Last Revised: 8/29/2023

Lead Information Packet

Module 1: Solar Power
6^{th} Grade

This document is not intended to give you all of the information you need to lead the module. It is only intended to be a reference during the module. You can find the complete instructions at scitrek.chem.ucsb.edu/module as well as the notebook and picture packet used during the module.

Important Things to Remember During the Module

1. You are responsible for keeping track of time in the classroom and making sure **all** activities run smoothly. There will be a time card in the lead box with suggested times to start/stop each activity.
2. You are responsible for keeping volunteers and students on track.
3. Walk around during times volunteers are working with students and help struggling groups/subgroups/teams.

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 are labeled.

In these instructions, all other example documents are labeled.

Day 1: Analysis Assessment/Observations/Technique/Variables

Schedule: *You are responsible for **BOLD** sections*

Introduction (SciTrek Lead) – 2 minutes
Analysis Assessment (SciTrek Lead) – 15 minutes
Observation Discussion (SciTrek Lead) – 2 minutes
Observations (SciTrek Volunteers) – 13 minutes
Technique (SciTrek Lead) – 12 minutes
Variable Discussion (SciTrek Lead) – 5 minutes
Variables (SciTrek Volunteers) – 9 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Preparation:

1. Make sure volunteers are passing out nametags.
2. Make sure volunteers are setting up for the initial observation.
3. Set up the document camera for the analysis assessment, technique activity (notebook, page 3), and class question (notebook, front cover).
4. Set up the lead set-up.
    a. Place a solar panel in the solar panel holder, turn the angle to 45°, and use the shading tool to shade $\frac{2}{8}$ of the panel.
    b. Hook the multimeter up to the panel.
    c. Place the AAA battery pack, 9 V battery, and breadboard near the lead set-up.
5. Pass out the analysis assessments.

Introduction: *(2 minutes – Full Class – SciTrek Lead)*

- Allow volunteers to introduce themselves.
- Introduce the module.

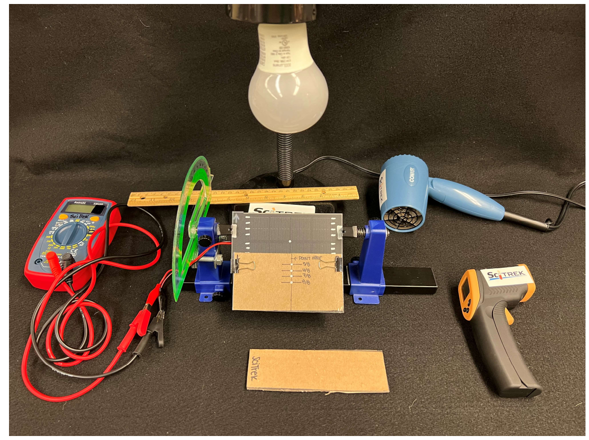
Analysis Assessment: *(15 minutes – Full Class – SciTrek Lead)*

- Questions *1-3*: Have students underline controls, circle changing variable(s), and box information about data collection, on the results tables. Then, have students answer the questions about each results table and possible conclusion.
- Pass out clear rulers to students.
- Question *4*: Under the document camera, show students how to annotate the graph by underlining the controls, circling the changing variable, and boxing information about data collection in the title, axes titles, and legend.
- Have students answer questions *4b-4f* on their own.
- Collect assessments and rulers.

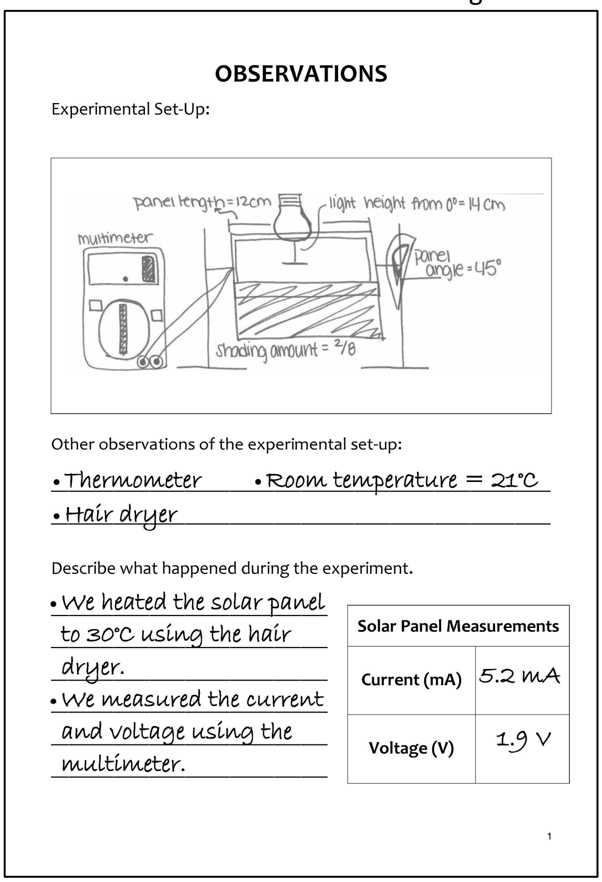
Observation Discussion: *(2 minutes – Full Class – SciTrek Lead)*

