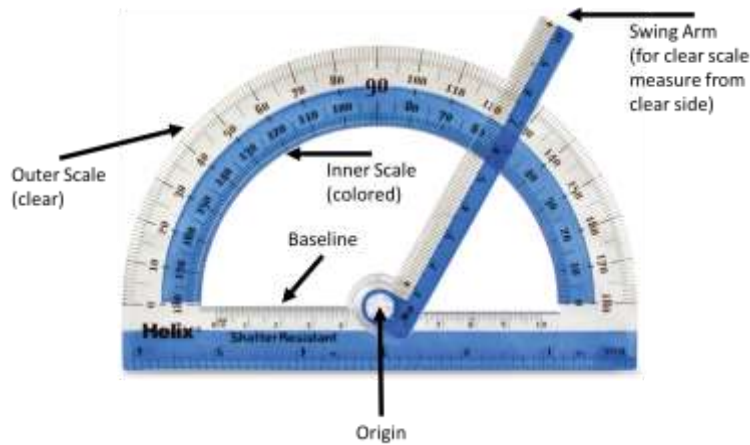
Technique:

(7 minutes – Full Class – SciTrek Lead)

Have volunteers pass out a protractor to each student.

Tell the class, "We will be working with light sources for this module and we will need to be able to describe the location of the light source. One tool scientists use to do this is a protractor." Show students a protractor. Have students turn to page 2 of their notebooks and place the class notebook under the document camera. Review the parts of the protractor while pointing to each part on an example protractor.

Tell students, "The outer clear scale shows the angle measurement from 0° - 180° and the inner colored scale shows the angle measurement from 180° - 0° . For this module, we will only use the clear outer scale. The swing arm is the part of the protractor that moves and is used to determine the angle of an object in relation to another object. The angle is read off the clear side of the swing arm regardless of the scale used. The origin of the protractor is where the swing arm is attached and should be placed at the center of one of the two objects. In our experiment we will place the origin on the center of a block. The baseline is where the start of the inner and outer scale meets and will be lined up parallel to the base of the reference object (block). To measure an angle, the protractor is put on the reference object and the swing arm is pointed at the other object. For this module, the other object will be the light source. The angle between the light and the block can then be read from the outer scale on the clear side of the swing arm." A picture of these parts is shown below.



Tell students, “We are now going to determine the angles of a flashlight relative to a block.” As a class, complete question 1 together. Then, have students complete the next three questions on their own. Once the majority of students are finished, go over the answers with the students. Tell students, “It is okay if your answers differ by up to 3° from the angle in the class notebook” (see example notebook below). Volunteers should walk around and assist struggling students as they complete page 2. As soon as students have completed page 2, have volunteers collect the protractors.

TECHNIQUE
Protractors

Protractors are used to measure and draw angles.

How to measure an angle using a protractor:

1. Line up the origin with the center point of the block and place the baseline parallel to the bottom of the block.
2. Move the swing arm to point to the center of the flashlight.
3. The angle is the value on the outer clear scale, on the clear side of the swing arm.

Identify the angle of the flashlight in relation to the box.

1.

+

Angle: 160°

2.

+

Angle: 90°

3.

+

Angle: 52°

4.

+

Angle: 136°

3

Tell students, “Now that you know how to use a protractor to measure angles, you will be able to use these skills to determine what angle the light is coming from to create a shadow.”

Observation Discussion:

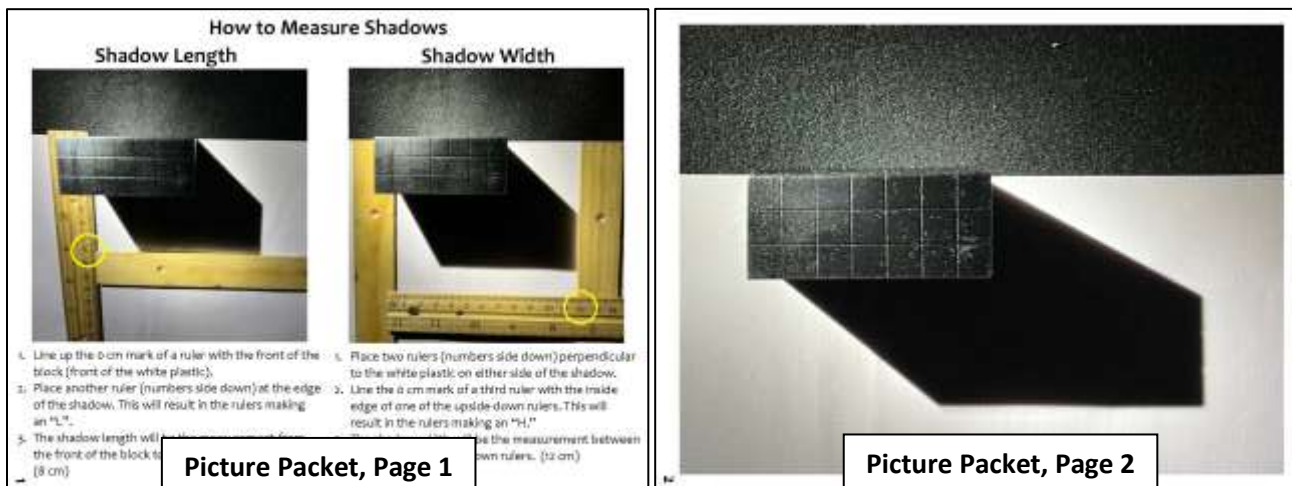
(4 minutes – Full Class – SciTrek Lead)

Tell students, “Scientists make many observations.” Ask the class, “What is an observation? What are the types of things you can record for an observation?” If they have trouble, show them an object and let them make observations. Turn these specific observations into general features of an observation. Examples of possible general observations are: color, texture, size, weight, temperature, etc. Lead students to understand an observation is a description using your five senses.

Tell students, “In this experiment we are going to make observations of a shadow made from two different light colors. We will need to be able to compare our data with one another, therefore, we will all need to measure the length and width of the shadows the same.” Put page 1 of the picture packet under the document camera (below; left).

Demonstrate how to measure the shadow length (picture packet, page 1, left). Line up the 0 cm mark of a ruler with the front of the block (edge of the white plastic). Place another ruler (numbers side down) perpendicular to the first ruler at the edge of the shadow, making an “L” with the two rulers. The shadow length will be the measurement from the front of the block to the beginning of the upside-down ruler and can be read from the ruler which has its numbers exposed. The shadow length for this example is 8 cm.

Demonstrate how to measure the shadow width (picture packet, page 1, right). Place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. Turn a third ruler, with its number side up perpendicular to the other rulers and line the 0 cm mark of it with the inside edge of one of the upside-down rules. This will result in the rulers making an “H.” The shadow width will be the measurement between the two upside-down rules and can be read from the ruler which has its number exposed. The shadow width in this example is 12 cm.



Picture Packet, Page 1

Picture Packet, Page 2

Turn to page 2 of the picture packet (above; right) and walk students through measuring the shadow length and width. For this example, you should measure the shadow length to be 9 cm and the shadow width to be 18 cm.

Tell the class, “You will now get in your groups and make observations. To determine your group, you will need to look at the color of your nametag (orange, blue, or green).” Tell each colored group where to go, as well as to bring a pencil and their notebook.

If a student does not have a nametag, identify the group color with the least number of students in it, and write the student’s name on one of the extra nametags in the lead box, using that color of marker.

Observations:

(25 minutes – Groups – SciTrek Volunteers)

Once students come over to your group, have them sit in boy/girl fashion on the floor around the set up. Verify the floor is set up as described in the Set-Up section. Pass out a clipboard to each student and have them turn to page 3 of their notebook.

As a group, have students generate approximately six observations about the experimental set-up before you turn on the flashlight. Observations should be recorded in the group notepad under *Experimental Set-Up*, or by circling the light position on the chart and then, copied by students into their notebooks. Observations about the experimental set-up should be recorded in bullet points to save time. Make sure to record the following observations about the experimental set-up: block dimensions (height – 5 cm, width – 7 cm, length – 3 cm), and light angle (60°). Show students how to fill in the chart which shows the light distance (25 cm) and light height (35 cm), making sure to shade in the box that represents their set-up. This should take you no longer than 10 minutes. Make sure students notice that each of the squares on the plastic blocks are 1 cm x 1 cm allowing them to easily tell the size of the blocks. An example filled out experimental set-up for the initial observation is shown below.

OBSERVATIONS

Experimental Set-Up:
 Block Height = 5 cm
 Block Width = 7 cm
 Block Length = 3 cm
 Light Angle = 60°
 Flashlight pointed at block
 Each square on the block is 1 cm x 1 cm

Circle the appropriate box:

1

OBSERVATIONS

Experimental Set-Up:
Block Height = 5 cm
Block Width = 7 cm
Block Length = 3 cm
Light Angle = 60°
Flashlight pointed at block
Each square on the block is 1 cm x 1 cm

On the chart below, color the box that indicates the light distance and light height.

3

Have students turn to page 4 of their notebooks while you turn to page 2 on the group notepad. Turn the flashlight on and point the light directly at the center of the block and then focus the light in as small of a circle as possible. The light color should be the same color as your group color (blue group will have a blue light source). Have students fill in the light color at the top of the chart. They should then fill in all of the observations for the colored light portion of the chart. For the shadow length measurement, have students measure from the front of the block to the longest end of the shadow. For the shadow width measurement, have students measure the widest part of the shadow. As students make observations,

Lead students through the following questions, and explanations:

What does the word 'variable' mean to a scientist?

variables are the parts of the experiment you can change

What was the changing variable in the experiment we just did?

light color

Do you think there are multiple variables that will affect the size of the shadow?

multiple variables might affect the size of the shadow

Explain, this is why we will need to work as a class to answer the class question: "What variables affect shadows?"

Tell the class, "You are going to think about variables, in the experiment, you could change, in order to help us answer the class question. In addition to generating variables, you should think about, how and/or why these variables might affect the outcome of the experiment." Ask the class, "What do you think is a variable that might affect the size (length and width) of the shadow?" Then, have them tell you how and why they think that variable would affect the size of the shadow. Probe them on how they would design an experiment to test whether this variable affected the shadow. Finally, have the students make a prediction of the results for the experiment they proposed. Remind students, "Predictions can be wrong, and we will not know the true answers until we carry out the experiment."

Ex: *Variable:* block height

Why might this variable affect the shadow? Shadows are caused by the object blocking light, therefore, different sized blocks might block different amounts of light.

How would you test this variable? Get blocks that are different heights, and measure the shadow length.

Prediction: The taller the block, the longer the shadow but it will not affect the width of the shadow.

Tell students, "You will now generate more variables and analyze them, in your groups."

Note: If you are running behind and there are less than 5 minutes remaining, generate variables as an entire class instead of in groups.

Variables:

(12 minutes – Groups – SciTrek Volunteers)

As a group, generate a variable and make a prediction about how it could affect the length and width of the shadow. Encourage and challenge students to explain why they think their prediction is correct. If needed, you can write down a sentence frame for students to use. Repeat this process two more times, record these ideas on the notepad, and have students copy them into their notebooks. If students have different predictions, they can write their own predictions in their notebooks. Next, students will individually generate additional variables, make predictions about how different values of these variables will affect the shadow, and record their ideas in their notebooks. Have students share these ideas with the group.

Prepare one student to share a variable, and why they think it will affect, shadows during the class discussion.

VARIABLES	
Variable	How will changing this variable affect the shadows?
Block Height	The taller the block, the shadow length will _____, and the width will _____.
Light Distance	The farther the light distance, the shadow length will _____, and the width will _____.
Light Angle	The closer the angle is to _____, the _____ the shadow length and the _____ the width.
	Choose your own!

3

VARIABLES	
Variable	How will changing this variable affect the shadows?
Block Height	The taller the block, the shadow length will be longer, and the width will stay the same.
Light Distance	The farther the light distance, the shadow length will be longer and the width will be wider.
Light Angle	The closer the angle is to 90°, the shorter the shadow length and the narrower the width.
Light Height	The higher the light height, the shadow length will be shorter and the width will be narrower.
Block Width	The wider the block, the shadow length will stay the same and the width will be wider.

3

Wrap-Up:

(2 minutes – Full Class – SciTrek Lead)

Have one student from each group share a variable they generated, as well as how and why they think it will affect the shadow.

Tell students, “Next session, you will design an experiment to answer the class question: What variables affect shadows?”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Take ring stand apart.
3. Put ring stand pole and clipboards back into their containers.
4. Place all other materials into your group box and bring them back to UCSB.

Day 2: Question/Materials Page/Experimental Set-Up/Procedure

Schedule:

Introduction (SciTrek Lead) – 13 minutes
Question (SciTrek Volunteers) – 10 minutes
Materials Page (SciTrek Volunteers) – 7 minutes
Experimental Set-Up (SciTrek Volunteers) – 8 minutes
Procedure (SciTrek Volunteers) – 19 minutes
Wrap-Up (SciTrek Lead) – 3 minutes

Materials:

(3) Volunteer Boxes:

- | | | |
|---|--|--|
| <input type="checkbox"/> Nametags | <input type="checkbox"/> Volunteer lab coat | <input type="checkbox"/> (2) Pencils |
| <input type="checkbox"/> Notebooks | <input type="checkbox"/> (3) Materials pages (subgroup color & number indicated) | <input type="checkbox"/> (2) Red pens |
| <input type="checkbox"/> Volunteer instructions | | <input type="checkbox"/> Paper notepad |

Lead Box:

- | | | |
|---|--|--|
| <input type="checkbox"/> (3) Blank nametags | <input type="checkbox"/> Time card | <input type="checkbox"/> (3) Markers (orange, blue, green) |
| <input type="checkbox"/> (3) Extra notebooks | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> Paper notepad |
| <input type="checkbox"/> Lead instructions | <input type="checkbox"/> (2) Red pens | <input type="checkbox"/> (2) Example blocks of different heights |
| <input type="checkbox"/> Shadows picture packet | <input type="checkbox"/> (2) Wet erase markers | |
| <input type="checkbox"/> Lead lab coat | <input type="checkbox"/> (2) Black pens | |
| <input type="checkbox"/> (3) Materials pages | | |

Notebook Pages:

Experimental Considerations:

- You will only have access to the materials on the materials page.
- You will only have access to one flashlight with white light and the light must be focused and pointed directly at the center of the block.
- All objects will be rectangular blocks and you will only be able to change one dimension of the block.

Changing Variable(s) (Independent Variable(s))

You will get to perform two experiments. For your first experiment, decide which variable(s) (max three) you would like to test. For each changing variable you select, discuss with your subgroup why you think that variable will affect the shadow.

Changing Variable 1: Light Distance
 Discuss with your subgroup how you think changing variable 1 will affect the shadow.

Changing Variable 2 (optional): Light Angle
 Discuss with your subgroup how you think changing variable 2 will affect the shadow.

Changing Variable 3 (optional): Block Width
 Discuss with your subgroup how you think changing variable 3 will affect the shadow.

What will you measure? (circle one) Shadow Length Shadow Width

QUESTION

Question our subgroup will investigate:

- If we change the light distance, light angle, and block width what will happen to the shadow length?

SciTrek Member Approval: LO

Get a materials page from your volunteer and fill it out before moving onto the experimental set-up.

EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: block height) and the values (Ex: 5 cm) you will use for your trials under each block.

Changing Variable(s):

- Light Distance: 25 cm, 60 cm, 10 cm, 45 cm
- Light Angle: 135°, 30°, 90°, 20°
- Block Width: 7 cm, 2 cm, 10 cm, 4 cm

Controls (variables you will hold constant):
 Write the controls and the values you will use in all your trials (controls table, Ex: light color/white).

Light Color / White Light Height / 25 cm
 Block Height / 7 cm Surface / White Plastic
 Block Length / 3 cm Block Material / Plastic

SciTrek Member Approval: LO

PROCEDURE

Procedure Note:
 Make sure to include all values of your changing variable(s) in the procedure (Ex: for a subgroup that decided to change block height, one step would be: place block that is 7 cm wide, 3 cm long, and A) 1 cm, B) 5 cm, C) 8 cm, and D) 10 cm high on the white plastic).

- Get a plastic block that is 7 cm high, 3 cm long, and A) 7 cm, B) 2 cm, C) 10 cm, and D) 4 cm wide.
- Place block on white plastic.
- Put light at height of 25 cm, distance and angle A) 25 cm, 135°, B) 60 cm, 30°, C) 10 cm, 90°, and D) 45 cm, 20°.
- Turn on white light.
- Measure the length of the shadow.
-

SciTrek Member Approval: LO

Preparation:

SciTrek Lead:

1. Make sure volunteers are setting out notebooks in such a way that allows students within the same subgroup to work together.
2. Set up the document camera for the question (notebook, page 6), materials page (lead box), and experimental set-up (notebook, page 7).
3. Have two example blocks of different heights to show during the Introduction.

SciTrek Volunteers:

1. Set out notebooks/nametags to allow students in the same subgroup (same number on the front of their notebook) to work together.
2. Make sure you have three materials pages, each filled out with a subgroup number (1, 2, or 3) and your group's color to give to subgroups after they complete their question.
3. Have a red pen available, to approve students' questions, experimental set-ups, and procedures (notebook, pages 6-8).

Note: Set notebooks where students will sit during the module, even if another student is currently at that desk. If needed, students will move to these spots after the Introduction.

Introduction:

(13 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell them, "A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your notebook after the Introduction."

Ask students, "What did we do and learn during our last session?" Possible student response: we did an experiment in which we changed the light color (colored and white light) and observed the shadow that a block cast. We learned the color of the light does not affect the size of the shadow, but it does affect how clearly we see the shadow's outline. We also generated variables that might affect shadows. Ask the class, "What is the class question we will be investigating?" Students should reply, "What variables affect shadows?"

Tell students, "One way scientists answer questions is by performing experiments. Today, you will design an experiment to help answer the class question." Ask the class, "Do you think there are multiple variables that could affect shadows?" Possible student response: there are probably multiple variables.

Explain to students, "Many times, when there is a broad question, like our class question, scientists break it down into smaller, more specific questions which small groups of scientists can investigate. The scientists then compile their work to answer the broader question. Therefore, each subgroup is going to generate a smaller question to investigate. Once we put all the subgroups' research together, we should be able to answer the class question."

Subgroups will first generate a question based on the changing variable(s) they plan to explore. They will then fill out their materials page, which will allow them to determine their experimental set-up. The experimental set-up will help them generate a procedure, or a set of steps to conduct an experiment. Tell students, "You will need to keep a few things in mind, while you are going through this process."

Experimental Considerations:

1. *You will only have access to the materials on the materials page.*
2. *You will only have access to one flashlight with white light and the light must be focused and pointed directly at the center of the block.*
3. *All objects will be rectangular blocks and you will only be able to change one dimension of the block.*

When you tell students experimental consideration 3, show students the two example blocks from the lead box and tell them, “Two of your block dimensions must be 7 cm and 3 cm, but you can rotate your block so that you will be able to choose to change either the height, width, or length, of the block.”

Tell students, “We are now going to generate an example question/experimental set-up together. I will write it in the class notebook, so you will be able to refer back to it when you are completing the process yourselves.” Make sure students **do not** fill out the example question/experimental set-up in their notebooks, as they will be completing these pages for their own experiments in subgroups.

Tell students, “For the example experiment, the changing variables will be light distance and block length.” Then, write down the changing variables in the class notebook (notebook, page 6), under the document camera. Tell students, “When you are going through this process in your subgroups, you may select one, two, or three changing variables.”

Note: It is important that you select the changing variables for the example experiment to have one variable about the block and one variable about the light. The materials page for this module is complex and picking these two variables allows you to go over how to fill out the page for any changing variable.

Tell students, “You will now select whether you will measure the shadow length or width. If you think you know what will happen to one of these, you might select the opposite to measure. For example, if I thought I knew how block height affected the length of the shadow, I might decide to measure the width of the shadow.” Then, circle the measurement that will be taken for the example experiment.

Show students how to insert the changing variables, and what they plan to measure into the question frame to generate the question that will be investigated, “If we change the light distance and block length, what will happen to the shadow length?”

Experimental Considerations:

1. You will only have access to the materials on the materials page.
2. You will only have access to one flashlight with white light and the light must be focused and pointed directly at the center of the block.
3. All objects will be rectangular blocks and you will only be able to change one dimension of the block.

Changing Variable(s) (Independent Variable(s))

You will get to perform two experiments. For your first experiment, decide which variable(s) (max three) you would like to test. For each changing variable you select, discuss with your subgroup why you think that variable will affect the shadow.

Changing Variable 1: Light Distance
Discuss with your subgroup how you think **changing variable 1** will affect the shadow.

Changing Variable 2 (optional): Block Length
Discuss with your subgroup how you think **changing variable 2** will affect the shadow.

Changing Variable 3 (optional): _____
Discuss with your subgroup how you think **changing variable 3** will affect the shadow.

What will you measure? (circle one) Shadow Length Shadow Width

QUESTION

Question our subgroup will investigate:

- If we change the light distance and block length (what you are changing (bolded independent variable)), what will happen to the shadow length (what you are measuring (bolded dependent variable))?

SciTrek Member Approval: _____

Get a materials page from your volunteer and fill it out before moving onto the experimental set-up.