- Review the definition of an observation (a description using your five senses).
- Tell students, “We will be making observations of solar panels.”
    - Lead students to understand that solar panels transfer light energy into electrical energy.
- Introduce the terms multimeter, current, and voltage.
    - Tell students, “We will measure current in milliamps by turning the dial to the multimeter setting boxed in black.”
    - Tell students, “We will measure voltage in volts by turning the dial to the multimeter setting boxed in silver.”
- Put page 2 of the picture packet under the document camera. Explain to students how they will use the protractor to measure angle and emphasize they need to read angles from the clear scale.
- Have students move to their groups.
    - 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: *(13 minutes – Groups – SciTrek Volunteers)*



- Walk around and help groups who are struggling.
- Make sure volunteers have students fill out the front cover of their notebook except for the subgroup number, team/subgroup symbol, and class question.
- Make sure volunteers are correctly assembling the set-up with students.
  - The panel angle should be 45° (clear scale)
  - The shading should be $\frac{2}{8}$
- Make sure volunteers have correctly demonstrated how to use the IR thermometer for the students and are not letting students use the thermometer.
- Make sure that groups are moving along and only spending ~7 minutes on the experimental set-up and ~6 minutes testing the LEDS and describing what happened.
- Make sure that volunteers are shining the LED cup around so each student can see the red and blue LED.



OBSERVATIONS

Experimental Set-Up:

Other observations of the experimental set-up:

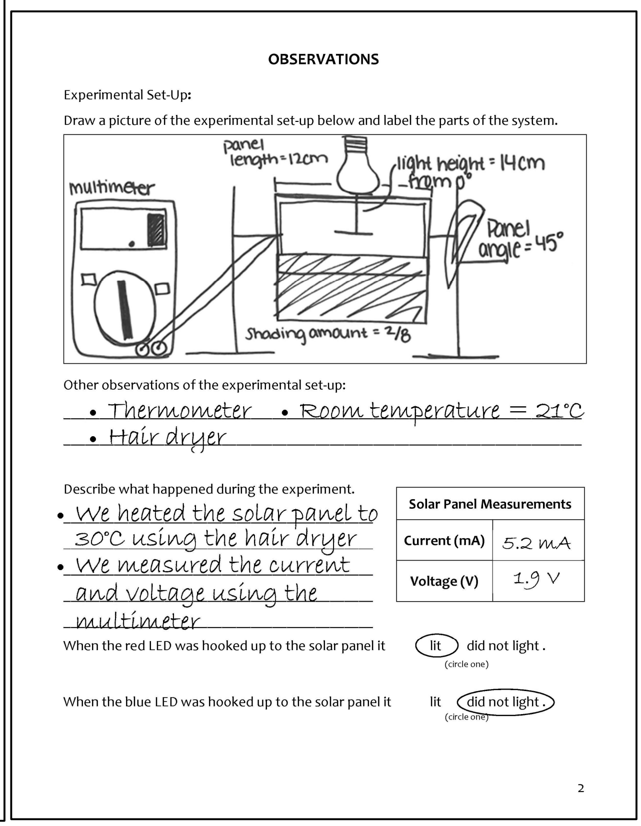
• Thermometer • Room temperature = 21°C
• Hair dryer

Describe what happened during the experiment.

• We heated the solar panel to 30°C using the hair dryer.
• We measured the current and voltage using the multimeter.

Solar Panel Measurements	
Current (mA)	5.2 mA
Voltage (V)	1.9 V

1



OBSERVATIONS

Experimental Set-Up:

Draw a picture of the experimental set-up below and label the parts of the system.

Other observations of the experimental set-up:

• Thermometer • Room temperature = 21°C
• Hair dryer

Describe what happened during the experiment.

• We heated the solar panel to 30°C using the hair dryer
• We measured the current and voltage using the multimeter

Solar Panel Measurements	
Current (mA)	5.2 mA
Voltage (V)	1.9 V

When the red LED was hooked up to the solar panel it (lit) did not light . (circle one)

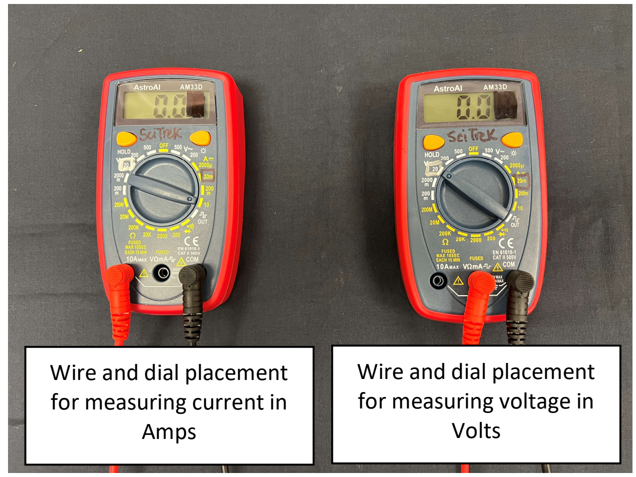
When the blue LED was hooked up to the solar panel it lit (did not light) . (circle one)

2

Technique: *(12 minutes – Full Class – SciTrek Lead)*

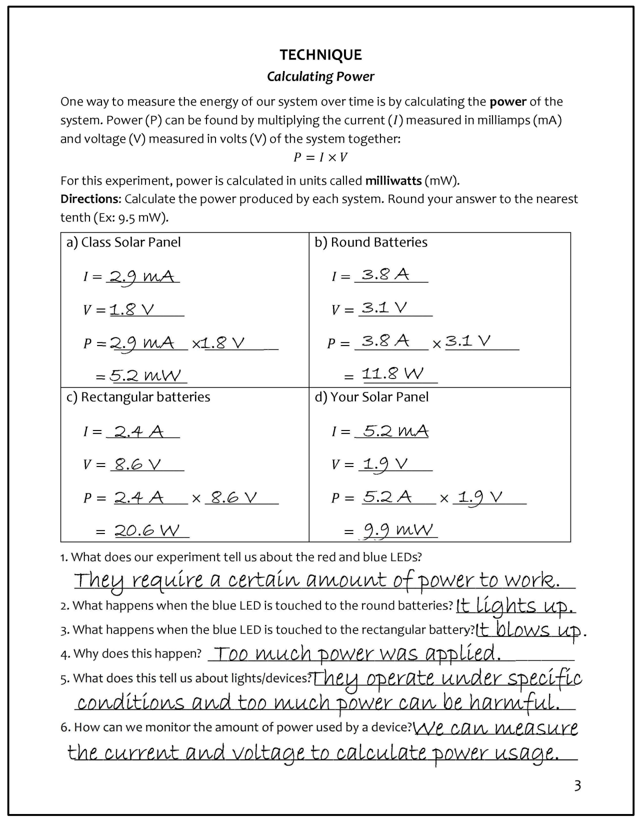
- Have groups share what they did/learned.
  - They set their solar panel to an angle of 45°, heated it to 30°C, and measured the current and voltage being produced using a multimeter. Then, they saw that this energy could light a red LED but not a blue LED.
- Introduce **power** (amount of energy per time a device uses or supplies) and how to calculate it (multiplying the current [mA] and voltage [V], which gives power in milliwatts [mW]).
- Have volunteers pass out calculators.

- Using the class solar panel (under classroom lights only), have students read and record the current and voltage being produced for letter *a*.
  - Show students how to set up the power equation and input the operation into their calculator.
  - Show students how to round the answer to the nearest tenth and record their answer in milliwatts.
- Hook up the round battery pack to the multimeter, and have students read and record the current and voltage produced.
  - You will use the same set up for measuring the voltage of the batteries as you did for the solar panel (picture, right).
  - To measure the current of the batteries, move the red probe to the 10AMAX hole and turn the dial to the 10 instead of the block boxed setting (picture, left).
  - They should then calculate power on their own.
- Repeat process for rectangular battery.
- Have the students answer letter *d*, about the power of their own solar panel.
- Have students remind you of what happened when the red and blue LEDs were hooked up to the solar panel.
- Under the document camera, connect the round batteries to the breadboard and plug in the blue LED (below, left).
  - Repeat for the rectangular battery. This time to LED will blow. Occasionally when this happens it ejects a small piece of plastic, therefore put your hand between it and the students so if this happens the plastic will not hit anyone (below, right)
- Go over questions *1-6* and write class consensus answers in the class notebook.
- Introduce the class question: What variables affect the power produced by a solar panel?
  - Write the class question on the front cover of the class notebook and have students copy the question onto their notebook.