Tell students, “Once you have determined your question, and have approval, your volunteer will give you a materials page for determining the values of your controls and changing variable(s).” Ask students, “What is a control?” Make sure, by the end of the conversation, students understand controls are variables that are held constant during an experiment. For example, if the light height was 45 cm for all of the trials, then one of their controls would be light height. These controls, and control values, can be different from the original experiment they conducted on Day 1, but must remain constant throughout all the trials they do for this experiment.

Show students the materials page (lead box), and read the first step (*For each bolded word, underline if it is a control and circle if it is a changing variable.*). Then, have students tell you what to do for each bolded word. Read steps 2 and 3 on the materials page (*For variables that are controls, choose 1 value. For variables that are changing variables, choose 4 values and write the trial letter next to each value.*). Read the general materials to students, ask them if they need each one, and check the box when they say yes. Go through the remaining items on the materials page. If a variable is a control, then choose (do not let students choose) a single value, such as the original value (Ex: 60° for light angle). Assign each control value to a student, and tell them, “You are in charge of remembering this control, and its value, to help when filling out the experimental set-up.” For variables that are changing variables, allow students to select the values. Write the trial letter next to each selected value. Ask students, “Do we want a narrow, or wide, range of values for the changing variables, and why?” Guide students through selecting a wide range of values for both changing variables. If they choose a value contrary to their proposed experimental design, question them on their reasoning. For example, if they said they wanted to use a wide range of block lengths, and they picked 4 cm, 3 cm, 2 cm, and 5 cm, ask them, “Would the selected values allow us to best answer the question?” Allow them to change their values if needed. Assign the changing variable values to the students who chose them.

When selecting the block, remind students that only one of the block dimensions can be a changing variable. Tell students, “If one of the block dimensions is a changing variable, then, this needs to go on the

first line under the block on the materials page. If all of the block dimensions are controls, you can select any block dimension you would like, and put it on the first line. You can then select which other block dimension will be 7 cm and which will be 3 cm.”

When selecting the light location (light distance and light height) show students how to use the chart. Tell them, “You can select any light location as long as it is not greyed out.” Show them how to fill out the section of the materials page above the chart. If one or both of light distance and light height are controls (such as for light height in the example experiment) show them how to write their selected value on the line. Then go to the chart and circle the row and/or column that corresponds to the selected value(s). If, on the other hand, one or both of light distance and light height are changing variables (such as for light distance in the example experiment), inform them to leave the line blank. Then read students the instructions directly above the chart and ask the following questions:

If you have no circles you can select/mark any value that is not greyed out.

Ask students, “Is this our case?” They should reply, “No.” Tell students, “If this was your case, you could put your trial letters in any four squares that are not greyed out.”

If you have one circle you can only select/mark values within that circle.

Ask students, “Is this our case?” They should reply, “Yes.” Have students select four values within the circle that are spread out, and mark them on the materials page with the trial letters.

If you have two circles you can only select the values that are circled by both circles.

Ask students, “When did we see something like this?” They should remember this is what they did on the first day when they were determining the light distance and height of the white and colored flashlights.

When selecting light angle(s) they can pick any angle(s) between 20° and 160° . They will circle the angle(s) they will be using in their experiment. If the angle is not on the picture, they can write in the desired angle in the appropriate spot and then circle it.

Color (circle one): Orange Blue **Green**

Subgroup Number (circle one): 1 2 3

MATERIALS PAGE

You will only have access to the following materials.


- For each boxed word, underline if it is a control and circle if it is a changing variable. Example control: Block Width, Example changing variable: Block Length.
- For variables that are controls, choose 1 value.
- For variables that are changing variables, choose 4 values and write the trial letter (A,B,C,D or E,F,G,H) next to each value. Ex: 2 cm A

General Materials:


<input checked="" type="checkbox"/> Flashlight	<input type="checkbox"/> Ring Stand with Clamp	<input type="checkbox"/> White Plastic
<input checked="" type="checkbox"/> Protractor	<input type="checkbox"/> Measuring Tape	<input checked="" type="checkbox"/> (3) Rulers

Look at the picture below that defines the block dimensions. Two of your block's dimensions (which are controls) must be 7 cm and 3 cm. The third dimension can be a control or changing variable and you may select the value(s). You may only circle ONE of these.


Block Length



Block Width



Block Height



The block's length will be:

<input checked="" type="checkbox"/> 2 cm C	<input type="checkbox"/> 5 cm (original)	<input checked="" type="checkbox"/> 8 cm D
<input type="checkbox"/> 3 cm	<input checked="" type="checkbox"/> 6 cm A	<input type="checkbox"/> 9 cm
<input type="checkbox"/> 4 cm	<input type="checkbox"/> 7 cm	<input checked="" type="checkbox"/> 10 cm B

The block's height will be 7 cm.

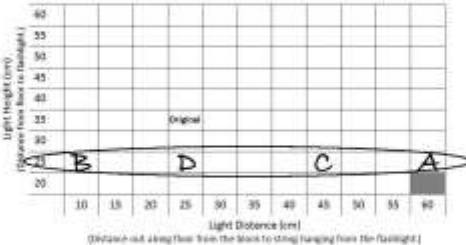
The block's width will be 5 cm.

Light Distance and Light Height

Only fill out step 1 if light height is a control and step 2 if light distance is a control.

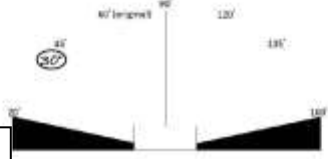
- If light height is one of your controls:
 - The value of light height that we will use is: 25 cm
 - Circle the row that corresponds to your control value (see example right top)
- If light distance is one of your controls:
 - The value of light distance that we will use is: _____
 - Circle the column that corresponds to your control value (see example right bottom)

If you have no circles you can select/mark any value that is not grayed out. If you have one circle you can only select/mark values within that circle. If you have two circles you can only select the value that are circled by both circles.



Light Angle

Circle the light angle(s) you will be using between 20° - 160°. If the light angle that you want to use does not appear in the picture below (example: 30°) write in the angle in the appropriate location and circle it.



Materials Page

Tell students, “Once you have completed your materials page, you will fill out your experimental set-up. First, you will fill out the information on the changing variable(s).” Ask students, “What are the changing variables for the example experiment, and what values did we select?” Then, fill in the values for trials A and B only. Tell students, “Second, you will fill in information about your controls.” Draw an additional control line under the existing control list. Ask students, “What is one of the controls, and its value, for the example experiment?” Show students how to record the control on the left side of the slash (Ex: light color) and the value of that control on the right side of the slash (Ex: white) by doing so in the class notebook. There are six possible variables to choose from on the materials page. If a subgroup changes three variables, they will be left with two control blanks empty after inserting in the information from the materials page. Since all control blanks must be filled out, tell students, “You may need to generate two additional controls that do not come from the materials page.” Lead students to realize this should be “surface/white plastic” and “block material/plastic.”

Ask students, “Should everyone choose the same changing variable and why or why not?” Possible student response: no, because we will not learn as much about the class question. Tell students, “This means you should try to explore a changing variable you think few other subgroups are exploring. Once your subgroup has completed your experimental set-up, you should raise your hands and get it approved by your volunteer.” Below is an example of what should be filled out for the experimental set-up in the class notebook. Note that several sections are left blank by the lead, but students will fill these in for their own notebooks.

EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: block height) and the values (Ex: 5 cm) you will use for your trials under each block.

A

B

C

D

Changing Variable(s):

1) Light Distance 60 cm 10 cm _____

2) Block Length 6 cm 10 cm _____

3) _____ _____

Controls (variables you will hold constant):
Write the controls and the values you will use in all your trials (control values, Ex: light color/table).

Light Color / White Light Height / 25 cm

Block Height / 7 cm Light Angle / 30°

Block Width / 3 cm Surface / White Plastic

Block Material / Plastic

SciTrek Member Approval: _____

7

Tell students, “After you finish your experimental set-up, you will write a procedure for your experiment that you will be able to follow next session. When writing a procedure, you should include all values of your controls, and changing variable(s), as well as what data you will collect.” Show students the example procedure step on page 8 of their notebook (*Place block that is 7 cm wide, 3 cm long and A) 2 cm, B) 5 cm, C) 8 cm, and D) 10 cm high on white plastic.*). Tell students, “Once your procedure is completed, you will get it approved by a volunteer.”

Have students start the design process. Place the example question (notebook, page 6) under the document camera so students may refer to it as they design their experiments. As subgroups move onto their experimental set-ups, put the example experimental set-up (notebook, page 7) under the document camera.

Question:

(10 minutes – Subgroups – SciTrek Volunteers)

Have subgroups decide what changing variable(s) they want to explore for their first experiment. Do not try and sway students in any particular direction when choosing their number of changing variables. If they only have one changing variable, do not encourage them to have more; if they have two/three changing variables, do not encourage them to have fewer. Students will analyze their data, and then perform an additional experiment to correct any mistakes they made on their first experiment.

After subgroups have decided on their changing variable(s), have them decide and circle what they will measure. They can then fill out their question. When you sign off on their question, give them a materials page with their subgroup color and number, designated in the upper right-hand corner. An example filled-out question is shown below.

Experimental Considerations:

1. You will only have access to the materials on the materials page.
2. You will only have access to one flashlight with white light and the light must be focused and pointed directly at the center of the block.
3. All objects will be rectangular blocks and you will only be able to change one dimension of the block.

Changing Variable(s) (Independent Variable(s))

You will get to perform two experiments. For your first experiment, decide which variable(s) (max three) you would like to test. For each changing variable you select, discuss with your subgroup why you think that variable will affect the shadow.

Changing Variable 1: Light Distance
(what each variable is, include units when applicable)
 Discuss with your subgroup how you think **changing variable 1** will affect the shadow.

Changing Variable 2 (optional): Light Angle
 Discuss with your subgroup how you think **changing variable 2** will affect the shadow.

Changing Variable 3 (optional): Block Width
 Discuss with your subgroup how you think **changing variable 3** will affect the shadow.

What will you measure? (circle one) Shadow Length Shadow Width

QUESTION

Question our subgroup will investigate:

- If we change the light distance, light angle,
(what each variable is, include units when applicable)
and block width,
 what will happen to the shadow length?
(what you are measuring (dependent variable))

SciTrek Member Approval: LO

Get a materials page from your volunteer and fill it out before moving onto the experimental set-up.

Materials Page:
 (7 minutes – Subgroups – SciTrek Volunteers)

Have subgroups underline their controls and circle their changing variable(s) on the materials page. Then, have them use the materials page to choose the values for their controls and changing variable(s). For the changing variable(s) values, have students write the trial letter (A, B, C, D) next to the value they select. Ask students, “Why did you choose the values you did for your controls and changing variable(s)?, Will these values make it easier or harder to answer your question?”

Make sure students have picked light distances and light heights that are **within the limitations** given on the materials page. In addition, ensure students have no more than one block dimension changing. An example filled-out materials page is shown below.

Color (circle one): Orange Blue Green

Subgroup Number (circle one): 1 2 3

MATERIALS PAGE

You will only have access to the following materials.

- For each bolded word, underline if it is a control and circle if it is a changing variable. Example control: **Block Width**, Example changing variable: **Block Length**.
- For variables that are controls, choose 1 value.
- For variables that are changing variables, choose 4 values and write the trial letter (A,B,C,D or E,F,G,H) next to each value. Ex: B 2 cm A

General Materials:


<input checked="" type="checkbox"/> Flashlight	<input checked="" type="checkbox"/> Ring Stand with Clamp	<input checked="" type="checkbox"/> White Plastic
<input checked="" type="checkbox"/> Protractor	<input checked="" type="checkbox"/> Measuring Tape	<input checked="" type="checkbox"/> (3) Rulers

Look at the picture below that defines the block dimensions. Two of your block's dimensions (which are controls) must be 7 cm and 3 cm. The third dimension can be a control or changing variable and you may select the value(s). You may only circle ONE of these.

Block Length

Block Width

Block Height



The block's width will be:

<input checked="" type="checkbox"/> 2 cm B	<input type="checkbox"/> 5 cm (original)	<input type="checkbox"/> 8 cm
<input type="checkbox"/> 3 cm	<input type="checkbox"/> 6 cm	<input type="checkbox"/> 9 cm
<input checked="" type="checkbox"/> 4 cm D	<input checked="" type="checkbox"/> 7 cm A	<input checked="" type="checkbox"/> 10 cm C

The block's height will be 7 cm.

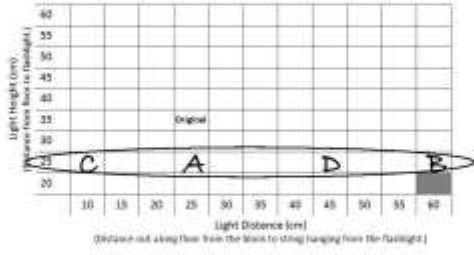
The block's length will be 3 cm.

Light Distance and Light Height

Only mark step 1 if light height is a control and step 2 if light distance is a control.

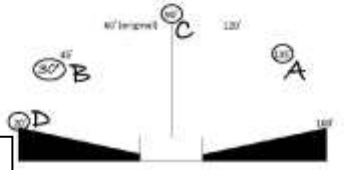
- If light height is one of your controls:
 - The value of light height that we will use is: 25 cm.
 - Circle the row that corresponds to your control value (see example right top).
- If light distance is one of your controls:
 - The value of light distance that we will use is: _____.
 - Circle the column that corresponds to your control value (see example right bottom).

If you have no circles you can select/mark any value that is not grayed out. If you have one circle you can only select/mark values within that circle. If you have two circles you can only select the value that are circled by both circles.



Light Angle

Circle the light angle(s) you will be using between 20° - 160°. If the light angle that you want to use does not appear in the picture below (example: 30°) write in the angle in the appropriate location and circle it.



Materials Page

Experimental Set-Up:
(8 minutes – Subgroups – SciTrek Volunteers)

Have subgroups use their materials page to fill in their experimental set-ups (notebook, page 7). For subgroups who have three changing variables, there will be two control blanks that will not come from the materials page. For these controls students should write “surface/white plastic” and “block material/plastic.” When you sign off on their experimental set-ups, ensure all students within a subgroup have the same trial letters corresponding to the same changing variable values; then, collect the materials page and verify that it is filled out correctly and completely. Filling out the materials page is essential for students to obtain the correct materials for their experiments on Day 3. An example filled out experimental set-up is shown below (left).

EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: block height) and the values (Ex: 5 cm) you will use for your four trials under each block.

Changing Variable(s):

1) Light Distance:	25 cm	60 cm	10 cm	45 cm
2) Light Angle:	135°	30°	90°	20°
3) Block Width:	7 cm	2 cm	10 cm	4 cm

Controls (variables you will hold constant):
Write the controls and the values you will use in all your trials (control/value, Ex: light color/white).

Light Color	/	White	Light Height	/	25 cm
Block Height	/	7 cm	Surface	/	White Plastic
Block Length	/	3 cm	Block Material	/	Plastic

SciTrek Member Approval: LO

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PROCEDURE

Procedure Note:
Make sure to include all values of your changing variable(s) in the procedure (Ex: for a subgroup that decided to change block height, one step would be place block that is 7 cm wide, 3 cm long, and A) 1 cm, B) 5 cm, C) 8 cm, and D) 10 cm high on the white plastic).

1. Get a plastic block that is 7 cm high, 3 cm long, and A) 7 cm, B) 2 cm, C) 10 cm, and D) 4 cm wide.
2. Place block on white plastic.
3. Put light at height of 25 cm, distance and angle A) 25 cm, 135°, B) 60 cm, 30°, C) 10 cm, 90°, and D) 45 cm, 20°.
4. Turn on white light.
5. Measure the length of the shadow.
- 6.

SciTrek Member Approval: LO

8

Procedure:

(19 minutes – Subgroups – SciTrek Volunteers)

After each subgroup has filled out their experimental set-up, they can start on their procedure (notebook, page 8). Make sure students within the same subgroup are collaborating to write their procedure. Keep procedures as brief as possible, while still conveying the pertinent information (control values, changing variable values, and the data they will collect) about the experiment. An example step for a subgroup with block height as a changing variable would be, “Place block that is 7 cm wide, 3 cm long, and A) 2 cm, B) 5 cm, C) 8 cm, and D) 10 cm tall on the white plastic.” Some subgroups may struggle with writing procedures. You can have these subgroups dictate each step while you transcribe them onto a notepad found in your group box. Give this sheet to students to copy into their notebooks. Once students have finished, they should raise their hands and get their procedures approved by their volunteer. An example filled out procedure is show above (right).

If there is time, have your subgroups fill out the variables and prediction section of the results table (see Day 3 for directions and example page).

Wrap-Up:

(3 minutes – Full Class – SciTrek Lead)

If there is time, have one student from each subgroup share what question they will investigate. Tell students, “Next session, you will start your experiments. All of your experiments will help us answer the class question: What variables affect shadows?”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Place materials into your group box and bring them back to UCSB.

Day 3: Results Table/Experiment/Graph/Conclusion Activity
Schedule:

Introduction (SciTrek Lead) – 8 minutes
 Results Table (SciTrek Volunteers) – 3 minutes
 Experiment (SciTrek Volunteers) – 22 minutes
 Graph (SciTrek Volunteers) – 10 minutes
 Conclusion Activity (SciTrek Lead) – 15 minutes
 Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

- | | | |
|--|---|--|
| <input type="checkbox"/> Nametags | <input type="checkbox"/> Picture of Experimental Set-up | <input type="checkbox"/> (2) Red pens |
| <input type="checkbox"/> Notebooks | <input type="checkbox"/> Volunteer lab coat | <input type="checkbox"/> Masking tape |
| <input type="checkbox"/> Volunteer instructions | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> Paper notepad |
| (3) Ziploc bags (gallon size), labeled (with subgroup number), with the following: | | |
| <input type="checkbox"/> Measuring tape (152 cm) | <input type="checkbox"/> Requested block(s) | <input type="checkbox"/> Filled out materials page |
| <input type="checkbox"/> Protractor | <input type="checkbox"/> (3) Rulers | |

Other Supplies:

- | | | |
|--|---|--|
| <input type="checkbox"/> Box with 9 ring stand bases, 9 flashlights, and 9 clamps with string attached | <input type="checkbox"/> Tube with 9 ring stand poles | <input type="checkbox"/> (35) Clipboards |
|--|---|--|

Lead Box:

- | | | |
|---|---|--|
| <input type="checkbox"/> (3) Extra notebooks | <input type="checkbox"/> (2) Red pens | <input type="checkbox"/> Bag of lead shadows supplies: ((3) measuring tapes (152 cm), (2) flashlights, (4) AAA batteries, (2) protractors, (2) clamps with string attached, (9) blocks – one of each size) |
| <input type="checkbox"/> Lead instructions | <input type="checkbox"/> (2) Wet erase markers | <input type="checkbox"/> White plastic surface |
| <input type="checkbox"/> Shadows picture packet | <input type="checkbox"/> (2) Black pens | |
| <input type="checkbox"/> Picture of Experimental Set-up | <input type="checkbox"/> Paper notepad | |
| <input type="checkbox"/> Lead lab coat | <input type="checkbox"/> (6) Rulers | |
| <input type="checkbox"/> Time card | <input type="checkbox"/> (2) Masking tapes | |
| <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> Example block (any size) | |

Notebook Pages:

RESULTS Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in Trial A. Then, draw an arrow through each box indicating the variable is a control.

Variables	Trial A	Trial B	Trial C	Trial D
Light Color:	White			
Block Height:	7 cm			
Block Width:	7 cm	2 cm	10 cm	4 cm
Block Length:	3 cm			
Light Distance:	25 cm	60 cm	10 cm	45 cm
Light Height:	25 cm			
Light Angle:	135°	30°	90°	20°
Surface:	White Plastic			
Block Material:	Plastic			
Predictions	Trial A	Trial B	Trial C	Trial D
Put an "S" in the box that will give the smallest shadow length/width and a "L" in the box that will give the biggest shadow length/width.	B			S
Data	Trial A	Trial B	Trial C	Trial D
Shadow Length or Width	9.5 cm	6 cm	12 cm	6.5 cm

The independent variable(s) is/are the changing variable(s) and the dependent variable is the measurement.

3

RESULTS Graph

Set up your graph. (Check off the steps as you complete them.)

- Label the y-axis (vertical) with what you measured, including units (Ex: Shadow Length (cm)).
- Determine an appropriate scale which will allow you to graph all of your data points and write the numbers on the given lines.
- Label the x-axis (horizontal) with your changing variable(s) #1, #2, and #3 (Ex: Block Height). Changing variable #2 and #3 will only be filled in if you have 2 or 3 changing variables.
- On your results table, label your measurements from 1 to 4, with 1 being the trial with the smallest measurement, and 4 being the trial with the largest measurement.

Plot your data in increasing order.

- Write the changing variable value(s) (Ex: 3 cm) for the trial that you labeled "1" under the first column.
- Graph your data for that trial and write the measurement above the bar.
- Repeat the process for the other trials.

Block Width:	2 cm	4 cm	7 cm	10 cm
Light Distances:	60 cm	45 cm	25 cm	10 cm
Light Angle:	30°	20°	135°	90°

10

SCIENTIFIC PRACTICES
Conclusions

1. Directions: Fill in the missing definition.

- Conclusion: a claim supported by data
 - Claim: A statement that can be tested. The explanation of the data, the first part of a conclusion.
 - Ex: Donuts have more fat than toast
 - Data: Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion.
 - Ex: 1 serving of donuts has 11 grams of fat while 1 serving of toast has 5 grams of fat.