Wire and dial placement for measuring current in Amps

Wire and dial placement for measuring voltage in Volts



TECHNIQUE

Calculating Power

One way to measure the energy of our system over time is by calculating the **power** of the system. Power (P) can be found by multiplying the current (I) measured in milliamps (mA) and voltage (V) measured in volts (V) of the system together:

$$P = I \times V$$

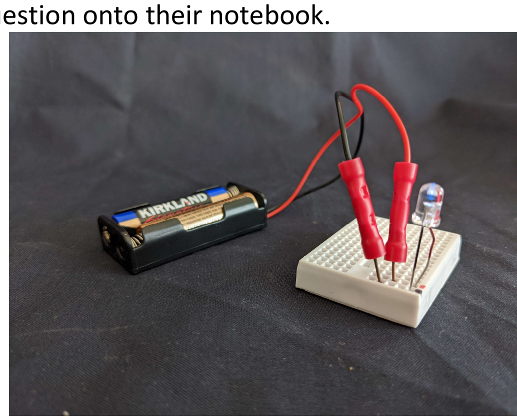
For this experiment, power is calculated in units called **milliwatts** (mW).

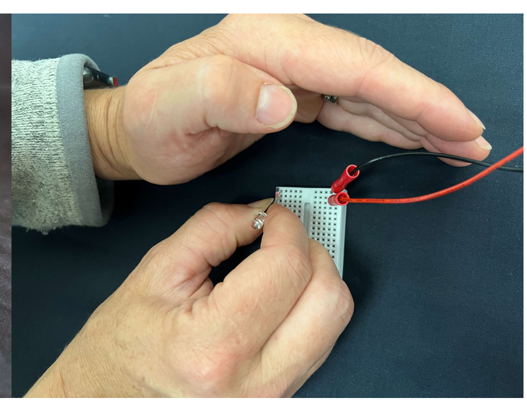
Directions: Calculate the power produced by each system. Round your answer to the nearest tenth (Ex: 9.5 mW).

a) Class Solar Panel	b) Round Batteries
I = 2.9 mA V = 1.8 V P = 2.9 mA × 1.8 V = 5.2 mW	I = 3.8 A V = 3.1 V P = 3.8 A × 3.1 V = 11.8 W
c) Rectangular batteries	**d) Your Solar Panel**
I = 2.4 A V = 8.6 V P = 2.4 A × 8.6 V = 20.6 W	I = 5.2 mA V = 1.9 V P = 5.2 A × 1.9 V = 9.9 mW

1. What does our experiment tell us about the red and blue LEDs? They require a certain amount of power to work.
2. What happens when the blue LED is touched to the round batteries? It lights up.
3. What happens when the blue LED is touched to the rectangular battery? It blows up.
4. Why does this happen? Too much power was applied.
5. What does this tell us about lights/devices? They operate under specific conditions and too much power can be harmful.
6. How can we monitor the amount of power used by a device? We can measure the current and voltage to calculate power usage.

3





Variable Discussion: *(5 minutes – Full Class – SciTrek Lead)*

- Review the definition of a variable (something in an experiment that can be changed).
- Explore one possible changing variable with the class and have students share how and why this variable might affect the power produced by the solar panel.

Variables: *(9 minutes – Groups – SciTrek Volunteers)*

- If there are less than 5 minutes in the session do this as a class instead of in groups.
- Walk around and help groups who are struggling.
- Make sure volunteers are having their group come up with three possible variables, as well as how and why these variables might affect the power produced by a solar panel.
- Make sure students are generating at least one additional variable by themselves.

VARIABLES

Variable	How will changing this variable affect the power produced by a solar panel?
Panel Angle	Flatter panels (closer to 0°), will produce ______________ power because __________________.
Light Brightness	Brighter lights, will produce ______________ power because _________________________.
Light Source	Natural light (like the sun), will produce ______________ power because ______________.
Choose your own!!	

2

VARIABLES

Variable	How will changing this variable affect the power produced by a solar panel?
Panel Angle	Flatter panels (closer to 0°) will produce more power because the light will hit the panel more directly.
Light Brightness	Brighter lights will produce more power because the light will be more intense over the panel.
Light Source	Natural light (like the sun) will produce more power because we normally use sunlight on solar panels.
Temperature	Higher temperatures will produce more power because the solar panel may break down when it gets too hot.
Dirt Amount	More dirt on the solar panel will produce less power because the panel will have dirt blocking the light.

4

Wrap-Up: *(2 minutes – Full Class – SciTrek Lead)*

- Have each group share one variable with the class, as well as how and why they think this variable will (or will not) affect the power produced by a solar panel.
- Go over what students will do next session.

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

Schedule: *You are responsible for **BOLD** sections*

Introduction (SciTrek Lead) – 14 minutes
Question (SciTrek Volunteers) – 7 minutes
Materials Page (SciTrek Volunteers) – 7 minutes
Experimental Set-Up (SciTrek Volunteers) – 8 minutes
Procedure (SciTrek Volunteers) – 18 minutes
Results Table (SciTrek Volunteers) – 3 minutes
Wrap-Up (SciTrek Lead) – 3 minutes
*If there is extra time, do the claim, data, opinion extra practice (notebook, page 31).