2. Directions: Circle if the statement is a CLAIM, DATA, or an OPINION.

- out of 10 people, only 3 can ride a unicycle. Claim Data Opinion
- puppies are cute. Claim Data Opinion
- people who get 4 hours of sleep experience dizziness. Claim Data Opinion
- ants were observed on syrup, starbursts, and frosted flakes. Claim Data Opinion
- the fastest land animal in the world is the cheetah. Claim Data Opinion
- when 2 mL of vinegar was mixed with 3 g of baking soda, 1 L of gas was produced. Claim Data Opinion
- the more simple the flower, the more bees on the flower. Claim Data Opinion

11

Preparation:

SciTrek Lead:

1. Make sure volunteers are setting out notebooks.
2. Make sure volunteers are setting up for the experiment.
3. Set up the document camera for the filled-out results table (picture packet, page 3), graph (notebook, page 10), conclusion activity (notebook, page 11), and block measurement picture (picture packet, page 1).
4. Have example block available to show students during the Introduction.

SciTrek Volunteers:

1. Set out notebooks/nametags.
2. Set-up experiments in separate areas on the floor.
 - a. Put the ring stands together and attach the flashlight to the clamp. Make sure the flashlight is flush with the front of the clamp. Place the clamp at the lowest place on the ring stand to allow students to put the clamp at the appropriate height(s) when they do their experiment.
 - b. Place bags with supplies (labeled with subgroup numbers), white plastics, and ring stand/clamp set-ups in three unique spots on the floor along with four clipboards.

Note: Set notebooks where students will sit during the module, even if another student is currently at that desk. If needed, students will move to these spots after the Introduction.

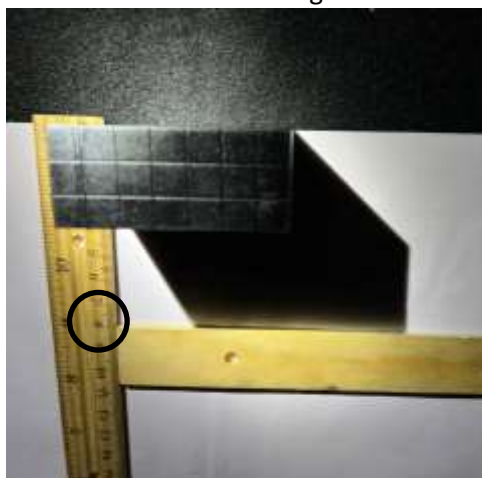
How to Measure Shadow Lengths (left image below)

1. Line up the 0 cm mark of a ruler with the front of the block (edge of the white plastic).
2. Place another ruler (numbers side down) at the edge of the shadow. This will result in the rulers making an "L."
3. The shadow length will be the measurement from the front of the block to the beginning of the upside-down ruler. This point is indicated with a circle in the image below (8 cm).

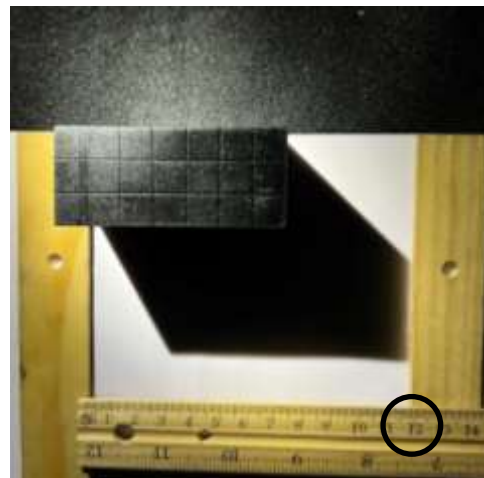
How to Measure Shadow Widths (right image below)

1. Place two rulers (numbers side down) perpendicular to the short side of white plastic on either side of the shadow.
2. Line the 0 cm mark of a third ruler with the inside edge of one of the upside-down rulers. This will result in the rulers making an "H."
3. The shadow width will be the measurement between the two number-side-down rulers. This point is indicated with a circle in this image below (12 cm).

Shadow Length



Shadow Width



Introduction:

(8 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell them, “A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your notebook after the Introduction.”

Ask the class, “What is the class question we are investigating?” Students should reply, “What variables affect shadows?”

Tell students, “Today, you will conduct your experiments to answer this question. However, before you start your experiments, you need to fill out the results table (some students might have completed this in the previous session).” Put the filled-out results table (picture packet, page 3, shown below) under the document camera. Tell students, “You should first underline controls, circle changing variables, and box information about data collection. For controls, you will write the control value in the *Trial A* box. Then, draw an arrow through the remaining trials’ boxes. For the changing variable(s), you will write the changing variable value in each box.” Show students both of these on the filled-out results table. Tell students, “Once you have filled out your results table, you will make predictions about which trial will produce the smallest and biggest shadows. You will write a ‘S’ in the box of the trial you think will produce the smallest (shortest or skinniest) shadow, and an ‘B’ in the box of the trial you think will produce the biggest (longest or widest) shadow. If you think all trials will produce the same size shadow, you will write ‘same’ over all boxes. Once finished, you can raise your hands and you will be dismissed to go to the spot on the floor that has your experimental supplies.”

Tell students, “Once you have collected your data, you will display your measurements on a graph.” Show them how to make a graph using the example data, but make sure they **do not** copy this data into their notebooks; they will graph their own data. Take out the example results table (picture packet, page 3; below, left) and put it under the document camera. Also, have the class notebook open to page 10. Tell students, “For this example experiment, the question was, ‘If we change the block height and light distance, what will happen to the length of the shadow?’” Point to the checklist at the top of page 10 of the class notebook and tell students, “In order to make a graph, you will need to follow the checklist at the top of this page.”

Go through the checklist, and use the results table in the picture packet, to show students how to set up the graph and plot the data points. For the example, only plot the first two data points.

Set up your graph. (Check off the steps as you complete them.)

Tell students, “First, we need to set up the graph, before we can plot the data.”

- Label the y-axis (vertical) with what you measured, including units (Ex: Shadow Length (cm)).*

Tell students, “Since the question is about shadow length, I will graph shadow length.”
Write “shadow length (cm)” on the y-axis of the graph.

- Determine an appropriate scale which will allow you to graph all of your data points and write the numbers on the given lines.*

Tell students, “We need to make sure the longest shadow can be plotted on the graph.” Have students refer to the results table in the picture packet and ask them to identify the longest shadow that was measured (47 cm). Then ask, “Would we be able to fit this shadow length on the graph if we counted by ones?” Students should reply, “No.” Then ask, “What should we count by in order to make sure that the longest shadow’s length will fit on the graph?” Make sure that the class reaches the consensus of fives. When students make their own graphs, they should only count by ones, twos, or fives. Number

the y-axis, making sure students know to start counting at zero. Completely number the y-axis to the top; do not stop numbering after you have passed the largest number you will graph. For example, with a maximum shadow length of 7.5 cm, you would number all the way to 10 cm.

- Label the x-axis (horizontal) with your changing variable(s) #1, #2, and #3 (Ex: Block Height). Changing variable #2 and #3 will only be filled in if you have 2 or 3 changing variables.*

Ask students, "What are the changing variables in this experiment?" Students should reply, "Block height and light distance." Record "Block Height" as changing variable #1, and "Light Distance" as changing variable #2.

- On your results table, label your measurements from 1 to 4, with 1 being the trial with the smallest measurement, and 4 being the trial with the largest measurement.*

Tell students, "Graphs are used to see how changing variables affect a measurement. One way to make it easier to find patterns is to graph the data in increasing order." Put the example results table (picture packet, page 3, below, left) under the document camera, and have students help determine the order in which the trials will be graphed (A, C, D, then B). Write the appropriate number by each trial. This is the step that both students and volunteers often forget, so emphasize its importance when completing it with the class.

Plot your data in increasing order.

Tell students, "Now that you have determined the order in which you will graph your data, you need to plot your data in increasing order. To do this, there are a few steps you need to follow."

- Write the changing variable value(s) (Ex: 3 cm) for the trial that you labeled 1 under the first column.*

Ask students, "Which trial was labeled 1?" Students should reply, "Trial A." Then, ask them, "What should I write next to block height and light distance for the first column?" Write "5 cm" for block height and "10 cm" for light distance in the class notebook.

- Graph your data for that trial and write the measurement above the bar.*

Ask students, "What shadow length should we graph for the first column?" Students should reply, "5 cm." Put your finger at zero, and tell students, "Tell me when to stop once I reach the appropriate level." Once you have reached the level, draw the line, write the numerical value over the line, and quickly shade below the line. Tell students, "Look how quickly I filled in the column. I challenge you to fill your graph in faster than I did, when you graph your own data."

- Repeat the process for the other trials.*

Ask students, "What are the values of the changing variables for the trial we will graph next?" Students should reply, "3 cm for block height, and 45 cm for light distance." Write these in the next column. Ask students, "What is the shadow length for this trial?" Students should reply, "23 cm." Have students help you identify 23 cm on the graph, then, draw a line, and write the numerical value over the line. Tell students, "I will only graph the first two data points, but in your subgroups, you will graph all four points."

RESULTS Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in Trial A. Then, draw an arrow through each line indicating the variable is a control.

Variables	Trial A	Trial B	Trial C	Trial D
Light Color:	White			
Block Height:	5 cm	10 cm	3 cm	7 cm
Block Width:	7 cm			
Block Length:	3 cm			
Light Distance:	10 cm	60 cm	45 cm	25 cm
Light Height:	25 cm			
Light Angle:	30°			
Surface:	White Plastic			
Block Material:	Plastic			
Predictions	Trial A 1	Trial B 4	Trial C 2	Trial D 3
Put an "S" in the trial that will give the smallest shadow length and a "L" in the trial that will give the biggest shadow length.	S	B		
Data	Trial A	Trial B	Trial C	Trial D
Shadow Length or Width	5 cm	30 cm	7 cm	10 cm

The independent variable(s) is/are the changing variable(s) and the dependent variable is the measurement.

Picture Packet, Page 3

RESULTS Graph

Set up your graph. (Check off the steps as you complete them.)

- Label the y-axis (vertical) with what you measured, including units (Ex: Shadow Length (cm)).
- Determine an appropriate scale which will allow you to graph all of your data points and write the numbers on the given lines.
- Label the x-axis (horizontal) with your changing variable(s) #1, #2, and #3 (Ex: Block Height). Changing variable #2 and #3 will only be filled in if you have 2 or 3 changing variables.
- On your results table, label your measurements from 1 to 4, with 1 being the trial with the smallest measurement, and 4 being the trial with the largest measurement.

Plot your data in increasing order.

- Write the changing variable value(s) (Ex: 3 cm) for the trial that you labeled 1 under the first column.
- Graph your data for that trial and write the measurement above the bar.
- Repeat the process for the other trials.

Block Heights: 5 cm 3 cm

Light Distances: 10 cm 45 cm

Remind students how we define the block dimensions. Show students the example block. Place the block on the edge of the picture packet and tell them, “The picture packet will represent the white plastic and the light source would be in front of the block.” Ask students, “What do we call the block dimension going up?” Students should reply, “Height.” Ask students, “What do we call the block dimension going across the front of the white plastic?” Students should reply, “Width.” Ask students, “What do we call the block dimension going away from the light?” Students should reply, “Length.” Show students they can look at the picture at the top of their results table if they forget which dimension is which.

Put page 1 of the picture packet under the document camera and review how to measure the length and width of the shadow. Have students identify, by raising their hands, if they are measuring shadow length. Then, tell those students, “When measuring the length of the shadow, you will line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). You will then place another ruler (numbers side down) perpendicular to the first ruler at the edge of the shadow, making an ‘L’ with the two rulers.” Have students identify by raising their hands if they are measuring shadow width. Then, tell those students, “When measuring the shadow width, you will place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. You will then measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an ‘H’ with the three rulers.”

Tell students, “You will now fill out your results tables and start your experiments. When you are done with your experiments, you can graph your results.”

Results Table:

(3 minutes – Subgroups – SciTrek Volunteers)

Have students underline the variables that are controls, circle the variable(s) that is/are their changing variable(s), and box information about data collection. When writing the values make sure for controls,

they only write the value of the control in the *Trial A* box, then, draw an arrow through the remaining trials' boxes. For the changing variable(s), they should write the values in each trial's corresponding box.

When students have finished, have them make predictions about the shadows. Have them write an "S" in the box of the trial they think will produce the smallest shadow length/width and a "B" in the box of the trial they think will produce the biggest shadow length/width. They will leave two of the boxes empty. If they think all trials will produce the same shadow length/width, have them write "same" over all of the boxes. It is okay if the students in a subgroup have different predictions. An example filled-out results table is shown in the Experiment Section below (left).

Experiment:

(22 minutes – Subgroups – SciTrek Volunteers)

Once subgroups have finished their results tables, show them where their supplies are. If students are missing any of their experimental materials, the lead box has extra materials. If students have a fixed light angle, you can give them masking tape from your group box to tape down their measuring tape so it does not move. For these students, the measuring tape should go under the protractor. For subgroups changing light angle, one option is to have the protractor's swing arm in the correct orientation and then put the measuring tape on top of the protractor. Do not tape down the measuring tape because it will be moved for the next trial. Another option for changing light angle is to keep the measuring tape taped down but move the white plastic instead to change the angle. Either way, remind students to make sure that the flashlight is in line with the protractor and the string is hanging down from the front of the clamp.

Have subgroups show you their set-ups for their first trial before taking any measurements. When checking subgroups' set-ups, verify they have their block in the correct orientation. If subgroups have chosen to change the light angle, and the shadow becomes too wide for the white plastic, the plastic may be moved to see the entire shadow. However, make sure that the direction the block faces does not change when the white plastic is moved. If the shadow is longer or wider than the ruler, have students use a measuring tape found in the lead box.

Make sure subgroups are measuring the correct shadow dimension (length or width) stated in their question and the shadow is being measured as described in the Preparation section above. Have students record the measurement before moving onto the next trial. If your group has things under control, help other subgroups. As soon as subgroups finish their experiments, they can graph their results. Do not take down the experimental set-ups until after subgroups have finished their graph. This way they can check their measurements, if needed. An example filled-out results table is shown below (left).

RESULTS
Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in Trial A. Then, draw an arrow through each box indicating the variable is a control.

Variables	Trial A	Trial B	Trial C	Trial D
Light Color:	White			
Block Height:	7 cm			
Block Width:	7 cm	2 cm	10 cm	4 cm
Block Length:	3 cm			
Light Distance:	25 cm	60 cm	10 cm	45 cm
Light Height:	25 cm			
Light Angle:	135°	30°	90°	20°
Surface:	White Plastic			
Block Material:	Plastic			
Predictions	Trial A	Trial B	Trial C	Trial D
Put an "S" in the trial that will give the smallest shadow length/width and a "L" in the trial that will give the biggest shadow length/width.	B			S
Data	Trial A	Trial B	Trial C	Trial D
Shadow Length Or Width	9.5 cm	6 cm	12 cm	6.5 cm

The independent variable(s) is/are the changing variable(s) and the dependent variable is the measurement.

RESULTS
Graph

Set up your graph. (Check off the steps as you complete them.)

- Label the y-axis (vertical) with what you measured, including units (Ex: Shadow Length (cm)).
- Determine an appropriate scale which will allow you to graph all of your data points and write the numbers on the given lines.
- Label the x-axis (horizontal) with your changing variable(s) #1, #2, and #3 (Ex: Block Height). Changing variable #2 and #3 will only be filled in if you have 2 or 3 changing variables.
- On your results table, label your measurements from 1 to 4, with 1 being the trial with the smallest measurement, and 4 being the trial with the largest measurement.

Plot your data in increasing order.

- Write the changing variable value(s) (Ex: 3 cm) for the trial that you labeled 1 under the first column.
- Graph your data for that trial and write the measurement above the bar.
- Repeat the process for the other trials.

Block Width:	2 cm	4 cm	7 cm	10 cm
Light Distance:	60 cm	45 cm	25 cm	10 cm
Light Angle:	30°	20°	135°	90°

Graph:

(10 minutes – Subgroups – SciTrek Volunteers)

Help subgroups fill out their graphs by having them complete the checklist on the top of page 10. Be sure students label the y-axis with “Shadow Length (cm)” or “Shadow Width (cm),” and the x-axis with all of their changing variable(s). Students will need to decide what scale to use on the y-axis. Students can use ones, twos, or fives. Step 4 of the graphing checklist has students label their measurements in increasing order (1-4) on their results table to ensure that they are graphed in increasing order, as seen in the example above. This makes it easier for the students to see trends in their data. In the example above, the trials were graphed in the following order: B, D, A, C. Once students have graphed their values, make sure they write the numerical value of the shadow length or light width on top of each column, so it is easy to quickly read the graph. An example filled-out graph is shown above (right).

Note: It is okay if students do not complete their graph by the time the lead starts the conclusion activity. **Do not** have students go back and finish their graph (even if they only changed one variable). Students who do not finish their first graph will present their second experiment and, therefore, will not need their first graph.

Conclusion Activity:

(15 minutes – Full Class – SciTrek Lead)

Note: Even if all students are not finished with their graphs, it is important to start the conclusion activity at least 10 minutes before the end of the session.

If students are still sitting on the floor, have them return to their original class seats. Have students turn to page 11 in their notebooks while you turn to page 11 in the class notebook displaying it under the

document camera. Tell students, “Before you analyze your graph and draw a conclusion, it is important that you recognize and understand other scientists’ conclusions.”

Ask the class, “What is a conclusion?” After listening to the students’ answers, make sure they understand a conclusion is a **claim supported by data**. Write this definition on page 11 of the class notebook for students to copy.

Tell students, “In order to make a conclusion, we need to make sure we understand the difference between a claim and data.” First, read the definition of a claim, then, read the example. Tell students, “A claim is a statement we can verify by testing.” Have the class generate two examples of statements that are claims. After a student suggests a possible claim, ask the class, “Can this statement be verified by testing?” Have students hold their thumb up if it can, making it a claim, and down if it cannot. Several examples are shown below.

Examples: rabbits are faster than mice
 giraffes are taller than horses
 watermelons weigh more than pumpkins

Next, read the definition of data and the example. The example data supports the example claim, therefore, by combining the two statements, a conclusion can be formed. This conclusion would be: Donuts have more fat than toast, because 1 serving of donuts has 11 g of fat, while 1 serving of toast has 5 grams of fat. Tell students, “Data often contains a numerical measurement such as a height (5 m), or a mass (20 kg). When you see data in a statement, you should box it.” Have students identify, and then box, the data in the statement (11 g and 5 g). Ask students, “Does data have to contain a numerical measurement?” By the end of the conversation, make sure students understand data can also exist in the form of observations. Tell students, “When a statement contains observational data, the statement will say things like ‘we observed’ or ‘we recorded’ to let you know the experiment was carried out.” If desired you can point out that bread type was the changing variable and circle donuts and toast.

Ask students, “Are all statements either a claim or data?” Lead students to realize some statements are neither a claim nor data. A common example of a statement that is not a claim or data is an opinion statement. Have students generate an example of an opinion statement.

Ex: Watermelons taste better than pumpkins.

Read the directions to part 2 aloud to the class. Tell students, “We will now work as a class to look for clues in the statements to identify whether it is a claim, data, or opinion, and then determine the type of statement.” For each statement, read it aloud to students, then have a student share what they think the correct answer is and why. Have students vote using thumbs up/thumbs down if they agree/disagree with the student’s reasoning. After the class has come to a consensus, circle the correct answer on the class notebook for students to copy. If the statement is a claim, have the students state the data they would need to collect in order to make a conclusion. If the statement is data, have the students generate a claim that could be supported by that data.

For each statement, underline any controls, box any information that is data, and double underline any opinions.

SCIENTIFIC PRACTICES
Conclusions

1. **Directions:** Fill in the missing definitions.

- **Conclusion:** a claim supported by data
 - **Claim:** A statement that can be tested. The explanation of the data, the first part of a conclusion.
 - Ex: Donuts have more fat than toast.
 - **Data:** Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion.
 - Ex: 1 serving of donuts has 11 grams of fat while 1 serving of toast has 5 grams of fat.

2. **Directions:** Circle if the statement is a CLAIM, DATA, or an OPINION.

a. out of <u>10</u> people, only <u>3</u> can ride a unicycle.	Claim	<u>Data</u>	Opinion
b. puppies are <u>cute</u> .	Claim	Data	<u>Opinion</u>
c. people who get <u>4 hours</u> of sleep experience dizziness.	<u>Claim</u>	Data	Opinion
d. ants were <u>observed</u> on syrup, starbursts, and frosted flakes.	Claim	<u>Data</u>	Opinion
e. the fastest land animal in the world is the cheetah.	<u>Claim</u>	Data	Opinion
f. when 2 mL of vinegar was mixed with 3 g of baking soda, <u>1 L</u> of gas was produced.	Claim	<u>Data</u>	Opinion
g. the more <u>simple</u> the flower, the more bees on the flower.	Claim	Data	<u>Opinion</u>

Below are the explanations and answers to part 2, letters a-g, on page 11.

a. out of 10 people, only 3 can ride a unicycle

What type of statement is this, and how do you know?

Data, because it contains a measurement

What claim could be paired with this statement to make a conclusion?

More people are unable to ride a unicycle than those who are able

b. puppies are cute

What type of statement is this, and how do you know?

Opinion, because it contains the word cute

c. people who get 4 hours of sleep experience dizziness

What type of statement is this, and how do you know?

Claim, because this is something that you can test

What data would you need to obtain to support the claim?

Count the number of people that feel dizzy after getting 4 hours of sleep and compare that with the number of people that do not feel dizzy

Are the numbers in this statement a measurement from the experiment?

No, the numbers are describing the experiment and are called descriptive numbers. Tell students, "Descriptive numbers are controls because they are values that are the same for all trials." Write "descriptive number" above 4 hours.

d. ants were observed on syrup, starbursts, and frosted flakes

What type of statement is this, and how do you know?

Data, because it contains an observation

What claim could be paired with this statement to make a conclusion?

Ants are attracted to sugar

e. the fastest land animal in the world is the cheetah

What type of statement is this, and how do you know?

Claim, because it can be tested

What data would you need to obtain to support the claim?

Find the time it takes different animals to run a set distance

f. when 2 mL of vinegar was mixed with 2 g of baking soda, 1 L of gas was produced

What type of statement is this, and how do you know?

Data, because it contains a measurement

What claim could be paired with this statement to make a conclusion?

Mixing vinegar and baking soda results in a chemical reaction

g. the more simple the flower, the more bees on the flower

What type of statement is this, and how do you know?

Opinion, because it contains the word simple

If there is additional time, you can continue on to the next page of the conclusion activity. For details on how to do this see Day 4.

Wrap-Up:

(2 minutes – Full Class – SciTrek Lead)

Tell students, “Next session, you will analyze other scientists’ data to identify appropriate claims and data statements. You will then analyze your own data, and either write a conclusion for your experiment or determine why you cannot draw a conclusion. Afterwards, you will get to design a second experiment.”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Take ring stands apart.
3. Put ring stand poles, flashlight, clamps, ring stand bases, and clipboards back into their containers.
4. Place all other materials into your group box and bring them back to UCSB.

Day 4: Conclusion Activity/Conclusion/Question/Materials Page/Experimental Set-Up/Procedure

Schedule:

- Introduction (SciTrek Lead) – 2 minutes
- Conclusion Activity (SciTrek Lead) – 30 minutes
- Conclusion (SciTrek Volunteers) – 5 minutes
- Question (SciTrek Volunteers) – 5 minutes
- Materials Page (SciTrek Volunteers) – 5 minutes
- Experimental Set-Up (SciTrek Volunteers) – 5 minutes
- Procedure (SciTrek Volunteers) – 6 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

- | | | |
|---|--|--|
| <input type="checkbox"/> Student nametags | <input type="checkbox"/> Volunteer lab coat | <input type="checkbox"/> (2) Pencils |
| <input type="checkbox"/> Notebooks | <input type="checkbox"/> (3) Materials pages (subgroup color/number indicated) | <input type="checkbox"/> (2) Red pens |
| <input type="checkbox"/> Volunteer instructions | | <input type="checkbox"/> Paper notepad |

Lead Box:

- | | | |
|---|--|--|
| <input type="checkbox"/> (3) Extra notebooks | <input type="checkbox"/> (3) Materials pages | <input type="checkbox"/> (2) Wet erase markers |
| <input type="checkbox"/> Lead instructions | <input type="checkbox"/> Time card | <input type="checkbox"/> (2) Black pens |
| <input type="checkbox"/> Shadows picture packet | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> Paper notepad |
| <input type="checkbox"/> Lead lab coat | <input type="checkbox"/> (2) Red pens | |

Notebook Pages:

SCIENTIFIC PRACTICES
Conclusions

3. Directions: Draw a line connecting claims with the correct data. If there is no data that supports the claim, do not draw a line.

Claim	Because	Data
1. More people go to soccer matches than basketball games		a. 1 ml of diet coke weighs 5 g and 1 ml of coke weighs 4.1 g.
2. Spicy food causes heartburn	_____	b. 50% of people get heartburn when they use hot sauce and 10% of people get heartburn when they don't use hot sauce.
3. Cars increase air pollution	_____	c. The air has been <u>observed</u> to be brown in areas with large numbers of cars.
4. Diet coke weighs less than regular coke		d. 10 people went to the movies, while 15 went shopping.

SCIENTIFIC PRACTICES
Conclusions

Variables	Trial A	Trial B
Light Color	White	_____
Block Height	9 cm	_____
Block Width	7 cm	_____
Light Distance	50 cm	_____
Light Height	30 cm	_____
Light Angle	30°	60°
Data	Trial A	Trial B
Shadow Lengths	6 cm	10 cm

4. Directions: Step 1: Identify the following statements as either CLAIM or DATA and write a C or D on the line. Step 2: Look at the results table and circle if the statement is a correct claim, correct data, or incorrect. Statements are INCORRECT if the statement does not agree with the data table or has not been tested.

Statement	Step 1: Claim or Data?	Step 2: Correct Claim, Correct Data, or Incorrect?	
a. the <u>light height</u> affects the length of the shadow	C	Correct Claim	Correct Data <u>Incorrect</u>
b. a large <u>light angle</u> will result in a longer shadow	C	Correct Claim	Correct Data <u>Incorrect</u>
c. when a block is 9 cm tall, different <u>light angles</u> give different shadow lengths	C	Correct Claim	Correct Data <u>Incorrect</u>
d. when the light angle was <u>60°</u> the shadow length was <u>6 cm</u>	D	Correct Claim	Correct Data <u>Incorrect</u>

What data can be used to support claim b above? when the light angle was 60°, the shadow length was 6 cm and when the light angle was 30°, the shadow length was 10 cm.

SCIENTIFIC PRACTICES
Conclusions

Variables	Trial A	Trial B
Light Color	White	→
Block Height	5 cm	10 cm
Block Width	7 cm	→
Light Distance	30 cm	50 cm
Light Height	25 cm	→
Light Angle	90°	→
Data		
	Trial A	Trial B
Shadow Length	5 cm	15 cm

5. a. the longer the light the longer the shadow C Correct Claim Correct Data Incorrect

b. when the block height was 5 cm the shadow length was 5 cm and when the block height was 10 cm the shadow length was 15 cm D Correct Claim Correct Data Incorrect

c. when the block height is smaller, the shadow length is longer C Correct Claim Correct Data Incorrect

d. the longer the light distance the longer the shadow length C Correct Claim Correct Data Incorrect

If no claim can be made from the data state why not. No claim can be made because there is more than one changing variable.

If no claim can be made from the results, can you make a conclusion?
 YES NO

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SCIENTIFIC PRACTICES
Conclusions

6. Directions: Decide if a claim/conclusion can be made for each of the following results tables and graph.

Table A

Variables	Trial A	Trial B
Light Color	White	→
Block Height	8 cm	6 cm
Block Width	3 cm	→
Light Distance	25 cm	30 cm
Light Height	55 cm	→
Light Angle	60°	60°
Data		
	Trial A	Trial B
Shadow Length	8 cm	6 cm

Can this scientist make a claim/conclusion? NO

Table B

Variables	Trial A	Trial B
Light Color	White	→
Block Height	10 cm	→
Block Width	7 cm	→
Light Distance	40 cm	→
Light Height	18 cm	40 cm
Light Angle	90°	→
Data		
	Trial A	Trial B
Shadow Length	8 cm	6 cm

Can this scientist make a claim/conclusion? YES

Table C

Variables	Trial A	Trial B
Light Color	White	→
Block Height	5 cm	6 cm
Block Width	7 cm	→
Light Distance	45 cm	→
Light Height	30 cm	→
Light Angle	30°	→
Data		
	Trial A	Trial B
Shadow Length	2 cm	1 cm

Can this scientist make a claim/conclusion? YES

Graph D

Can this scientist make a claim/conclusion? NO

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Making a Conclusion from Your Data

How many changing variables did you have in your experiment? 2

Can you make a conclusion from your data? YES NO

IF NO

Why? I cannot make a conclusion because my experiment had more than 1 changing variable.

IF YES

CONCLUSION

We can conclude _____ data _____

because _____ data (measurements/observations) _____

SciTrek Member Approval: LO

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Changing Variable(s) (Independent Variable(s))

For your second experiment, decide which variable(s) (max three) you would like to test.

Changing Variable 1: Block Length

Changing Variable 2 (optional): _____

Changing Variable 3 (optional): _____

What will you measure? (circle one) Shadow Length Shadow Width

QUESTION

Question our subgroup will investigate:

- If we change the block length what will happen to the shadow length?

SciTrek Member Approval: LO

Get a materials page from your volunteer and fill it out before moving onto the experimental set-up.

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EXPERIMENTAL SET-UP	PROCEDURE
<p>Write your changing variable(s) (Ex: block height) and the values (Ex: 5 cm) you will use for your trials under each block.</p> <div style="text-align: center;"> </div> <p>Changing Variable(s):</p> <p>1) Block Length : 3 cm 10 cm 8 cm 6 cm</p> <p>2) _____ :</p> <p>3) _____ :</p> <p>Controls (variables you will hold constant): Write the controls and the values you will use in all your trials (control/values, Ex: light color/white).</p> <p>Light Color / White Light Distance / 50 cm</p> <p>Block Height / 7 cm Light Height / 50 cm</p> <p>Block Width / 3 cm Light Angle / 60°</p> <p style="text-align: right;">SciTrek Member Approval: <u>LO</u></p>	<p>Procedure Note: Make sure to include all values of your changing variable(s) in the procedure (Ex: For a subgroup that decided to change block height, one step would be Place block that is 7 cm wide, 3 cm long, and E) 3 cm, F) 10 cm, G) 8 cm, and H) 6 cm high on the white plastic.)</p> <ol style="list-style-type: none"> 1. Get a plastic block that is 7 cm high, 3 cm wide, and E) 3 cm, F) 10 cm, G) 8 cm, and H) 6 cm long. 2. Place block on white plastic. 3. Set up light with distance of 50 cm, height 50 cm, and angle 60°. 4. Turn on white light. 5. Measure the length of the shadow. 6. _____ <p style="text-align: right;">SciTrek Member Approval: <u>LO</u></p>

Preparation:

SciTrek Lead:

1. Make sure volunteers are passing out notebooks.
2. Set up the document camera for the conclusion activity (notebook, pages 12-15).

SciTrek Volunteers:

1. Pass out notebooks/nametags.
2. Make sure you have three materials pages, each filled out with a subgroup number (1, 2, or 3) and your group's color to give to subgroups after they complete their question.
3. Have a red pen available to approve students' conclusions, questions, experimental set-ups, and procedures (notebook, pages 16-19).

Note: Pass out notebooks to students. If needed, students will move to their subgroups after the conclusion activity.

Introduction:

(2 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell students, “You will move to your subgroups after the conclusion activity.”

Tell students, “Today, you are going to match claims with appropriate data and then analyze scientists’ data to determine which claims and data are appropriate for a given set of results. Afterwards, you will analyze your own data to see if you can make a claim/conclusion. You will then have the opportunity to design a second experiment or redesign your first experiment, which will be carried out during the next meeting.”

Conclusion Activity:

(30 minutes – Full Class – SciTrek Lead)

Have students turn to page 12 in their notebooks. While you put the same page of the class notebook under the document camera.

Ask students, “What is the definition of a conclusion?” Students should reply, “A claim supported by data.” Ask students, “What is the definition of a claim?” Students should reply, “A statement that can be tested.” Ask students, “What type of information can be used for data?” Students should reply, “Measurements or observations.”

Tell students, “You are now going to try matching claims with supporting data. Be sure to read the statements carefully, because not all of the claims will make a match. Only draw lines between the claims that match up with supporting data.” Allow students approximately 2 minutes to work by themselves, then go over the answers as a class.

Ask the class, “Has anyone identified a match?” Then, have them give you the number and the letter of the possible match. Read each suggested claim/data match and have the rest of the class show whether they agree/disagree using thumbs up/thumbs down. If they disagree, ask a student to explain. Continue asking students if they are able to make any other connections until all possible matches are made.

SCIENTIFIC PRACTICES
Conclusions

3. **Directions:** Draw a line connecting claims with the correct data. If there is no data that supports the claim, do not draw a line.

Claim	Because	Data
1. More people go to soccer matches than basketball games		a. 1 ml of diet coke weighs 5 g and 1 ml of coke weighs 11g.
2. Spicy food causes heartburn	—————	b. 50% of people get heartburn when they use hot sauce and 10% of people get heartburn when they don't use hot sauce.
3. Cars increase air pollution	—————	c. The air has been observed to be brown in areas with large numbers of cars.
4. Diet coke weighs less than regular coke		d. 10 people went to the movies, while 15 went shopping.

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Below are correct matches that can be made from this activity.

1. Spicy food causes heartburn, because 50% of people get heartburn when they use hot sauce and 10% of people get heartburn when they don't use hot sauce.
This is a correct match, because the data clearly supports the claim using numerical values as data to make a conclusion.
2. Cars increase air pollution, because the air has been observed to be brown in areas with large numbers of cars.
This is a correct match, because the data clearly supports the claim, using an observation to make a conclusion.

Below are incorrect matches that can be made from this activity.

3. Diet coke weighs less than regular coke, because 1 mL of diet coke weighs 5 g and 1 mL of coke weighs 1.1 g.
This is an incorrect match, because the data does not support the claim. The claim says diet coke weighs less than regular coke, however, the data supports the opposite claim, diet coke weighs more. Ask students, "In order to make a conclusion, do you think scientists can change the claim or the data?" Students should realize that scientists can change their claims, but they cannot change their data. In addition, scientists must include all data when generating a claim.
4. More people go to soccer matches than basketball games, because 10 people went to the movies, while 15 went shopping.
This is an incorrect match, because the data has nothing to do with the claim, and thus does not support it. Therefore, this is an incorrect conclusion.

Once this page is complete have the students turn to page 13 in their notebooks.

Have students annotate the results table. As a group, identify then underline the controls (light color, block height, block width, light distance, and light height), circle the changing variable (light angle), and box the information about the data collected (shadow length).

Tell students, "We are now going to look over a list of statements about this results table and decide whether each statement is an example of a claim or data. If the statement is a claim, we will identify and circle the changing variable, if the statement is data, we will box the data. We will then use the results table to determine whether the statement is a correct claim, correct data, or incorrect."

First, read the statement and have students classify the statement as claim, C, or data, D, and write the corresponding letter on the line. Second, have students help you annotate the statement by underlining controls, circling the changing variable (every claim statement will have a changing variable), and boxing any data. Third, have students check the results table to determine whether the statement is a correct claim, correct data, or incorrect, and circle the appropriate answer. Repeat this process for each statement.

If students are struggling to identify the changing variable, ask them, "What experiment would we need to carry out to test this claim?" From their answer, have them identify what they changed.

a. the light height affects the length of the shadow

What type of statement is this and how do you know?

Claim, because it can be tested (write "C" on the line)

What would need to be the changing variable for this claim to be correct?

Light height (circle *light height*)

Is light height a changing variable in this experiment?

No

What should we circle?

Incorrect

b. a larger light angle, will result in a longer shadow

What type of statement is this and how do you know?

Claim, because it can be tested (write "C" on the line)

What would need to be the changing variable for this claim to be correct?

Light angle (circle *light angle*)

Is light angle a changing variable in this experiment?

Yes

Is the claim consistent with the data?

Yes

What should we circle?

Correct claim

c. when a block is 9 cm tall, different light angles give different shadow lengths

What type of statement is this and how do you know?

Claim, because it can be tested (write "C" on the line)

What would need to be the changing variable for this claim to be correct?

Light angle (circle *light angle*)

Is the 9 cm data?

No, it is a descriptive number (one of the controls; underline *9 cm*)

Is light angle a changing variable in this experiment?

Yes

Is the claim consistent with the data?

Yes

What should we circle?

Correct claim

d. when the light angle was 60° the shadow length was 6 cm

What type of statement is this and how do you know?

Data, because it contains a measurement (write "D" on the line and box *6 cm*)

What is the 60°?

This is a value of the changing variable (circle *60°*)

Is the data correct based on the results table?

No

What should we circle?

Incorrect

Tell students, "We are now going to determine the data to support claim b." Read claim *b* aloud (*a larger light angle will result in a longer shadow*) and ask students, "What data can be used to support this claim?" Possible student response: when the light angle was 30° the shadow length was 6 cm and when the light angle was 60° the shadow length was 10 cm. Record this statement in the class notebook. Ask students, "How would people know that the statement generated was data?" Possible student response:

the statement contains measurements. In the statement, box the measurements 6 cm and 10 cm and circle the changing variable values 30° and 60° . Then, read the complete conclusion: a larger light angle will result in a longer shadow, because when the light angle was 30° , the shadow length was 6 cm , and when the light angle was 60° the shadow length was 10 cm .

Ask students, "Can multiple claims be made about a given set of results?" Possible student response: both b and c were correct claims therefore, multiple claims can be made from the same data. Ask students, "Which claim do you think gives the most information, or tries to explain why the shadow is changing lengths?" Students should realize that the claim (claim b), a larger light angle will result in a longer shadow, gives the most information because it states how the shadow might be getting longer. Tell them, "This type of claim also allows scientists to make predictions about systems that have not been experimented with yet. I encourage you all to think about how and why your shadows are changing lengths when you make a claim from your own data."

SCIENTIFIC PRACTICES
Conclusions

Variables	Trial A	Trial B
Light Color	white	→
Block Height	9 cm	→
Block Width	7 cm	→
Light Distance	50 cm	→
Light Height	30 cm	→
Light Angle	30°	60°
Data	Trial A	Trial B
Shadow Lengths	6 cm	10 cm

4. Directions: Step 1: Identify the following statements as either CLAIM or DATA and write a C or D on the line. Step 2: Look at the results table and write if the statement is a correct claim, correct data, or incorrect. Statements are INCORRECT if the statement does not agree with the data table or has not been tested.

	Step 1: Statement Type: C or D	Correct Claim	Correct Data	Incorrect
a. the <u>light height</u> affects the length of the shadow	C	Correct Claim	Correct Data	Incorrect
b. a large <u>light angle</u> will result in a longer shadow	C	Correct Claim	Correct Data	Incorrect
c. when a block is <u>9 cm</u> tall, different <u>light angles</u> give different shadow lengths	C	Correct Claim	Correct Data	Incorrect
d. when the light angle was <u>30°</u> the shadow length was <u>6 cm</u>	D	Correct Claim	Correct Data	Incorrect

What data can be used to support claim b above? when the light angle was 30° , the shadow length was 6 cm and when the light angle was 60° , the shadow length was 10 cm .

Have students turn to page 14 in their notebooks while you do the same in the class notebook.

Have students annotate the results table. As a group, identify and underline the controls (*Light Color*, *Block Width*, *Light Height*, and *Block Angle*), circle the changing variables (*Block Height* and *Light Distance*), and box the information about the data collected (*Shadow Length*).

Tell students, "We are now going to go through the same process that we went through for the statements about the last results table."

a. *the brighter the light, the longer the shadow*

What type of statement is this and how do you know?

Claim, because it can be tested (write "C" on the line)

What would need to be the changing variable for this claim to be correct?

Light brightness (circle *brighter the light*)

Is light brightness a changing variable in this experiment?

No

What should we circle?

Incorrect

b. *when the block height was 6 cm, the shadow length was 5 cm, and when the block height was 10 cm, the shadow length was 13 cm*

What type of statement is this and how do you know?

Data, because it contains measurements (write "D" on the line and box 5 cm and 13 cm)

What are 6 cm and 10 cm?

6 cm and 10 cm are both changing variables (circle 6 cm and 10 cm)

Is the data correct based on the data table?

Yes

What should we circle?

Correct data

c. *when the block height is smaller the shadow length is longer*

What type of statement is this, and how do you know?

Claim, because it can be tested (write "C" on the line)

What would need to be the changing variable for this claim to be correct?

Block height (circle *block height*)

Is block height a changing variable in this experiment?

Yes

Is the claim consistent with the data?

No

What should we circle?

Incorrect

d. *the longer the light distance, the longer the shadow length*

What type of statement is this, and how do you know?

Claim, because it can be tested (write "C" on the line)

What would need to be the changing variable for this claim to be correct?

Light distance (circle *light distance*)

Is light distance a changing variable in this experiment?

Yes

Is the claim consistent with the data?

Yes

Is this claim fair, or could the shadow length be changing because of another reason?

This claim is not fair, because the shadow length could have changed as a result of changing the block height, or light distance

What should we circle?

Incorrect

Ask students, "Why can't a claim be made from the data?" Possible student response: there is more than one changing variable, so you cannot tell which variable affected the results, or how/why these changing

variables affected the shadow length. Record this answer on the class notebook, and have students copy this into their notebooks.

Ask students, "Do you think a conclusion can be made from the data if a claim cannot be made?" Possible student response: since a conclusion is defined as a claim supported by data, you would need both a claim and data to make a conclusion. Since no claims can be made, a conclusion cannot be made either. Have students check the *NO* box in their notebook.