Preparation:

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 5), materials page (lead box), experimental set-up (notebook, page 6), and results table (picture packet, page 1).

Introduction: *(13 minutes – Full Class – SciTrek Lead)*

- Review the class question as well as what students did and learned last session.
- Review experimental considerations with the class (notebook, page 5, top):
    - *You will only have access to the materials on the materials page.*
    - *If you are not chaning the light height, the light height must be 14 cm.*
    - *See materials page for restrictions on experimental design.*
- Design an example experiment with the class.
    - For the changing variable, pick one variable (Ex: temperature; notebook, page 5).
    - Show students how to write the question.
        - If we change the <u>temperature,</u> what will happen to the <u>power produced by the solar panel</u>?
    - Fill out the materials page for the example experiment (lead box).
        - Read step 1 and have students tell you what to do for each bolded word (underline controls and circle changing variables).

Experimental Considerations:

1. You will only have access to the materials on the materials page.
2. If you are not changing lamp height, the lamp height must be 14 cm.
3. See materials page for restrictions on experimental design.

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

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

Changing Variable 1: Panel Angle
Discuss with your subgroup how you think **changing variable 1** will affect the power produced by the solar panel.

Changing Variable 2 (optional): ____________
Discuss with your subgroup how you think **changing variable 2** will affect the power produced by the solar panel.

QUESTION

Question our subgroup will investigate:

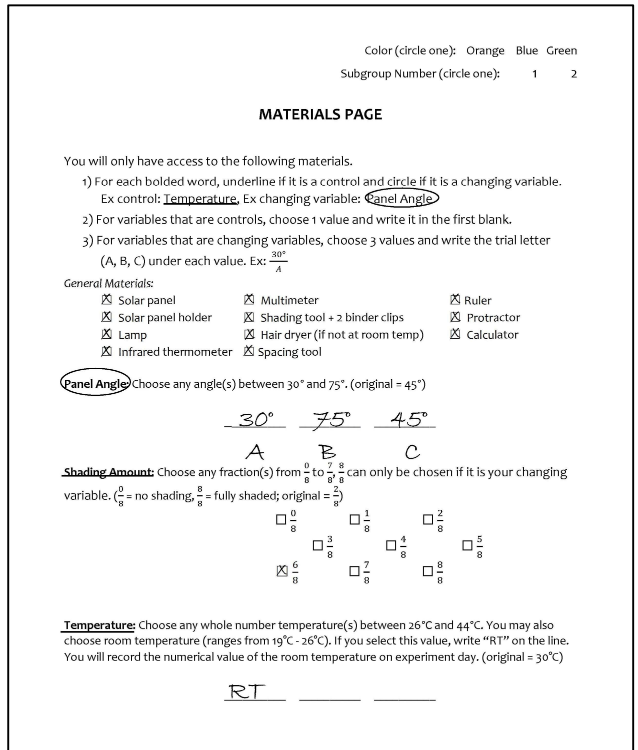
- If we change the panel angle (insert each changing variable (independent variable)), what will happen to the power produced by the solar panel (insert what you are calculating)?

SciTrek Member Approval: ____________

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

5

  - Go through the list of general materials, and check them off.
    - Show students the spacing tool and tell them they will use it to quickly measure the distance between the solar panel and the lamp.
  - Read steps *2* and *3*. You should choose the control values, but let students choose the three changing variable values.
    - Remind students to pick changing variable values that are spread out.
    - Write trial letters underneath the changing variable values.
- Fill out the experimental set-up for the example experiment (only *Trials A* and *B* for the changing variable; notebook, page 6).
  - Draw an additional line under the controls list for another control and its value.
  - If students choose to change two variables, there will be one additional blank for controls. Lead students to come up with "light height/14 cm."
- Read the example procedure step that includes the changing variable (notebook, page 7, top).
- Show students the filled-out results table (picture packet, page 1) and explain how they will fill out their results tables and make predictions.