SCIENTIFIC PRACTICES
Conclusions

Variables	Trial A	Trial B
Light Color	White	→
Block Height	5 cm	10 cm
Block Width	7 cm	→
Light Distance	30 cm	50 cm
Light Height	25 cm	→
Light Angle	90°	→
Data	Trial A	Trial B
Shadow Length	5 cm	15 cm

5. **Step 1:** Statement Type C or D. **Step 2:** Based on the table, is the statement a correct claim, correct data, or incorrect?

a. the lighter the light the longer the shadow. **C** Correct Claim Correct Data **Incorrect**

b. when the block height was 5 cm the shadow length was 5 cm and when the block height was 10 cm the shadow length was 15 cm. **D** Correct Claim **Correct Data** Incorrect

c. when the block height is smaller, the shadow length is longer. **C** Correct Claim Correct Data **Incorrect**

d. the longer the light distance the longer the shadow length. **C** Correct Claim Correct Data **Incorrect**

If no claim can be made from the data state why not. No claim can be made because there is more than one changing variable.

If no claim can be made from the results, can you make a conclusion?
 YES NO

SCIENTIFIC PRACTICES
Conclusions

6. Directions: Decide if a claim/conclusion can be made for each of the following results tables and graphs.

Table A

Variables	Trial A	Trial B
Light Color	White	→
Block Height	8 cm	4 cm
Block Width	5 cm	→
Light Distance	25 cm	30 cm
Light Height	50 cm	→
Light Angle	40°	60°
Data	Trial A	Trial B
Shadow Length	8 cm	5 cm

Can this scientist make a claim/conclusion? **No**

Table B

Variables	Trial A	Trial B
Light Color	White	→
Block Height	10 cm	→
Block Width	7 cm	→
Light Distance	40 cm	→
Light Height	15 cm	45 cm
Light Angle	90°	→
Data	Trial A	Trial B
Shadow Length	8 cm	5 cm

Can this scientist make a claim/conclusion? **Yes**

Table C

Variables	Trial A	Trial B
Light Color	White	→
Block Height	5 cm	5 cm
Block Width	7 cm	→
Light Distance	45 cm	→
Light Height	30 cm	→
Light Angle	30°	→
Data	Trial A	Trial B
Shadow Length	2 cm	5 cm

Can this scientist make a claim/conclusion? **Yes**

Graph D

Can this scientist make a claim/conclusion? **No**

Ask students, "What did you learn about conclusions from this activity?" Make sure, by the end of the conversation, students understand that in order to draw a conclusion, there must only be one changing variable in an experiment.

Tell students, "You are now going to look at three results tables and one graph to determine which data sets would allow you to make a claim/conclusion." As a class, go through each table/graph and underline controls, circle changing variable(s), and box information about data collection. It is important for this section that every student has a chance to tell you how to annotate one of the words in the results table. This will help you know who needs extra practice with reading results tables. Once the table/graph has been annotated, have students decide if that group could make a claim/conclusion before moving to the next table/graph.

Once students have completed page 15, ask them the following questions:

- How many changing variables are there?
- Can a claim/conclusion be made from this data?
- Why not or why not?

Tell students, "Tables (such as tables A-C) and graphs (such as graph D) represent two different ways of displaying results from an experiment." Ask students, "What are the advantages and disadvantages of

tables versus graphs?" Students should realize that viewing the data in table form yields a complete idea about what experiment was conducted and which controls were used. However, it is harder to see patterns in the data. Alternatively, viewing the data in graph form allows patterns and trends to be viewed, but does not display the controls the experimenter used.

Tell students, "You will now analyze your own data to see whether or not you can make a conclusion. Remember, it is okay if you cannot draw a conclusion from your first experiment, because you will have the opportunity to run another experiment. When you run a second experiment, you should only change one variable, so that you will be able to draw a conclusion. Once you have decided whether you can or cannot make a conclusion, you will either use your results to make a conclusion, or state why you cannot make a conclusion from your data. After, you can move on to designing your new experiment. You are going to give poster presentations at the end of the module and the presentations will be more interesting if there are a wide range of changing variables that have been tested. In addition, if a wide range of variables are chosen, the class question (What variables affect shadows?) will be more completely answered. Therefore, I challenge you to explore a changing variable that you think few other subgroups are investigating."

Tell students, "You will start working with your subgroup to analyze your old experiment and plan your new experiment."

Conclusion:

(5 minutes – Subgroups – SciTrek Volunteers)

Help subgroups fill out page 16 of their notebooks. If the subgroup has more than one changing variable, they will not be able to draw a conclusion. An example of a scenario in which a subgroup cannot make a conclusion, is shown below (left).

If the subgroup has only one changing variable, they will be able to make a conclusion. Make sure subgroups' conclusions have both a claim (a statement that can be tested) and supporting data (measurements and/or observations), and these statements are in the appropriately labeled sections. Conclusions are still valid, and important, if they show a changing variable does not have an effect on the shadow. Even if their conclusion is contrary to what you think, have students make a claim based solely on their data. If you think their data is flawed, it is okay to ask them what they think went wrong, and encourage them to repeat their experiment. An example of a scenario in which a subgroup can make a conclusion is shown below (right).

<p>Making a Conclusion from Your Data</p> <p>How many changing variables did you have in your experiment? <u>2</u></p> <p>Can you make a conclusion from your data? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO</p> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p>IF NO</p> <p>Why? <u>I cannot make a conclusion because my experiment had more than 1 changing variable.</u></p> </div> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p>IF YES</p> <p style="text-align: center;">CONCLUSION</p> <p>We can conclude _____ <small>claim</small></p> <p>because _____ <small>data (measurements/observations)</small></p> </div> <p style="text-align: right;">SciTrek Member Approval <u>LO</u></p> <p style="text-align: right; font-size: small;">10</p>	<p>Making a Conclusion from Your Data</p> <p>How many changing variables did you have in your experiment? <u>1</u></p> <p>Can you make a conclusion from your data? <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO</p> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p>IF NO</p> <p>Why? _____</p> </div> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p>IF YES</p> <p style="text-align: center;">CONCLUSION</p> <p>We can conclude <u>that the taller the block height, the longer the shadow.</u> <small>claim</small></p> <p>because <u>the 5 cm tall block had a 2 cm long shadow, and the 9 cm tall block had a 5 cm long shadow.</u> <small>data (measurements/observations)</small></p> </div> <p style="text-align: right;">SciTrek Member Approval <u>LO</u></p> <p style="text-align: right; font-size: small;">10</p>
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Question:
(5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups decide what changing variable they want to explore for their second experiment. Make sure each subgroup has only one changing variable, so they will be able to make a claim/conclusion after their experiment. Encourage your subgroups to have different changing variables. The lead will help coordinate between groups to ensure there is a variety of changing variables.

After subgroups have decided on their single changing variable, have them decide and circle what they will measure. They can then fill out their question. When you sign off on their question, give them a materials page with their subgroup color and number designated in the upper right-hand corner. An example filled out question is shown below.

Changing Variable(s) (Independent Variable(s))

For your second experiment, decide which variable(s) (max three) you would like to test.

Changing Variable 1: Block Length

Changing Variable 2 (optional): _____

Changing Variable 3 (optional): _____

What will you measure? (circle one) Shadow Length Shadow Width

QUESTION

Question our subgroup will investigate:

• If we change the block length _____
(pick the changing variable (independent variable))

what will happen to the shadow length _____?
(pick what you are measuring/observing (dependent variable))

SciTrek Member Approval: LO

Get a materials page from your volunteer and fill it out before moving onto the experimental set-up.

17

Materials Page:
(5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups underline their controls and circle their changing variable, on the materials page. Then, have them use the materials page to choose the values for their controls and changing variable. For the changing variable values, have students write the trial letter (E, F, G, H) next to the value they select. Ask students, “Why did you choose the values you did for your controls and changing variable?, Will these values make it easier or harder to answer your question?”

Make sure students have picked light distances and light heights that are **within the limitations** given on the materials page. An example filled-out materials page is shown below.

Color (circle one): Orange Blue **Green**

Subgroup Number (circle one): 1 2 3

MATERIALS PAGE

You will only have access to the following materials.

1) For each boxed word, underline if it is a control and circle if it is a changing variable. Example control: Block Width, Example changing variable: Block Length.

2) For variables that are controls, choose 1 value.


3) For variables that are changing variables, choose 4 values and write the trial letter (A,B,C,D or E,F,G,H) next to each value. Ex: B 2 cm A

General Materials:

Flashlight Ring Stand with Clamp White Plastic
 Protractor Measuring Tape (3) Rulers

Look at the picture below that defines the block dimensions. Two of your block's dimensions (which are controls) must be 7 cm and 3 cm. The third dimension can be a control or changing variable and you may select the value(s). You may only circle ONE of these.

Block Length Block Width Block Height



The block's length will be:

2 cm 5 cm (original) 8 cm **G**
 3 cm **E** 6 cm **H** 9 cm
 4 cm 7 cm 10 cm **F**

The block's height will be 7 cm.

The block's width will be 3 cm.

Light Distance and Light Height

Only fill out step 1 if light height is a control and step 2 if light distance is a control.

1) if light height is one of your controls:

a. The value of light height that we will use is: 50 cm

b. Circle the row that corresponds to your control value (see example right top)

2) if light distance is one of your controls:

a. The value of light distance that we will use is: 50 cm

b. Circle the column that corresponds to your control value (see example right bottom)

If you have no circles you can select/mark any value that is not grayed out.
 If you have one circle you can only select/mark values within that circle.
 If you have two circles you can only select the value that are circled by both circles.

Light Angle

Circle the light angle(s) you will be using between 20° - 160°. If the light angle that you want to use does not appear in the picture below (example: 30°) write in the angle in the appropriate location and circle it.

Materials Page

Experimental Set-Up:
 (5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups use their materials page to fill in their experimental set-ups (notebook, page 18). When you sign off on their experimental set-ups, ensure all students within a subgroup have the same trial letters corresponding to the same changing variable values; then, collect the materials page and verify that it is filled out correctly and completely. Filling out the materials page is essential for students to obtain the correct materials for their experiments on Day 5. An example filled-out experimental set-up is shown below.

EXPERIMENTAL SET-UP	PROCEDURE						
<p>Write your changing variable(s) (Ex: block height) and the values (Ex: 5 cm) you will use for your trials under each block.</p> <div style="text-align: center;"> </div> <p>Changing Variable(s):</p> <p>1) Block Length : 3 cm 10 cm 8 cm 6 cm</p> <p>2) _____ :</p> <p>3) _____ :</p> <p>Controls (variables you will hold constant): Write the controls and the values you will use in all your trials (control values, Ex: light color/white).</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">Light Color / White</td> <td style="width: 50%;">Light Distance / 50 cm</td> </tr> <tr> <td>Block Height / 7 cm</td> <td>Light Height / 50 cm</td> </tr> <tr> <td>Block Width / 3 cm</td> <td>Light Angle / 60°</td> </tr> </table> <p style="text-align: right;">SciTrek Member Approval: <u>LO</u></p>	Light Color / White	Light Distance / 50 cm	Block Height / 7 cm	Light Height / 50 cm	Block Width / 3 cm	Light Angle / 60°	<p>Procedure Note: Make sure to include all values of your changing variable(s) in the procedure (Ex: For a subgroup that decided to change block height, one step would be Place block that is 7 cm wide, 3 cm long, and E) 2 cm, F) 5 cm, G) 8 cm, and H) 10 cm high on the white plastic.)</p> <ol style="list-style-type: none"> 1. Get a plastic block that is 7 cm high, 3 cm wide, and E) 3 cm, F) 10 cm, G) 8 cm, and H) 6 cm long. 2. Place block on white plastic. 3. Set up light with distance of 50 cm, height 50 cm, and angle 60°. 4. Turn on white light. 5. Measure the length of the shadow. 6. _____ <p style="text-align: right;">SciTrek Member Approval: <u>LO</u></p>
Light Color / White	Light Distance / 50 cm						
Block Height / 7 cm	Light Height / 50 cm						
Block Width / 3 cm	Light Angle / 60°						

Procedure:

(6 minutes – Subgroups – SciTrek Volunteers)

After each subgroup has filled out their experimental set-up, they can start on their procedure (notebook, page 19). Make sure students within the same subgroup are collaborating to write their procedure. Keep procedures as brief as possible, while still conveying the pertinent information (control values, changing variable values, and the data they will collect) about the experiment. An example step for a subgroup that had block height as a changing variable would be: “Place block that is 7 cm wide, 3 cm long, and E) 2 cm, F) 5 cm, G) 8 cm, and H) 10 cm tall on the white plastic.” Some subgroups may struggle with writing a procedure. If they are struggling, tell them to look back at their initial procedure on page 8 of their notebooks. If they are still having trouble, you can have these subgroups dictate each step while you transcribe them onto a notepad found in your group box. Give this sheet to the students to copy into their notebooks. Students might not finish their procedure this day. There will be additional time for them to finish their procedure on Day 5. If students do finish their procedure, they should raise their hands and get their procedures approved by their volunteer. An example filled out procedure is shown above.

Wrap-Up:

(2 minutes – Full Class – SciTrek Lead)

Tell students, “Next session, you will carry out the experiments you just designed.”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Place materials into your group box and bring them back to UCSB.

Day 5: Procedure/Results Table/Experiment/Graph/Conclusion

Schedule:

Introduction (SciTrek Lead) – 10 minutes
 Procedure (SciTrek Volunteers) – 5 minutes
 Results Table (SciTrek Volunteers) – 5 minutes
 Experiment (SciTrek Volunteers) – 25 minutes
 Graph (SciTrek Volunteers) – 5 minutes
 Conclusion (SciTrek Volunteers) – 8 minutes
 Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

- | | | |
|---|---|--|
| <input type="checkbox"/> Nametags | <input type="checkbox"/> Picture of Experimental Set-up | <input type="checkbox"/> (2) Red pens |
| <input type="checkbox"/> Notebooks | <input type="checkbox"/> Volunteer lab coat | <input type="checkbox"/> Masking tape |
| <input type="checkbox"/> Volunteer instructions | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> Paper notepad |
| <input type="checkbox"/> (3) Ziploc bags (gallon size), labeled (with subgroup number), with the following: | | |
| <input type="checkbox"/> Measuring tape (152 cm) | <input type="checkbox"/> Requested block(s) | <input type="checkbox"/> Filled out materials page |
| <input type="checkbox"/> Protractor | <input type="checkbox"/> (3) Rulers | |

Other Supplies:

- | | | |
|--|---|--|
| <input type="checkbox"/> Box with (9) ring stand bases, (9) flashlights, and (9) clamps with string attached | <input type="checkbox"/> Tube with (9) ring stand poles | <input type="checkbox"/> (35) Clipboards |
|--|---|--|

Lead Box:

- | | | |
|---|---|--|
| <input type="checkbox"/> (3) Extra notebooks | <input type="checkbox"/> (2) Red pens | <input type="checkbox"/> Bag of lead shadows supplies: ((3) measuring tapes (152 cm), (2) flashlights, (4) AAA batteries, (2) protractors, (2) clamps with string attached, (9) blocks – one of each size) |
| <input type="checkbox"/> Lead instructions | <input type="checkbox"/> (2) Wet erase markers | <input type="checkbox"/> White plastic surface |
| <input type="checkbox"/> Shadows picture packet | <input type="checkbox"/> (2) Black pens | |
| <input type="checkbox"/> Picture of Experimental Set-up | <input type="checkbox"/> Paper notepad | |
| <input type="checkbox"/> Lead lab coat | <input type="checkbox"/> (6) Rulers | |
| <input type="checkbox"/> Time card | <input type="checkbox"/> (2) Masking tapes | |
| <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> Example block (any size) | |

Notebook Pages:

SCIENTIFIC PRACTICES

Conclusions

Questions: If we change the block materials, what will happen to the shadow length?

Variables	Trial A	Trial B	Trial C	Trial D
Light Color:	White			
Block Height:	7 cm			
Block Width:	3 cm			
Block Length:	5 cm			
Light Distance:	20 cm			
Light Height:	25 cm			
Light Angle:	90°			
Block Material:	Wood	Foam	Metal	Cardboard
Data	Trial A	Trial B	Trial C	Trial D
Shadow Length:	12 cm	12 cm	12 cm	12 cm

Write a conclusion from the results above:

We can conclude for a given block dimension, the shadow length will be the same, regardless of the block material, because the metal and the foam blocks both had a shadow length of 12 cm.

RESULTS

Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in Trial E. Then, draw an arrow through each box indicating the variable is a control.

Variables	Trial E	Trial F	Trial G	Trial H
Light Color:	White			
Block Height:	7 cm			
Block Width:	3 cm	10 cm	8 cm	6 cm
Block Length:	3 cm			
Light Distance:	50 cm			
Light Height:	50 cm			
Light Angle:	60°			
Surface:	White Plastic			
Predictions	Trial E	Trial F	Trial G	Trial H
	S	B		
Data	Trial E	Trial F	Trial G	Trial H
Shadow Length:	5.5 cm	14 cm	11.5 cm	9 cm

The independent variable is the changing variable and the dependent variable is the measurement.

RESULTS

Graph

Set up your graph. (Check off the steps as you complete them.)

- Label the y-axis (vertical) with what you measured, including units. (Ex: Shadow Length (cm).)
- Determine an appropriate scale which will allow you to graph all of your data points and write the numbers on the given lines.
- Label the x-axis (horizontal) with your changing variable(s) x_1 , x_2 , and x_3 . (Ex: Block Height). Changing variable x_2 and x_3 will only be filled in if you have 2 or 3 changing variables.
- On your results table, label your measurements from 1 to 4, with 1 being the trial with the smallest measurement, and 4 being the trial with the largest measurement.
- Put your data in increasing order.
- Write the changing variable value(s) (Ex: 3 cm) for the trial that you labeled under the first column.
- Graph your data for that trial and write the measurement above the bar.
- Repeat the process for the other trials.

Block Length: 3 cm 6 cm 8 cm 10 cm

CONCLUSION

Generate a **claim** about how your changing variable affected your results. (Ex: The block material does not affect the shadow length.)

We can conclude increasing the block length will slightly increase the shadow length, when the light distance, and light height, are both 50 cm.

What data do you have to support your claim? (Remember to include your measurements, not trial letters.)

because when the block length was 3 cm the shadow length was 5.5 cm, and when the block length was 10 cm the shadow length was 14 cm.

Can you test the first part (claim) of the conclusion?

YES NO (If you checked this box, go back and revise your claim so that it can be tested.)

The second part of the conclusion is data because it contains a measurement.

I acted like a scientist when I wrote a procedure for the experiment.

Preparation:

SciTrek Lead:

1. Make sure volunteers are passing out notebooks.
2. Make sure volunteers are setting up for the experiment.
3. Set up the document camera for the conclusion example (notebook, page 20) and the block measurement picture (picture packet, page 1).
4. Have example block available to show students during the introduction.

SciTrek Volunteers:

1. Pass out notebooks/nametags.
2. Set-up experiments in separate areas on the floor.
 - a. Put the ring stands together and attach the flashlight to the clamp. Make sure the flashlight is flush with the front of the clamp. Place the clamp at the lowest place on the ring stand to allow students to put the clamp at the appropriate height(s) when they do their experiment.
 - b. Place bags with supplies (labeled with subgroup numbers), white plastics, and ring stand/clamp set-ups in three unique spots on the floor along with four clipboards.
3. Have a red pen available to approve students' procedure (notebook, page 19).

Note: Pass out notebooks to students. If needed, students will move to their subgroups after the Introduction.

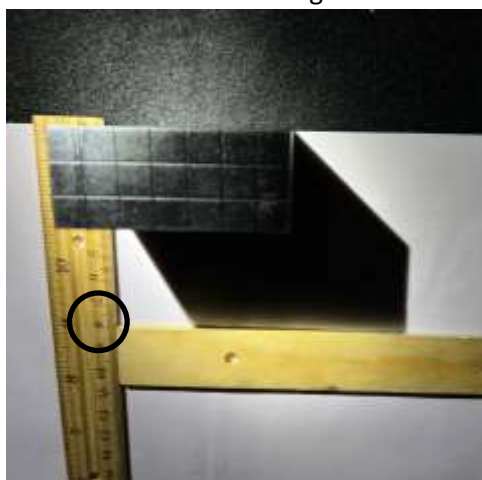
How to Measure Shadow Lengths (left image below)

4. Line up the 0 cm mark of a ruler with the front of the block (edge of the white plastic).
5. Place another ruler (numbers side down) at the edge of the shadow. This will result in the rulers making an "L."
6. The shadow length will be the measurement from the front of the block to the beginning of the upside-down ruler. This point is indicated with a circle in the image below (8 cm).

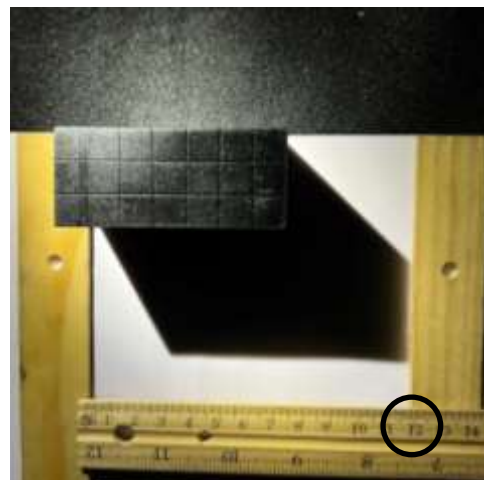
How to Measure Shadow Widths (right image below)

4. Place two rulers (numbers side down) perpendicular to the short side of white plastic on either side of the shadow.
5. Line the 0 cm mark of a third ruler with the inside edge of one of the upside-down rulers. This will result in the rulers making an "H."
6. The shadow width will be the measurement between the two number-side-down rulers. This point is indicated with a circle in this image below (12 cm).

Shadow Length



Shadow Width



Introduction:

(10 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell them, “You will move to your subgroups after the Introduction.”

Ask the class, “What is the class question that we have been investigating?” Students should reply, “What variables affect shadows? Tell students, “Today, you are going to perform your second experiment. Once the experiment is complete, you will analyze your data, and determine what conclusions can be drawn from your results. Your conclusions will help answer the class question.” Ask students, “What is the definition of a conclusion?” Students should reply, “A claim supported by data.” Ask students, “Could we all make conclusions from our data in the first experiment?” Students should reply, “No.” Ask students, “Why not?” Possible student response: because some of us had more than one changing variable. Ask students, “How many changing variables can experiments have in order to make claims/conclusions?” Students should reply, “One changing variable.” Ask them, “Why can we only have one changing variable in order to draw a conclusion?” Possible student response: if there is more than one changing variable, we would not be able to tell which one of the multiple changing variables affects the shadow.

Tell students, “To help learn how to analyze data, we will look at other scientists’ data to see if we can draw a conclusion from their results.” Have students turn to page 20 of their notebook, and place the class notebook under the document camera. Tell students, “Look over the data in this results table.” Ask students, “What was the changing variable in the experiment?” Students should reply, “Block material.” Have students circle *block material*. Next, have students identify, and underline, the controls for the experiment. Students should underline *light color*, *block height*, *block width*, *block length*, *light distance*, *light height*, and *light angle*. Lastly, have students identify the data the scientists collected, and box that information. Students should box *shadow length*. Ask students, “What was the question these scientists were exploring?” Students should reply, “If we change the block material, what will happen to the shadow length?” Fill in the changing variable in the blank in the question above the results table in the class notebook while students do the same in their notebooks. Ask students, “Can a claim/conclusion be made from this data?” Students should realize there is only one changing variable, so a claim/conclusion can be made from these results.

Tell the class, “Now that you know a conclusion can be made from the data, you are going to work together to come up with a conclusion. When drawing a conclusion from data, the first step is making a claim to explain the results.”

Then ask, “Can anyone look at the data and tell me how the block material affected the shadow length?” Possible student response: since all of the shadow lengths are the same, the block material does not affect the shadow length.

Example claim that states how the shadow is affected by the block material:

1. for a given light source and a given block dimension, the shadow length will be the same regardless of the block material

Example claim that states what happened:

1. the block material does not affect the length of the shadow

If possible, try to lead the students to a claim that explains how the shadow changed instead of a claim that just states what happened to the shadow. Tell students, “Claims that allow you to make predictions are more valuable in science, because we can go out and further test our claims to see if they are correct. Therefore, when you try to generate a claim about your data, you should try to have a claim that would allow you to make a prediction.” Write the claim in the class notebook, and have students copy it into theirs.

Ask students, “What data was collected to support this claim?” Lead students to select the two most convincing data points to support their claim, in this case the materials which are the most different from each other and still have the same shadow length. Below is an example of data that supports claims that stated how the shadow was affected.

1. the metal and the foam blocks both had a shadow length of 12 cm.

Ask students, “How do you know that the statement generated was data?” Possible student response: the statement contains measurements, showing that scientists had to go and physically carry out an experiment to discover the results. Write the data after the claim in the class notebook and have students copy it into their notebooks. Make sure students understand the conclusions they will make will be the outcome of their experiments and should answer their experimental questions. In addition, these smaller experimental questions can be combined to help answer a larger question, such as the class question.

SCIENTIFIC PRACTICES
Conclusions

Question: if we change the block materials, what will happen to the shadow length?

Variables	Trial A	Trial B	Trial C	Trial D
Light Color:	White			
Block Height:	7 cm			
Block Width:	3 cm			
Block Length:	5 cm			
Light Distance:	30 cm			
Light Height:	25 cm			
Light Angle:	90°			
Block Material:	Wood	Foam	Metal	Cardboard
Data	Trial A	Trial B	Trial C	Trial D
Shadow Length:	12 cm	12 cm	12 cm	12 cm

Write a conclusion from the results above:

We can conclude for a given block dimension, the shadow length will be the same, regardless of the block material, because the metal and the foam blocks both had a shadow length of 12 cm.

Remind students how we define the block dimensions. Show students the example block. Place the block on the edge of the picture packet and tell them, “The picture packet will represent the white plastic and the light source would be in front of the block.” Ask students, “What do we call the block dimension going up?” Students should reply, “Height.” Ask students, “What do we call the block dimension going across the front of the white plastic?” Students should reply, “Width.” Ask students, “What do we call the block dimension going away from the light?” Students should reply, “Length.” Show students they can look at the picture at the top of their results table if they forget which dimension is which.

Put page 1 of the picture packet under the document camera and review how to measure the length and width of the shadow. Have students identify, by raising their hands, if they are measuring shadow length. Then, tell those students, “When measuring the length of the shadow, you will line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). You will then place another ruler (numbers side down) perpendicular to the first ruler at the edge of the shadow, making an ‘L’ with the two rulers.”

Have students identify by raising their hands if they are measuring shadow width. Then, tell those students, "When measuring the shadow width, you will place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. You will then measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an 'H' with the three rulers."

Tell students, "After you have finished your procedure and results table, you can start your experiment, and then graph your data. This will help you make a conclusion about how your changing variable affects shadows."

Procedure:

(5 minutes – Subgroups – SciTrek Volunteers)

Help subgroups complete their procedures (notebook, page 19). Make sure students within the same subgroup are collaborating to write their procedure. Keep procedures as brief as possible, while still conveying the pertinent information (control values, changing variable values, and the data they will collect). An example step for a subgroup that had block height as a changing variable would be: "Place block that is 7 cm wide, 3 cm long, and E) 2 cm, F) 5 cm, G) 8 cm, and H) 10 cm tall on the white plastic." Some subgroups may struggle with writing a procedure. If they are struggling, tell them to look back at their initial procedure on page 8 of their notebooks. If they are still having trouble, you can have these subgroups dictate each step while you transcribe them onto a notepad found in your group box. Give this sheet to the students to copy into their notebooks. Once students finish, they should raise their hands and get their procedures approved by their volunteer. An example filled out procedure is shown below (left).

PROCEDURE

Procedure Note:
Make sure to include all values of your changing variable(s) in the procedure (Ex: for a subgroup that decided to change block height, one step would be: place block that is 7 cm wide, 3 cm long, and E) 2 cm, F) 5 cm, G) 8 cm, and H) 10 cm high on the white plastic).

1. Get a plastic block that is 7 cm high, 3 cm wide, and E) 3 cm, F) 10 cm, G) 8 cm, and H) 6 cm long.
2. Place block on white plastic.
3. Set up light with distance of 50 cm, height 50 cm, and angle 60°.
4. Turn on white light.
5. Measure the length of the shadow.
- 6.

SciTrek Member Approval LD

RESULTS Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in Trial E. Then, draw an arrow through each box indicating the variable is a control.

Variables	Trial E	Trial F	Trial G	Trial H
Light Color:	White			
Block Height:	7 cm			
Block Width:	3 cm	10 cm	8 cm	6 cm
Block Length:	3 cm			
Light Distance:	50 cm			
Light Height:	50 cm			
Light Angle:	60°			
Surface:	White Plastic			
Predictions	Trial E	Trial F	Trial G	Trial H
Put an "S" in the trial that will give the smallest shadow length/width and a "B" in the trial that will give the biggest shadow length/width.	S	B		
Data	Trial E	Trial F	Trial G	Trial H
Measurements: <div style="border: 1px solid black; padding: 2px; display: inline-block;"> Shadow Length Or Width </div>				

The independent variable is the changing variable and the dependent variable is the measurement.

Results Table:

(5 minutes – Subgroups – SciTrek Volunteers)

Have students underline the variables that are controls, circle the variable that is their changing variable, and box information about data collection. When writing the values make sure for controls, they only write the value of the control in the *Trial E* box, then, draw an arrow through the remaining trials' boxes. For the changing variable, they should write the values in each trial's corresponding box.

When students have finished, have them make predictions about the shadows. Have them write an "S" in the box of the trial they think will produce the smallest shadow length/width and a "B" in the box of the trial they think will produce the biggest shadow length/width. They will leave two of the boxes empty. If they think all trials will produce the same shadow length/width, have them write "same" over all of the boxes. It is okay if the students in a subgroup have different predictions. An example filled out results table can be seen above (right).

Experiment:

(25 minutes – Subgroups – SciTrek Volunteers)

Once subgroups have finished their results tables, show them where their supplies are. If students are missing any of their experimental materials, the lead box has extra materials. If students have a fixed light angle, you can give them masking tape from your group box to tape down their measuring tape so it does not move. For these students, the measuring tape should go under the protractor. For subgroups changing light angle, one option is to have the protractor's swing arm in the correct orientation and then put the measuring tape on top of the protractor. Do not tape down the measuring tape because it will be moved for the next trial. Another option for changing light angle is to keep the measuring tape taped down but move the white plastic instead to change the angle. Either way, remind students to make sure that the flashlight is in line with the protractor and the string is hanging down from the front of the clamp.

Have subgroups show you their set-ups for their first trial before taking any measurements. When checking subgroups' set-ups, verify they have their block in the correct orientation. If subgroups have chosen to change the light angle, and the shadow becomes too wide for the white plastic, the plastic may be moved to see the entire shadow. However, make sure that the direction the block faces does not change when the white plastic is moved. If the shadow is longer or wider than the ruler, have students use a measuring tape found in the lead box.

Make sure subgroups are measuring the correct shadow dimension (length or width) stated in their question and the shadow is being measured as described in the Preparation section above. Have students record the measurement before moving onto the next trial. If your group has things under control, help other subgroups. As soon as subgroups finish their experiments, they can graph their results. Do not take down the experimental set-ups until after subgroups have finished their graph. This way they can check their measurements, if needed. An example filled-out results table is shown below (left).

Graph:

(5 minutes – Subgroups – SciTrek Volunteers)

Help subgroups fill out their graphs by having them complete the checklist on the top of page 22. Be sure students label the y-axis with "Shadow Length (cm)" or "Shadow Width (cm)," and the x-axis with their changing variable. Students will need to decide what scale to use on the y-axis. Students can use ones, twos, or fives. Step 4 of the graphing checklist has students label their measurements in increasing order (1-4) on their results table to ensure that they are graphed in increasing order, as seen in the example below. This makes it easier for the students to see trends in their data. In the example below, the trials

were graphed in the following order: E, H, G, F. Once students have graphed their values, make sure they write the numerical value of the shadow length or width on top of each column, so it is easy to quickly read the graph. An example filled out graph is shown below (right).

RESULTS Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in Trial E. Then, draw an arrow through each box indicating the variable is a control.

Variables	Trial E	Trial F	Trial G	Trial H
Light Color:	White			
Block Height:	7 cm			
Block Width:	3 cm	10 cm	8 cm	6 cm
Block Length:	3 cm			
Light Distance:	50 cm			
Light Height:	50 cm			
Light Angle:	60°			
Surface:	White Plastic			
Predictions				
Put an "S" in the trial that will give the smallest shadow length/width and a "B" in the trial that will give the biggest shadow length/width.	S	B		
Data	Trial E 1	Trial F 4	Trial G 3	Trial H 2
Measurements: Shadow Length Or Width	5.5 cm	14 cm	11.5 cm	9 cm

The independent variable is the changing variable and the dependent variable is the measurement.

RESULTS Graph

Set up your graph. (Check off the steps as you complete them.)

- Label the y-axis (vertical) with what you measured, including units (Ex: Shadow Length (cm)).
- Determine an appropriate scale which will allow you to graph all of your data points and write the numbers on the given lines.
- Label the x-axis (horizontal) with your changing variable(s) #1, #2, and #3 (Ex: Block Height). Changing variable #2 and #3 will only be filled in if you have 2 or 3 changing variables.
- On your results table, label your measurements from 1 to 4, with 1 being the trial with the smallest measurement, and 4 being the trial with the largest measurement.

Plot your data in increasing order.

- Write the changing variable value(s) (Ex: 3 cm) for the trial that you labeled 1 under the first column.
- Graph your data for that trial and write the measurement above the bar.
- Repeat the process for the other trials.

Changing variable 1: _____
 Changing variable 2: _____
 Changing variable 3: _____

Conclusion:

(8 minutes – Subgroups – SciTrek Volunteers)

Have subgroups use their graphs to look for patterns in their data. Challenge subgroups to think about how their changing variable did, or did not, affect the shadows’ length/width.

When writing their conclusion (notebook, page 23), make sure subgroups begin the statement with a claim (statement that can be tested), about the trend, or pattern in their data. If the values of their changing variable have an order (Ex: 2 cm → 5 cm → 8 cm → 10 cm), then that variable does have an effect on the shadow length/width. If, on the other hand, there was no order for their changing variable values (Ex: 5 cm → 10 cm → 2 cm → 8 cm), and/or the difference between shadow lengths/widths for each trial is small, then that variable does not have an effect on the shadow length/width. If possible, try to have subgroups generate a claim that allows them to make predictions about something they have not tested. Challenge subgroups to think about how (claims 1 and 2 below) their changing variable does or does not affect their measurements, instead of just what happened (claim 3 below).

Example claims that state how the changing variable did or did not affect the shadow.

Claim 1: the taller the block, the longer the shadow

Claim 2: as the light height increases, the shadow becomes more rectangular and less trapezoidal

Example claims that state what happened to the shadow.

Claim 3: the block height affects the shadow length

Once they have discussed their ideas, have the subgroups fill out the section labeled, “Generate a claim about how your changing variable affected your results” (notebook, page 23).

If there is time, subgroups can determine the data to support their claim. For an example of how to do this, see the Conclusion section on Day 6. Example student work for the conclusion section can be seen below.

CONCLUSION

Generate a claim about how your changing variable affected your results. (Ex: The block material does not affect the shadow length.)	We can conclude <u>increasing the block length will slightly increase the shadow length, when the light distance, and light height, are both 50 cm</u>
What data do you have to support your claim? (Remember to include your measurements, not trial letters.)	because <u>when the block length was 3 cm the shadow length was 5.5 cm, and when the block length was 10 cm the shadow length was 14 cm.</u>

Can you test the first part (claim) of the conclusion?

YES NO (If you checked this box, go back and revise your claim so that it can be tested.)

The second part of the conclusion is data because it contains a measurement.

I acted like a scientist when I wrote a procedure for the experiment.

23

Wrap-Up:

(2 minutes – Subgroups – SciTrek Lead)

Tell students, “Next session, you will have time to finish your conclusions, and then make a poster to share your results with the class.”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Take ring stand apart.
3. Put ring stand poles, flashlights, clamps, ring stand bases, and clipboards back into their containers.
4. Place all other materials into your group box and bring them back to UCSB.

Day 6: Conclusion/Poster Making

Schedule:

Introduction (SciTrek Lead) – 2 minutes
 Conclusion (SciTrek Volunteers) – 18 minutes
 Poster Making (SciTrek Volunteers) – 35 minutes
 Wrap-Up (SciTrek Lead) – 5 minutes

Materials:

(3) Volunteer Boxes:

- | | | |
|--|---|---|
| <input type="checkbox"/> Nametags | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> (3) Poster parts packs
(scientists' names, question,
experimental set-up, procedure,
results table, results graph,
conclusion, (4) <i>I acted like a
scientist when</i> , (4) picture
spaces) |
| <input type="checkbox"/> Notebooks | <input type="checkbox"/> Paper notepad | |
| <input type="checkbox"/> Volunteer instructions | <input type="checkbox"/> (Bag) Paperclips | |
| <input type="checkbox"/> Volunteer lab coat | <input type="checkbox"/> Highlighter | |
| <input type="checkbox"/> Poster diagram | <input type="checkbox"/> Scissors | |
| <input type="checkbox"/> (3) Stickers on how to present
graph | <input type="checkbox"/> (2) Glues | |

Other Supplies:

- Poster paper tube

Lead Box:

- | | | |
|---|--|--|
| <input type="checkbox"/> (3) Extra notebooks | <input type="checkbox"/> (3) Stickers on how to present
graph | <input type="checkbox"/> (2) Highlighters |
| <input type="checkbox"/> Lead instructions | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> (2) Scissors |
| <input type="checkbox"/> Shadows picture packet | <input type="checkbox"/> (2) Wet erase markers | <input type="checkbox"/> (2) Glues |
| <input type="checkbox"/> Lead lab coat | <input type="checkbox"/> (2) Black pens | <input type="checkbox"/> Scotch tape |
| <input type="checkbox"/> Poster diagram | <input type="checkbox"/> Paper notepad | <input type="checkbox"/> (3 each color) Poster part
packs |
| <input type="checkbox"/> Time card | <input type="checkbox"/> (Bag) Paperclips | |

Preparation:

SciTrek Lead:

1. Make sure volunteers are setting out notebooks.
2. Find a place to leave student posters.

SciTrek Volunteers:

1. Set out notebooks/nametags.

Note: Set notebooks where students will sit during the module, even if another student is currently at that desk. If needed, students will move to these spots after the Introduction.

Notebook Page:

CONCLUSION	
Generate a claim about how your changing variable affected your results. (Ex: The block material does not affect the shadow length.)	We can conclude <u>increasing the block length will slightly increase the shadow length, when the light distance, and light height, are both 50 cm</u>
What data do you have to support your claim? (Remember to include your measurements, not trial letters.)	because <u>when the block length was 3 cm the shadow length was 5.5 cm, and when the block length was 10 cm the shadow length was 14 cm.</u>
Can you test the first part (claim) of the conclusion?	
<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO (If you checked this box, go back and revise your claim so that it can be tested.)	
The second part of the conclusion is data because it contains a <u>measurement.</u>	
I acted like a scientist when <u>I wrote a procedure for the experiment.</u>	
23	

Introduction:

(2 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups tell them, “A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your notebook after the Introduction”

Ask the class, “What is the class question we have been investigating?” Students should reply, “What variables affect shadows?” Tell students, “Today, you are going to finish your conclusions and make posters to present your findings to the class.” Ask students, “How do scientists define a conclusion?” Students should reply, “A claim supported by data.” Ask students, “What is a claim?” Students should reply, “A statement that can be tested.” Ask students, “What can be used for data?” Students should reply, “Measurements or observations.”

Tell students, “After you finish your conclusion, you will fill in the sentence frame ‘I acted like a scientist when,’ stating how you acted like a scientist during your SciTrek experience. Try to come up with a unique answer that is something besides ‘I did an experiment.’”

Tell students, “When scientists complete their experiments, they make posters to present their findings to other scientists. Each subgroup will create a poster to present to the class during the next session. You will get to pick which one of your two experiments to present, but it should be an experiment in which you were able to draw a conclusion. This presentation will be your chance to tell the class what your subgroup has discovered about the class question. You should write as neatly as possible on the poster parts, so the other class members can read your posters. You will now start working with your subgroup to analyze your experimental results, and make a poster.”

Conclusion:

(18 minutes – Subgroups – SciTrek Volunteers)

If subgroups have not made a claim about their data, have them analyze the data in their graph in order to make one. For an example of how this is done, see the Conclusion section in Day 5.

After generating a claim about their experiment, subgroups will put the supporting data after the *because* in their conclusion sentence. Their supporting data should include at least two pieces of data, typically the minimum and maximum lengths/heights. Make sure subgroups are using their changing variable values (not trial letters), and specific measurements, to support their claims.

Example data to support the three claims that were previously listed.

Data 1: the shadow length for the 10 cm (tallest) block was 15 cm, and the shadow length for the 3 cm (shortest) block was 4.5 cm

Data 2: it was observed that when the light height was 10 cm, the shadow was a trapezoid and when the light height was 60 cm the shadow was a rectangle

Data 3: the shadow length for the 10 cm block was 15 cm, and the shadow length for the 3 cm block was 4.5 cm

Conclusions are still valid, and important, if they show the changing variable tested does not have an effect on the shadow length/height. Even if their conclusion is contrary to what you think, have subgroups make a claim based solely on their data.

Once subgroups have written their conclusions, have them complete the two questions that follow. First, have them verify that the first part of their statement is testable, making it a claim. If it is not a claim, have them go back and revise the first part of the statement. Second, have students justify how they know the second part of the statement is data. Statements that are data contain measurements or observations. If the statement is an observation, make sure the word “recorded” or “observed” is in the statement to indicate that the experiment was carried out. If the data statement does not have a measurement or an observation, have students modify their statement.

An example filled out conclusion is shown below.

CONCLUSION

Generate a claim about how your changing variable affected your results. (Ex: The block material does not affect the shadow length.)

We can conclude increasing the block length will slightly increase the shadow length, when the light distance, and light height, are both 50 cm.

What data do you have to support your claim? (Remember to include your measurements, not trial letters.)

because when the block length was 3 cm the shadow length was 5.5 cm, and when the block length was 10 cm the shadow length was 14 cm.