Color (circle one): Orange Blue Green
Subgroup Number (circle one): 1 2

MATERIALS PAGE

You will only have access to the following materials.
1) For each bolded word, underline if it is a control and circle if it is a changing variable.
Ex control: Temperature, Ex changing variable: Panel Angle
2) For variables that are controls, choose 1 value and write it in the first blank.
3) For variables that are changing variables, choose 3 values and write the trial letter (A, B, C) under each value. Ex: $\frac{30°}{A}$

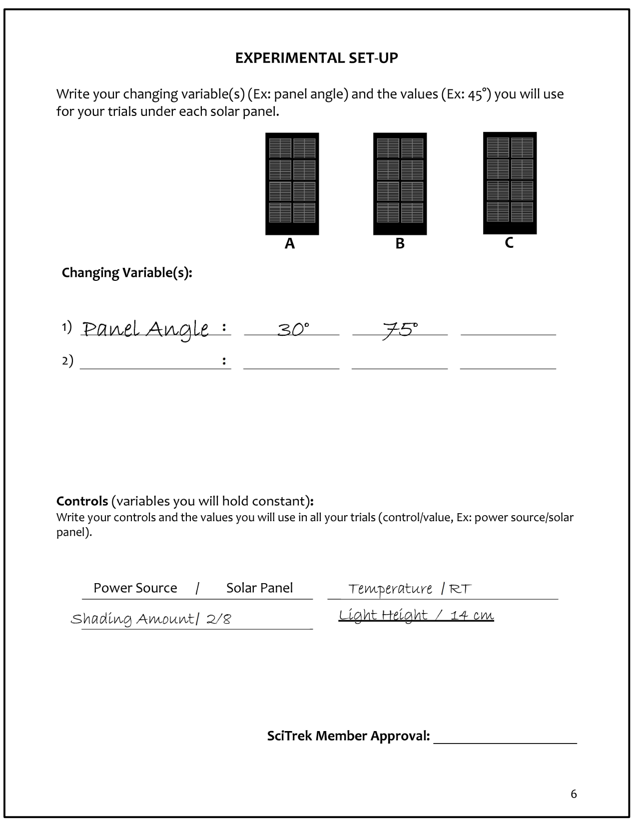
General Materials:
☒ Solar panel ☒ Multimeter ☒ Ruler
☒ Solar panel holder ☒ Shading tool + 2 binder clips ☒ Protractor
☒ Lamp ☒ Hair dryer (if not at room temp) ☒ Calculator
☒ Infrared thermometer ☒ Spacing tool

Panel Angle: Choose any angle(s) between 30° and 75°. (original = 45°)
30° 75° 45°
A B C

Shading Amount: Choose any fraction(s) from $\frac{0}{8}$ to $\frac{7}{8}$. $\frac{8}{8}$ can only be chosen if it is your changing variable. ($\frac{0}{8}$ = no shading, $\frac{8}{8}$ = fully shaded; original = $\frac{2}{8}$)
☐ $\frac{0}{8}$ ☐ $\frac{1}{8}$ ☐ $\frac{2}{8}$ ☐ $\frac{3}{8}$ ☐ $\frac{4}{8}$ ☐ $\frac{5}{8}$ ☒ $\frac{6}{8}$ ☐ $\frac{7}{8}$ ☐ $\frac{8}{8}$

Temperature: Choose any whole number temperature(s) between 26°C and 44°C. You may also choose room temperature (ranges from 19°C - 26°C). If you select this value, write "RT" on the line. You will record the numerical value of the room temperature on experiment day. (original = 30°C)
RT

Materials Page



EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: panel angle) and the values (Ex: 45°) you will use for your trials under each solar panel.

Changing Variable(s):

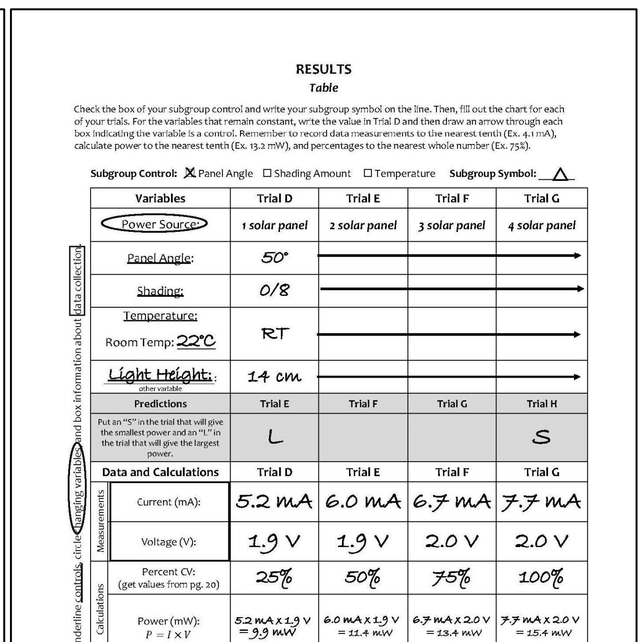
1) Panel Angle : 30° 75°
2) :

Controls (variables you will hold constant):
Write your controls and the values you will use in all your trials (control/value, Ex: power source/solar panel).

Power Source / Solar Panel
Temperature / RT
Shading Amount/ 2/8
Light Height / 14 cm

SciTrek Member Approval: ____________

6



RESULTS
Table

Check the box of your subgroup control and write your subgroup symbol on the line. Then, fill out the chart for each of your trials. For the variables that remain constant, write the value in Trial D and then draw an arrow through each box indicating the variable is a control. Remember to record data measurements to the nearest tenth (Ex. 4.1 mA), calculate power to the nearest tenth (Ex. 13.2 mW), and percentages to the nearest whole number (Ex. 75%).

Subgroup Control: ☒ Panel Angle ☐ Shading Amount ☐ Temperature **Subgroup Symbol:** △

Underline controls, circle changing variables and box information about data collection.

Variables	Trial D	Trial E	Trial F	Trial G
Power Source:	*1 solar panel*	*2 solar panel*	*3 solar panel*	*4 solar panel*
Panel Angle:	50°	→	→	→
Shading:	0/8	→	→	→
Temperature: Room Temp: 22°C	RT	→	→	→
Light Height: (other variable)	14 cm	→	→	→
Predictions	**Trial E**	**Trial F**	**Trial G**	**Trial H**
Put an "S" in the trial that will give the smallest power and an "L" in the trial that will give the largest power.	L			S
Data and Calculations	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Measurements: Current (mA):	5.2 mA	6.0 mA	6.7 mA	7.7 mA
Measurements: Voltage (V):	1.9 V	1.9 V	2.0 V	2.0 V
Calculations: Percent CV: (get values from pg. 20)	25%	50%	75%	100%
Calculations: Power (mW): $P = I \times V$	5.2 mA x 1.9 V = 9.9 mW	6.0 mA x 1.9 V = 11.4 mW	6.7 mA x 2.0 V = 13.4 mW	7.7 mA x 2.0 V = 15.4 mW

Picture Packet, Page 1
Note: This results table is for experiment 2, but is only used to show students how to represent controls and changing variables.

Question: *(9 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Encourage subgroups to pick different changing variables.
- **Make sure volunteers are not giving advice on how many changing variables to use.**
- Make sure, for the second part of the question (what you are calculating), students are specific (they should write, “the power produced by the solar panel” and not just “the power”).

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

- Walk around and help subgroups who are struggling.
- Make sure subgroups are underlining their controls and circling their changing variable(s).
- Make sure subgroups are filling out the materials page correctly and completely.

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

- Walk around and help subgroups who are struggling.
- Make sure, within one subgroup, all students have the same order for their changing variable(s) values.
- Make sure all control blanks are filled out.

Procedure: *(18 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Make sure procedures are concise, but still include all values of the controls and changing variable(s), as well as the data that will be collected and the calculation that will be performed.
    - Students within each subgroup can vary the wording in their procedures, as long as the steps are in the same order and correct values are included.

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 panel angle one step would be: Place the panel at an angle of A) 30°, B) 45°, and C) 60°.

1. Set up lamp using spacing tool at 14 cm above panel.
2.
Place shading tool on solar panel so it is 6/8
3. shaded.
Set panel angle to A) 30°, B) 75°, and C) 45°.
4.
Place solar panel directly under lamp, and then
5. turn lamp on.
Heat the solar panel to A) RT, B)30°C, and C)
6. 44°C.
Use multimeter to measure the current (mA)
7. and voltage (V).
Calculate the power produced by the solar cell by
8.

7

Note: Procedure does not match the lead experiment

Results Table: *(3 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Make sure students are underlining controls, circling the changing variable(s), and boxing data collection boxes.
- Make sure control values are written in the *Trial A* box with an arrow through the rest of the trials’ boxes, while changing variable(s) values are written in each trial’s box.
- Make sure students are making predictions for which trial they think will produce the smallest (S) and largest (L) power.

Wrap-Up: *(3 minutes – Full Class – SciTrek Lead)*

- Go over what students will do next session.

Extra Time:

- On this day there is often extra time. If so, go over page 31 in the notebook, which gives students practice on distinguishing between claim and data statements. Do not do any more than page 31 of the extra practice.