Once students have filled out their conclusion have them fill in the sentence frame *I acted like a scientist when* (notebook, page 23). Each student’s response should be unique and specific. They should **not** write, “when I did an experiment,” because this is general and applies to all of the students in the class. If students are having trouble with this sentence frame, ask them, “What did you do during SciTrek?”

Poster Making:

(35 minutes – Subgroups – SciTrek Volunteers)

Each subgroup (three/four students) will make one poster for one of their experiments from which they were able to draw a conclusion. If a subgroup was able to make a conclusion from both experiments, they can choose whichever experiment they think will better help answer the class question. Every student in the subgroup will have both a writing and a speaking part in their presentation.

Pass out the writing portions (general poster parts and *I acted like a scientist when*) and have students write their names on them and complete them. In addition, have each student write their name on the scientists’ names poster part. Use the following guidelines when assigning poster parts:

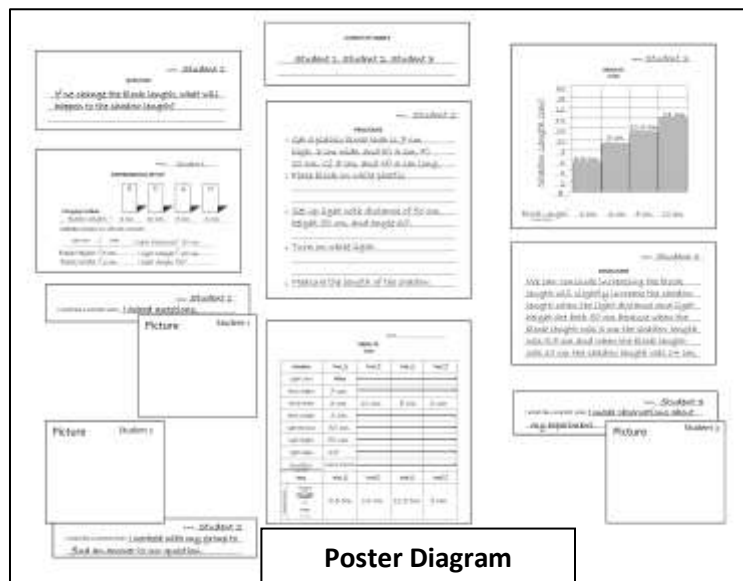
Number of Students in Subgroup	Poster Division	
	Each student gets an <i>I acted like a scientist when</i> and picture space.	
3	1. Question and Experimental Set-Up 2. Procedure 3. Results Graph* and Conclusion	Student who finishes 1 st completes the results table (<u>not</u> presented)
4	1. Question and Experimental Set-Up 2. Procedure 3. Results Graph* 4. Conclusion	Student who finishes 1 st completes the results table (<u>not</u> presented)

*Give the results graph to the student who is most confident in presenting.

for the student, but leave the *value* and *measurement* blanks empty. The student will fill these in verbally for each data piece.

As soon as students have completed some of their pieces, start gluing them onto the large poster paper, in landscape orientation, exactly as they are arranged in the example below. Do not allow students to glue the poster parts on the posters. Do not wait until students have completed all the pieces to start gluing them onto the posters.

Once the poster is complete, have students start practicing for the presentation. Make sure students read from their notebooks, instead of from the poster.



Ask each of your subgroups a few questions about their posters. Have them use their findings to predict what would happen to the shadow for other changing variable values they did not perform tests on. For instance, if the subgroup’s conclusion was, “The shorter the light height, the longer the shadow, because when the light height was 25 cm the shadow length was 40 cm, and when the light height was 45 cm the shadow length was 20 cm,” ask the subgroup to predict what the shadow length will be for 35 cm. They should be able to predict that it would be ~35 cm.

If there is additional time, tell each subgroup, “Other students will ask you questions during your poster presentations. You should think about what questions you might be asked, and think of the answers to those questions, so you will be prepared during your presentation.”

Wrap-Up:

(5 minutes – Full Class – SciTrek Lead)

Ask students the following questions:

- How did you act like a scientist during this project?
- What did you do, that scientists do?

After discussing how they acted like scientists, and talking about how everyone does things scientists do in their everyday lives, tell students, “Next session, you will present your findings to the class, and I am looking forward to hearing about all of your experiments.”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Leave posters in the classroom.
3. Place all other materials into your group box and bring them back to UCSB.

Day 7: Poster Presentations
Schedule:

Introduction (SciTrek Lead) – 2 minutes

Practice Posters (SciTrek Volunteers) – 5 minutes

Poster Presentations (SciTrek Volunteers/SciTrek Lead) – 51 minutes

Wrap-Up (SciTrek Lead) – 2 minutes

Materials:
(3) Volunteer Boxes:

- | | | |
|---|---|--|
| <input type="checkbox"/> Nametags | <input type="checkbox"/> Volunteer lab coat | <input type="checkbox"/> Highlighter |
| <input type="checkbox"/> Notebooks | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> (12) Sharpened SciTrek pencils (all same color) |
| <input type="checkbox"/> Volunteer instructions | <input type="checkbox"/> (Bag) Paperclips | |

Lead Box:

- | | | |
|---|---|---|
| <input type="checkbox"/> (3) Extra notebooks | <input type="checkbox"/> (3) Stickers on how to present graph | <input type="checkbox"/> (2) Black pens |
| <input type="checkbox"/> Lead instructions | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> (Bag) Paperclips |
| <input type="checkbox"/> Shadows picture packet | <input type="checkbox"/> (2) Wet erase markers | <input type="checkbox"/> (2) Highlighters |
| <input type="checkbox"/> Lead lab coat | | <input type="checkbox"/> Scotch tape |
| <input type="checkbox"/> Time card | | |

*Student posters should already be in the classroom.

Preparation:
SciTrek Lead:

1. Make sure volunteers are passing out notebooks.
2. Set up the document camera for the *Notes on Presentations* (picture packet, pages 4 and 5).
3. Organize posters so experiments featuring the same changing variable will be presented back to back and posters are presented from simplest to understand, to most difficult to understand (suggested order: block height, block width, block length, light height, light distance, light angle).

SciTrek Volunteers:

1. Pass out notebooks/nametags.
2. Have pencils ready to distribute to your group after the poster presentations.

Note: Today, students will sit in their regular classroom seats during poster presentations.

Picture Packet Pages: (Notebook pages 24 and 25 are almost identical to picture packet pages 4 and 5, but have one less subgroup space.)

NOTES ON PRESENTATIONS
What variables affect shadows?

Subgroup 1
Changing Variable: Block Height (cm)

Block Height (cm)	2	4	7	10
Shadow Length (cm)	3	4	5.5	6.5

Summary: The taller the block, the longer the shadow.

Subgroup 2
Changing Variable: Block Width (cm)

Block Width (cm)	3	6	9	10
Shadow Length (cm)	5	7	11.5	13

Summary: The wider the block, the wider the shadow.

Subgroup 3
Changing Variable: Block Length (cm)

Block Length (cm)	3	6	8	10
Shadow Length (cm)	5.5	9	11.5	14

Summary: The longer the block, the longer the shadow.

Subgroup 4
Changing Variable: Block Length (cm)

Block Length (cm)	2	4	7	10
Shadow Length (cm)	8	8	8	8

Summary: Block length does not affect shadow width.

4

Picture Packet, Page 4

Subgroup 5
Changing Variable: Light Height (cm)

Light Height (cm)	55	40	25	10
Shadow Length (cm)	4	5	7	28

Summary: The higher the light, the narrower the shadow.

Subgroup 6
Changing Variable: Light Height (cm)

Light Height (cm)	60	45	35	20
Shadow Length (cm)	6	10	15	20

Summary: The higher the light, the shorter the shadow.

Subgroup 7
Changing Variable: Light Distance (cm)

Light Distance (cm)	15	30	50	60
Shadow Length (cm)	5	12	21	30

Summary: The farther the light, the longer the shadow.

Subgroup 8
Changing Variable: Light Distance (cm)

Light Distance (cm)	15	30	45	60
Shadow Length (cm)	4	10	28	45

Summary: Agrees with previous group.

Subgroup 9
Changing Variable: Light Angle (°)

Light Angle (°)	90°	135°	45°	20°
Shadow Length (cm)	4	7	7	18

Summary: As the light angle gets closer to 90°, the shadow gets narrower.

5

Picture Packet, Page 5

Introduction:

(2 minutes – Full Class – SciTrek Lead)

Tell students, “Today you will present your posters to the class. This is a common practice in science. Scientists go to conferences where they present posters about the experiments they conducted. At these presentations, other scientists give them feedback on their experiments, which allows them to return to the lab with new ideas for future experiments. You will have 5 minutes to practice presenting your poster with your subgroup. When you present, you should read from your notebooks, not your poster. After practicing, you will return to your normal classroom seats.”

Practice Posters:

(5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups practice their poster presentation, making sure they are reading the poster parts in the correct order (scientists’ names, question, experimental set-up, procedure, results graph, and conclusion). Make sure each student’s part is highlighted in their notebook. If students are reading from multiple pages, use a paperclip to clip these pages together, to make it easier for them to flip back and forth. Remind students to read from their notebooks rather than from their posters.

Do not let poster practice go over 5 minutes.

Poster Presentations:

(51 minutes – Full Class – SciTrek Volunteers/SciTrek Lead)

Have students return to their original class seats. Ask the class, “What is the question we have been investigating?” Students should reply, “What variables affect shadows?” Tell students, “During the presentations, you are going to take notes.” Have them turn to page 24 in their notebooks while you turn to page 5 of the picture packet. Tell them, “You will need to record each subgroup’s changing variable, as well as what data they have collected after the subgroup says their question. In addition, when the group presents their graph, you will need to record the values of the changing variable, as well as the corresponding measurements collected by the subgroup.”

Tell students, “You will get the chance to ask scientific questions after each presentation. These questions are important, because you will have to summarize what you learned from the subgroup and record it in your notebook. Therefore, your questions should focus on helping you be able to summarize the subgroup’s findings. If you ask a scientific question during the presentation, you will get a SciTrek pencil at the end of the presentations.”

Notebooks only have room for notes on eight presentations. Therefore, they will not take notes on their own presentation.

Volunteers should make sure students are quiet and respectful when other subgroups are presenting. When one of your subgroups is presenting, go to the front of the room with them; prompt students if they do not know who talks next and remind them to read from their notebooks.

During the student question time, the lead and/or volunteers should ask at least one question. Examples of possible questions are: “How do you know...?” or “Is there anything else you can do to get more information about your question?” Each subgroup should answer approximately four questions (one question per student). When students are done asking questions, have them summarize what the subgroup found.

An example filled out *Notes on Presentations*, are shown below.

NOTES ON PRESENTATIONS
What variables affect shadows?

Subgroup 1

Changing Variable:		Block Height (cm)	2	4	7	10
Shadow	Length	Width (cm)	3	4	5.5	6.5

Summary: The taller the block, the longer the shadow.

Subgroup 2

Changing Variable:		Block Width (cm)	3	6	9	10
Shadow	Length	Width (cm)	5	7	11.5	13

Summary: The wider the block, the wider the shadow.

Subgroup 3

Changing Variable:		Block Length (cm)	3	6	8	10
Shadow	Length	Width (cm)	5.5	9	11.5	14

Summary: The longer the block, the longer the shadow.

Subgroup 4

Changing Variable:		Block Length (cm)	2	4	7	10
Shadow	Length	Width (cm)	8	8	8	8

Summary: Block length does not affect shadow width.

4

Picture Packet, Page 4

Subgroup 5

Changing Variable:		Light Height (cm)	55	40	25	10
Shadow	Length	Width (cm)	4	5	7	28

Summary: The higher the light, the narrower the shadow.

Subgroup 6

Changing Variable:		Light Height (cm)	60	45	35	20
Shadow	Length	Width (cm)	6	10	15	20

Summary: The higher the light, the shorter the shadow.

Subgroup 7

Changing Variable:		Light Distance (cm)	15	30	50	60
Shadow	Length	Width (cm)	5	12	21	30

Summary: The farther the light, the longer the shadow.

Subgroup 8

Changing Variable:		Light Distance (cm)	15	30	45	60
Shadow	Length	Width (cm)	4	10	28	45

Summary: Agrees with previous group.

Subgroup 9

Changing Variable:		Light Angle (°)	90°	135°	45°	20°
Shadow	Length	Width (cm)	4	7	7	18

Summary: As the light angle gets closer to 90°, the shadow gets narrower.

5

Picture Packet, Page 5

After all poster presentations have been given, ask the class, “What did we learn about shadows?” Have them summarize the class findings. The highlights from many experiments are shown below. Do not expect students to know highlights from experiments that were not run.

- The taller the *block height*, the longer the shadow but the shadow width stays the same.
- The wider the *block width*, the wider the shadow but the shadow length stays the same.
- The longer the *block length*, the longer the shadow but the shadow width stays the same.
- As the *light height* increases, the shadow length and width decreases.
- As the *light distance* increases, the shadow length increases but the shadow width stays the same.
- The closer the *light angle* is to 90° the longer and thinner the shadow.

When summarizing experiments, use student-collected data and not what they should have found from the list above. Ask students, “If you want to get the longest shadow, what values of the variables should you use?”

- Block Height: As tall as possible
- Block Width: Any width
- Block Length: As long as possible
- Light Height: As low as possible
- Light Distance: As far out as possible
- Light Angle: 90°

Ask students, “If you want to get the widest shadow, what values of the variables should you use?”

- Block Height: Any height
- Block Width: As wide as possible
- Block Length: Any width
- Light Height: As low as possible
- Light Distance: Any distance
- Light Angle: Close to 0° or 180°

If no one in the class did experiments on one of the variables above, they will not know how that variable affects the shadow length/width, and do not expect them to tell you which value to use. Tell students, “You have taught me a lot about shadows.”

Wrap-Up:

(2 minutes – Full Class – SciTrek Lead)

Tell students, “The mentors who have been working with you are undergraduate and graduate students who volunteer their time, so you can do experiments. This is the last day you will see your volunteers, so we should say thank you and goodbye to them. I will come back and work with you one more day.”

Have students remove the paper parts of their nametags (which they can keep) from the plastic holders and return the plastic holders to their volunteers.

Have volunteers pass out pencils to the students that asked questions. If a student did not ask a question during the poster presentations, have them ask/answer a question about the experiments before the volunteer gives them a pencil.

Clean-Up:

1. Collect plastic nametag holders and allow students to keep the paper part of their nametags.
2. Collect notebooks.
3. Leave posters in the classroom.
4. Place all other materials into your group box and bring them back to UCSB.
5. If you will not be attending the tie to standards day, remove all materials from your lab coat pockets, remove your nametag, unroll your lab coat sleeves, and put your lab coat into the dirty clothes bag at UCSB.

Day 8: Conclusion Assessment/Tie to Standards

Schedule:

Conclusion Assessment (SciTrek Lead) – 10 minutes

Tie to Standards (SciTrek Lead) – 50 minutes

Materials:

Lead Box:

- | | | |
|---|--|---|
| <input type="checkbox"/> (3) Extra notebooks | <input type="checkbox"/> (35) Conclusion Assessments | <input type="checkbox"/> (2) Black pens |
| <input type="checkbox"/> Notebooks | <input type="checkbox"/> Time card | <input type="checkbox"/> (35) Red pens |
| <input type="checkbox"/> Lead instructions | <input type="checkbox"/> (2) Pencils | <input type="checkbox"/> (3) Rulers |
| <input type="checkbox"/> Shadows picture packet | <input type="checkbox"/> (2) Wet erase markers | <input type="checkbox"/> 7 cm block |
| <input type="checkbox"/> Lead lab coat | | |

Notebook Pages:

TIE TO STANDARDS

1. Using the given information for each experiment draw a **circle** around your prediction of what will happen to the shadow length and width. Once you have seen the pictures of the experiment draw a **box** around what **actually** happened to the shadow length and width. For all the experiments a 3 cm x 7 cm x 3 cm block was used.

Experiment 1: Effects of Changing Light Color		What will happen to: Shadow Length Shorter <u>Same</u> Longer
		Shadow Width Thinner <u>Same</u> Wider
Experiment 2: Effects of Changing Light Height		What will happen to: Shadow Length <u>Shorter</u> Same Longer
		Shadow Width <u>Thinner</u> Same Wider
Experiment 3: Effects of Changing Light Distance		What will happen to: Shadow Length Shorter Same <u>Longer</u>
		Shadow Width Thinner <u>Same</u> Wider
Experiment 4: Effects of Changing Light Angle		What will happen to: Shadow Length <u>Shorter</u> Same Longer
		Shadow Width Thinner Same <u>Wider</u>

26

2. What is the most important light source in your life? the sun

3. The sun rises in the east and sets in the west.

4. What causes the changes in the sun's position throughout the day? The Earth is rotating.

5. Draw the sun's position and the corresponding shadow for each of the following times:
A: Sunrise B: Midmorning C: Noon D: Afternoon E: Sunset

6. What time(s) of day are shadows the longest? sunrise and sunset

7. What time(s) of day are shadows the shortest? noon

8. Using what you have learned about shadows, make a line graph showing how shadow length changes over the course of 24 hours in the winter. Use a red line to show your predicted values and a pencil line to show the actual data.

How Shadow Length Varies in the Winter

27

9. Using what you have learned about shadows, make a line graph showing how shadow length changes over the course of 24 hours in the summer. Use a red line to show your predicted values and a pencil line to show the actual data.

How Shadow Length Varies in the Summer

10. What conclusion can you make from the graphs about the amount of daylight throughout the year?

We can conclude that the number of daylight hours in the summer is more than in the winter because in the summer there were 14 hours of daylight, and in the winter there were 10 hours of daylight.

11. Using the sundials below, determine what time of day it is (morning / noon / afternoon).

What time of day is it?
noon

What time of day is it?
morning

What time of day is it?
afternoon

28

Preparation:

SciTrek Lead:

1. If the teacher is not leading the tie to standards activity, do the following:
 - a. Give the teacher an extra notebook and have them fill it out with their students, to follow along during the tie to standards activity.
 - b. Collect the teacher's lab coat and put it in the lead box.
2. Pass out conclusion assessments and notebooks.
3. Set up the document camera for the tie to standards activity (notebook, pages 26-28 and picture packet, pages 6-11).
4. Put your lab coat in the lead box at the end of the day.

Conclusion Assessment:

(10 minutes – Full Class – SciTrek Lead)

Tell students, "Before we start our activity today, we will determine how your ideas on conclusions are developing." Have students write their name, teacher's name, and date at the top of the assessment. Tell students, "When doing this assessment, you should work individually, so there should be no talking." As you are giving the assessment, walk around the room and verify students have written their names on their assessments.

For page 1 (top), read questions 1 and 2 aloud and give students time to answer each before moving on to the next question.

For page 1, question 3 (bottom), read the instructions to students. Then, read each of the statements aloud and have students circle whether the statement is an example of a claim, data, or opinion.

For page 2 (top), have students circle the changing variable(s), underline the controls, and box information about data collection on the results table. Then, have them decide if the group could make a conclusion question 4.

For page 2, question 5 (bottom), read step 1 of the instructions aloud to students (*Identify the following statements as either CLAIM or DATA and write a C or D on the line.*). Then, have students fill in whether they think statement a is a claim or data by writing a C or D on the line. Tell students, "This part is similar to question 3 of the assessment." Read step 2 of the instructions aloud to students (*Look at the results table and circle if the statement is a correct claim, correct data, or incorrect. Statements are INCORRECT if the statement does not agree with the results table or has not been tested.*). Point to the results table and have students circle whether they think statement a is a correct claim, correct data, or incorrect claim or data. Once students have completed statement a, read statement b aloud and tell students, "Write a C or D on the line depending on whether you think the statement is a claim or data." After about 15 seconds tell students, "Now, look at the results table and circle whether the statement is a correct claim, correct data, or incorrect." Repeat the process for statements c-e.

For page 3, questions 6-7, repeat the process.

When students are finished, collect the assessments and verify students' names are written on the top of the papers.

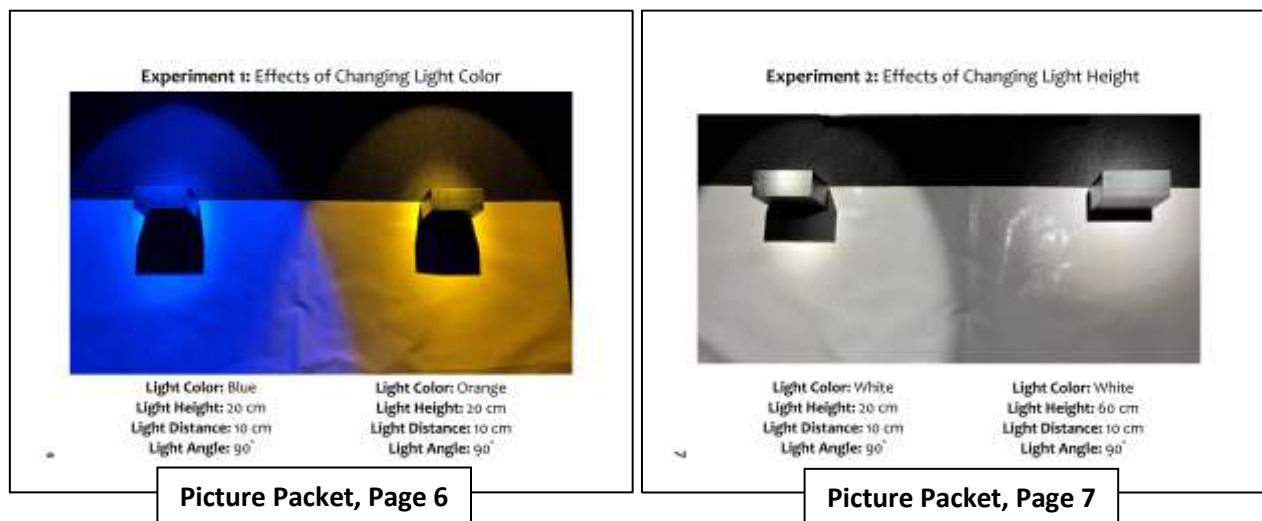
Tie to Standards:

(50 minutes – Full Class – SciTrek Lead)

Effects of Changing the Light (15 minutes)

Tell students, “Today you are going to talk about your previous experiments and hopefully answer any questions that you may still have about what variables affect shadows.” Have students turn to page 26 in their notebooks. Tell students, “We are going to look at four experiments and compare the lengths and widths of the shadows to one another. The four experiments that we will look at are light color, light height, light distance, and light angle. For all experiments, a 5 cm × 7 cm × 3 cm block was used.”

Tell students, “For the first experiment, we are going to explore how changing light color affects the shadow when the light height is 20 cm, the light distance is 10 cm, and the light angle is 90°. When the light color is changed from blue to orange, circle whether you think the shadow length will be shorter, stay the same, or be longer and whether the shadow width will be thinner, stay the same, or be wider.” Once students have finished their predictions have a student share their predictions and have the rest of the students use thumbs up/down to show if they agree or disagree. Show students the experiment 1 picture (picture packet, page 6, below). Ask students, “When the light color changes, what happened to the shadow length and width?” Tell students, “Do not erase your predictions, but put a box around the correct answers.” On the class notebook box *same* for shadow length and shadow width.

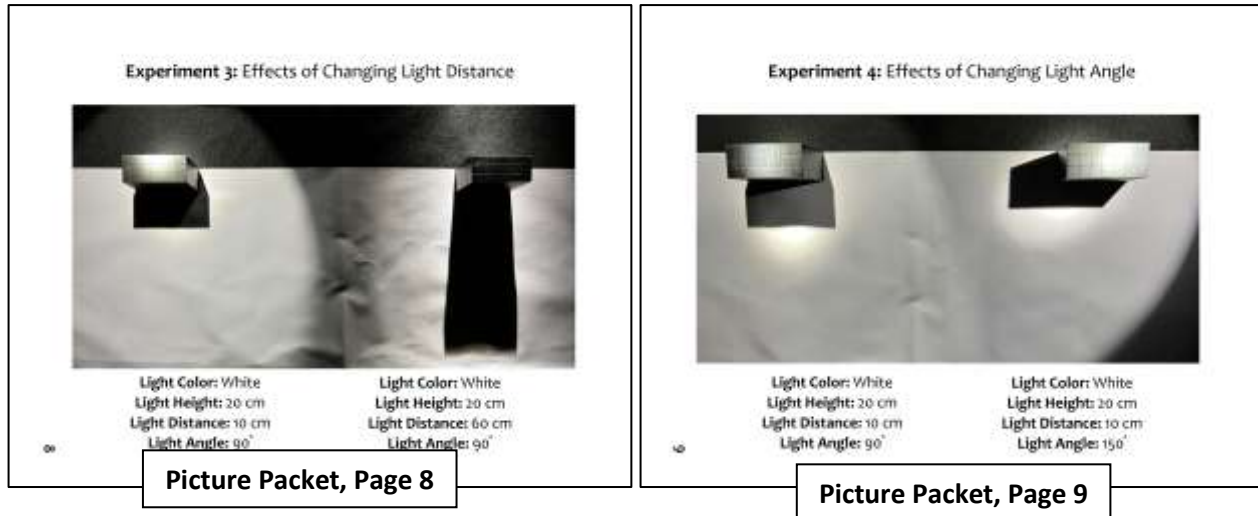


Tell students, “For the second experiment, we will explore changing light height. For this experiment, we will use the same block as the previous experiment, a light distance of 10 cm, a light angle of 90°, and we will use white light instead of colored light. Circle what you think will happen to the shadow length and width when the light height is increased from 20 cm to 60 cm.” Once students have finished their predictions, have a student share their predictions and have the rest of the students use thumbs up/down to show if they agree or disagree. Show students the experiment 2 picture (picture packet, page 7, above). Ask students, “When the light height increased, what happened to the shadow length and width?” Tell students, “Do not erase your predictions, but put a box around the correct answers.” On the class notebook, box *shorter* for shadow length and *thinner* for shadow width.

Tell students, “For the third experiment, we will explore changing light distance. For this experiment, we will use the same block as the previous experiments, white light, a light height of 20 cm, and a light angle of 90°. Circle what you think will happen to the shadow length and width when the light distance is changed from 10 cm to 60 cm.” Once students have finished their predictions, have a student share their

predictions and have the rest of the students use thumbs up/down to show if they agree or disagree. Show students the experiment 3 picture (picture packet, page 8, below). Ask students, “When the light distance increased, what happened to the shadow length and width?” Tell students, “Do not erase your predictions, but put a box around the correct answers.” On the class notebook box *longer* for shadow length and the *same* for shadow width.

Note: If students do not believe that the widths are the same use the rulers in the lead box to measure the shadow width.



Tell students, “For the fourth experiment, we will explore changing light angle. For this experiment, we will use the same block as the previous experiments, white light, a light height of 20 cm, and a light distance of 10 cm. When the light angle is changed from 90° to 150°, circle what you think will happen to the shadow length and width.” Once students have finished their predictions, have a student share their predictions and have the rest of the students use thumbs up/down to show if they agree or disagree. Show students the experiment 4 picture (picture packet, page 9, above). Ask students, “When the light angle increased, what happened to the shadow length and width?” Make sure by the end of the conversation, students understand the shadow will always be in line with (or 180° from) the light source. Tell students, “Do not erase your predictions, but to put a box around the correct answers.” On the class notebook, box *shorter* for shadow length and *wider* for shadow width.

TIE TO STANDARDS

1. Using the given information for each experiment draw a **circle** around your **prediction** of what will happen to the shadow length and width. Once you have seen the pictures of the experiment draw a **box** around what **actually** happened to the shadow length and width. For all the experiments a 3 cm x 7 cm x 3 cm block was used.

Experiment 1: Effects of Changing Light Color		What will happen to:
	Light Color: Blue Light Height: 20 cm Light Distance: 10 cm Light Angle: 90°	Shadow Length Shorter <input type="radio"/> <input checked="" type="radio"/> Same <input type="radio"/> Longer
	Light Color: Orange Light Height: 20 cm Light Distance: 10 cm Light Angle: 90°	Shadow Width Thinner <input type="radio"/> <input checked="" type="radio"/> Same <input type="radio"/> Wider
Experiment 2: Effects of Changing Light Height		What will happen to:
	Light Color: White Light Height: 20 cm Light Distance: 10 cm Light Angle: 90°	Shadow Length Shorter <input checked="" type="radio"/> Same <input type="radio"/> Longer
	Light Color: White Light Height: 40 cm Light Distance: 10 cm Light Angle: 90°	Shadow Width Thinner <input checked="" type="radio"/> Same <input type="radio"/> Wider
Experiment 3: Effects of Changing Light Distance		What will happen to:
	Light Color: White Light Height: 20 cm Light Distance: 10 cm Light Angle: 90°	Shadow Length Shorter <input type="radio"/> Same <input checked="" type="radio"/> Longer
	Light Color: White Light Height: 20 cm Light Distance: 40 cm Light Angle: 90°	Shadow Width Thinner <input checked="" type="radio"/> Same <input type="radio"/> Wider
Experiment 4: Effects of Changing Light Angle		What will happen to:
	Light Color: White Light Height: 20 cm Light Distance: 10 cm Light Angle: 90°	Shadow Length Shorter <input checked="" type="radio"/> Same <input type="radio"/> Longer
	Light Color: White Light Height: 20 cm Light Distance: 10 cm Light Angle: 45°	Shadow Width Thinner <input type="radio"/> Same <input checked="" type="radio"/> Wider

Connection to the Sun (10 minutes)

Tell students, “Now that you understand how to predict what shadows will look like, we will connect these predictions to other uses.” Have students turn to page 27 in their notebooks and ask them, “What is the most important light source in your life?” They may answer the lights in their home. Lead students to understand the lights in their home are useful, but humans have lived without them in the past, so if needed, people could live without them again. However, there is one source of light no one would be able to live without. The light source that is most important in all of our lives is the sun. Fill this in on the class notebook while students do the same in their notebook.

1. What is the most important light source in your life? the sun

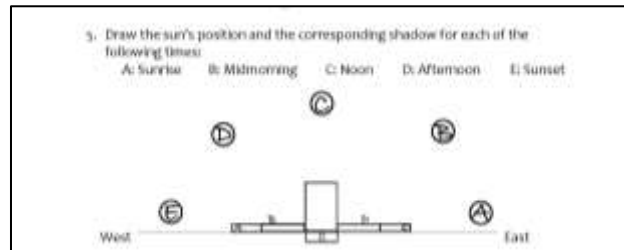
Next, ask students, “Which direction (north, south, east, or west) does the sun rise and which does it sets in?” Possible student response: the sun rises in the east and sets in the west. Fill this in for question 3 in the class notebook while students do the same. Then ask students, “What causes the sun’s position to change throughout the day?” Lead the students to understand the sun is not moving, but the Earth is rotating, causing it to look like the sun is moving. Fill this in for question 4 in the class notebook while students do the same.

3. The sun rises in the east and sets in the west.

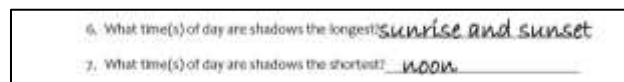
4. What causes the changes in the sun's position throughout the day? The Earth is rotating.

Tell students, “Now that we understand where the sun rises and sets, as well as what a shadow will look like for a corresponding light source, you are going to draw a picture showing where the sun will be and what the shadow will look like for the sunrise, midmorning, noon, afternoon, and sunset.” With the students, draw in the location of the sun for each of the points. Draw the suns in the following order: A

(sunrise), C (noon), E (sunset), D (afternoon), B (midmorning). Draw in the shadow for A (sunrise) in the class notebook while students do the same. Ask students, “What will happen to the shadow as it gets to midmorning where the sun is higher in the sky?” Possible student response: the shadow will get shorter. Draw in the midmorning shadow on the class notebook while students do the same. Then have students try to fill in the remaining shadows in their notebooks. Have one student volunteer to share their shadow placement with the rest of the class. Put that student’s notebook under the document camera and have the rest of the class discuss the placements of the shadows and if they agree or disagree with the placements. Once a consensus is reached, draw the shadows into the class notebook. Make sure by the end of the conversation, students understand the shadow will initially be in the west and very long, at approximately noon the shadow will be the shortest and right before sunset the shadow will be very long and in the east. An example is shown below.



After completing the picture, ask students, “What time of day are shadows the longest, and when are they the shortest?” Students should see shadows are longest at sunrise and sunset, when the sun is low, and shortest at noon, when the sun is directly above the objects. Next, ask students, “Why do you think this is?” Possible student response: during sunrise and sunset the light source is coming from the side of the object rather than directly above. As we have learned earlier, when the light is coming from a low light height the shadows are longer. A low light height could represent the sunrise and sunset. We also learned that a high light height will lead to a short shadow. A high light height could represent noon. Fill in questions 6 and 7 in the class notebook while students do the same.



Seasonal Shadows (23 minutes)

Pass out a red pen to each student.

Tell students, “You are now going to graph how you think an objects shadow length changes over the course of 24 hours, in the winter.” Ask students “What is the first point on the graph?” Students should reply, “Midnight.” Ask students “What does it look like outside at midnight?” Students should reply, “Dark.” Ask students, “If it is dark will there be a shadow?” Students should reply, “No.” Tell students, “This means our first point will have a shadow length of 0.” Put a red dot at 0 shadow length at midnight. Ask students, “What do you think the shadow length will be at 2:00 am and why?” Possible student response: 0 because it is still dark. Put a red dot at 0 shadow length at 2:00 am. Tell students, “You will now predict the shadow length for the rest of the 24-hour period. Put down dots for each time and then connect the dots. Therefore, if you thought the shadow length was 0 for the entire 24-hour period, your graph would look like a straight line at 0.” Show them what this would look like on the class notebook (below). Ask students, “Is this prediction correct?” They should reply, “No.”



Once students have had a chance to complete their predictions, pick one student to show their prediction under the document camera. Have students give critiques of the graph. Help them through this process by asking guiding questions such as, “At noon I see that you drew the shadow the longest, how would the light be position in our set up to represent noon, and what did that shadow look like?”

Tell students, “You will now graph the actual data showing how shadow length changes with time during the winter using your pencils and not the red pen.” Show students the data table point-by-point while reading it to them (picture packet, page 10, below [left]). In addition, plot the data points in the class notebook. Draw in a solid line connecting the points. Ask the class the following questions:

Why are the data points all zero between midnight and 4 am?

It was night so there was no shadow.

What time does sunrise occur and how do you know?

It occurs at approximately 7 am because this is the first time a shadow was seen.

Does shadow length change faster in the morning or closer to midday?

Shadow length changes faster in the morning and evening and slower as it approaches midday.

What time was the sun directly overhead?

The shadow length was 0 at 12 pm, therefore, the sun must have been directly overhead at this time.

How many hours passed between the time that the sun rose and the time the sun was directly overhead?

5 hours

How much time passed between the time the sun was directly overhead and the time the sun set?

5 hours

Is the graph symmetric?

Yes

How many hours of daylight are there during the winter?

10 hours

How Shadow Length Varies in the Winter

Time	Shadow Length
12:00 am	0
2:00 am	0
4:00 am	0
6:00 am	0
7:00 am	5
8:00 am	2
10:00 am	0.5
12:00 pm	0
2:00 pm	0.5
4:00 pm	2
5:00 pm	5
6:00 pm	0
8:00 pm	0
10:00 pm	0
12:00pm	0

Picture Packet, Page 10

8. Using what you have learned about shadows, make a line graph showing how shadow length changes over the course of 24 hours in the winter. Use a **red** line to show your **predicted** values and a **pencil** line to show the **actual** data.

How Shadow Length Varies in the Winter

Ask students, “Would a graph of shadow length vs. time be the same for all times of the year?” Students should reply, “No.” On question 9 have students draw a red line to show their predictions of what a graph of shadow length vs. time would look like during the summer. Once students have had a chance to complete their predictions, pick one student to show their prediction under the document camera. Have students give critiques of the graph. In addition, ask questions to help guide student thinking. Collect the red pens.

Tell students, “You will now graph the actual data showing shadow length vs. time during the summer using your pencil.” Show students the data table point-by-point while reading it to them (picture packet, page 11, below [left]). In addition, plot the data points in the class notebook. Draw in a solid line connecting the points. Ask students the following questions:

How many hours passed between the time that the sun rose and the time the sun was directly overhead?

7 hours

How much time passed between the time the sun was directly overhead and the time the sun set?

7 hours

Is this graph symmetric?

Yes

How many hours of daylight are there during the summer?

14 hours

How Shadow Length Varies in the Summer

	Shadow Length
12:00 am	0
2:00 am	0
4:00 am	0
6:00 am	5
8:00 am	2
10:00 am	1
12:00 pm	0.5
1:00 pm	0
2:00 pm	0.5
4:00 pm	1
6:00 pm	2
8:00 pm	5
10:00 pm	0
12:00pm	0

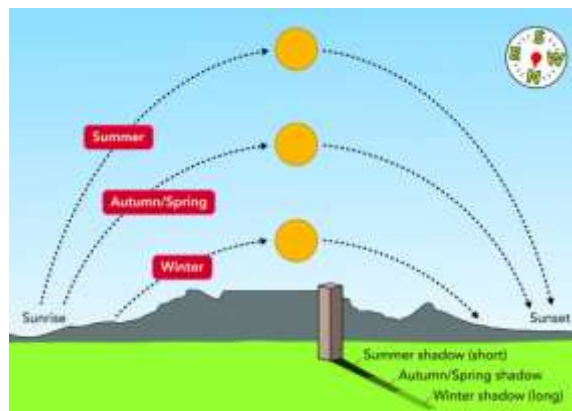
Picture Packet, Page 11

9. Using what you have learned about shadows, make a line graph showing how shadow length changes over the course of 24 hours in the summer. Use a **red** line to show your **predicted** values and a **pencil** line to show the **actual** data.

How Shadow Length Varies in the Summer

Note: The reason that the sun is not overhead at noon is because of daylight savings time (DST). Do not bring this up with students unless they ask specifically about this. DST shifts our clocks one hour later in the day. We are on DST from March through November.

Note: Shadows are longer in the winter than in the summer because of the tilt of the Earth. During the winter, the tilt of the Earth causes the sun to be lower in the sky than during the summer, making the shadow longer. See picture below. Do not bring this up with students unless asked.



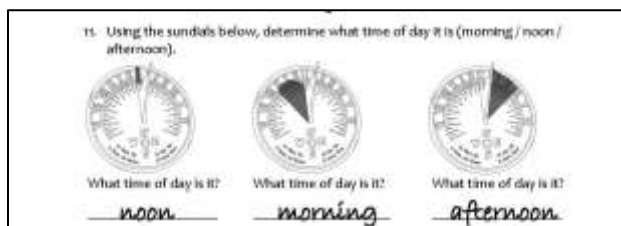
Ask students, “What conclusion can we make about the number of daylight hours throughout the year?” Have one student share what they think the conclusion will be and once a class consensus is reached, record the conclusion in the class notebook and have students copy it into their notebook. Ask the class, “What part of the conclusion was the claim and how do you know?” Possible student response: the number of daylight hours in the summer is more than in the winter is the claim because it is a statement that we can test. Ask the class, “what part of the conclusion is the data and how do you know?” Possible student response: in the summer there were 14 hours of daylight, and in the winter there were 10 hours of daylight is the data, because it contains measurements.

10. What conclusion can you make from the graphs about the amount of daylight throughout the year?

We can conclude that the number of daylight hours in the summer is more than in the winter because in the summer there were 14 hours of daylight, and in the winter there were 10 hours of daylight.

Sundials (2 minutes)

Tell students, “In the past, before there was electricity, people relied on the sun to determine what time of the day it was. One method of doing this was by using a sundial. Sundials are set so their gnomons (piece that sticks up out of a sundial) point to the north. People who know and understand the properties of shadows can determine the time of day by looking at the shadow on the dial plate. We will use the three sundials in your notebooks to determine what direction (east/west/directly above) the sun is coming from as well as what time of day it is (morning/noon/afternoon).” Have students look at the sundials and determine where the sun was in each of the pictures and then identify the time of the day. Record these for question 11 in the class notebook while students do the same.



Note: Sundials are made for a specific latitude to account for the actual distance the sun is away from the location it is being used. If you know the latitude your sundial is made for, you can make mathematical corrections to find the time for your latitude, if the two are different. Additional corrections need to be made in areas where there is daylight savings time. Do not bring this up with students unless asked.

Tell students, “You have taught me a lot about shadows. I now know that the larger the light distance, and the smaller the light height, the longer the shadow. In addition, I saw that the shadow is always 180° from the light source. Knowing these facts about shadows has allowed me to see how shadows can be used to tell time.”

Tell students, “You can keep your notebooks, I have enjoyed learning science with you. I hope you will continue to see yourselves as scientists and explore the world around you. You will get another opportunity for SciTrek to come to your class, and run another long-term investigation with you, later in the year, so it is important that you remember what you learned for your next module.”

Clean- Up:

1. Leave notebooks with students.
2. Place all other materials into the lead box and bring them back to UCSB.
3. Remove all materials from your lab coat pockets, remove your nametag, unroll your lab coat sleeves, and put your lab coat into the dirty clothes bag at UCSB.

Extra Practice Solutions:

EXTRA PRACTICE

Conclusions

Directions:
On the results table, underline each control, circle each changing variable, and box information about data collection.

Variables	Trial A	Trial B
<u>Light color</u>	White	→
<u>Block height</u>	5 cm	10 cm
<u>Block width</u>	7 cm	→
<u>Light distance</u>	25 cm	→
<u>Light height</u>	25 cm	→
<u>Light angle</u>	90°	→
Data	Trial A	Trial B
Shadow Lengths	7 cm	15 cm

Can this group make a claim/conclusion? Yes No I Don't Know

Step 1: Statement Type: C or D Step 2: Based on the table, is the statement a correct claim, correct data, or incorrect?

- the 5 cm block had a 7 cm shadow length and the 10 cm block had a 15 cm shadow length. D Correct Claim Correct Data incorrect
- the block height does not affect the shadow length. C Correct Claim Correct Data incorrect
- when the light height is 25 cm, a taller block results in a longer shadow. C Correct Claim Correct Data incorrect
- the light distance affects the shadow length. C Correct Claim Correct Data incorrect
- the block height affects the shadow length. C Correct Claim Correct Data incorrect

What data can be used to support the correct claim(s) above? When the block height was 5 cm, the shadow length was 7 cm, and when the block height was 10 cm, the shadow length was 15 cm.

29