EXTRA PRACTICE

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

1.	a.	The Nile River is 6,650 km long and the Amazon River is 6,575 km long.	Claim	Data	Opinion
	b.	McDonalds French fries have more salt than In-N-Out French fries.	Claim	Data	Opinion
	c.	Dogs weighing over 50 lbs. sleep more than smaller dogs.	Claim	Data	Opinion
	d.	30 people used a black pen and 12 people used a blue pen.	Claim	Data	Opinion
	e.	Peaches are the most delicious fruit.	Claim	Data	Opinion
	f.	The car door handle was observed to be warmer after sitting in sunlight.	Claim	Data	Opinion
	g.	The tallest building in the world is in Dubai.	Claim	Data	Opinion
	h.	The more interesting the story, the longer the student will read.	Claim	Data	Opinion

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Day 3: Experiment/Analysis Activity/Conclusion

Schedule: *You are responsible for **BOLD** sections*

Introduction (SciTrek Lead) – 3 minutes
Experiment (SciTrek Volunteers) – 20 minutes
Analysis Activity (SciTrek Lead) – 30 minutes
Conclusion (SciTrek Volunteers) – 6 minutes
Wrap-Up (SciTrek Lead) – 1 minute

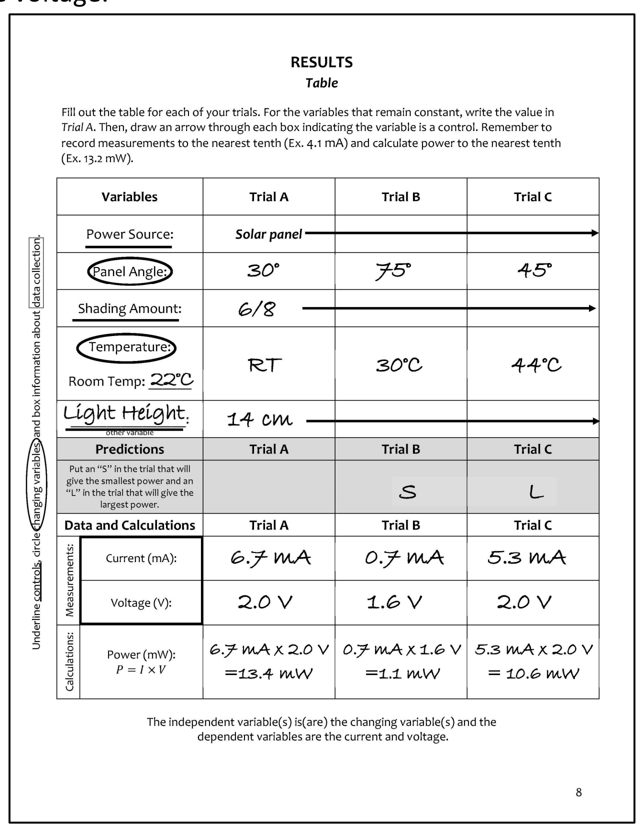
Preparation:

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 Introduction (picture packet, page 2) and the analysis activity (notebook, pages 9-11).
4. Have a solar panel, solar panel holder, spacing tool, shading tool, multimeter, thermometer, hair dryer, and lamp available to show students during the Introduction.

Introduction: *(3 minutes – Full Class – SciTrek Lead)*

- Review the class question and how students will calculate power.
- Set up an example solar panel set up while tell students the following:
  - How to connect the multimeter to the solar panel.
    - Connect the red wire with the red wire and the black wire with the back wire and the red and black wires should not touch.
  - How to use the shading tool.
    - Shading amount increases from the bottom of the solar panel ($\frac{0}{8}$) to the top of the solar panel ($\frac{8}{8}$).
  - How to use the spacing tool.
  - How to use the protractor to read the angle (picture packet, page 2).
    - Use the clear scale on the protractor.

- How to use thermometer.
  - Measure the temperature by holding the thermometer at 90° from the panel then pulling the trigger. This will put a red laser dot where the temperature is being measured from. Keep holding the trigger until the laser is on the dot on either the solar panel or the shading tool record the temperature.
    - If a student releases the trigger the thermometer will say hold and display the last temperature it was pointed at.
  - Review laser safety with students (do not point thermometer at anything other than the solar panel set up). Tell them, "If you point the thermometer at people or other objects you will lose the rights to use the thermometer for the rest of the experiment."
  - Show students where they will need to record the room temperature on their results table.
- How to heat the solar panel while taking the temperature.
  - To heating the solar panel, hold the hair dry on high about 6 inches from the panel and move back and forth for about 10 seconds then check the temperature. If needed, repeat the process until the solar panel is about 2°C above their target temperature and then let the panel cool to the target temperature.
  - During the heating process there are three roles that should be rotated through: thermometer and hairdryer operator, current and voltage reader, and recorder.
  - If temperature is a changing variable if there is a trial at room temperature, do that first, followed by the trial with the hottest temperature, and finishing with the trial with the coolest temperature, no matter the trial letters.
- How to read current and voltage
  - Start with their multimeter on the setting boxed in black to measure the current, then flip to the setting boxed in silver to measure the voltage.
- How to calculate power
  - Multiple the current and the voltage to get power and record it to the nearest tenths place.



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. Remember to record measurements to the nearest tenth (Ex. 4.1 mA) and calculate power to the nearest tenth (Ex. 13.2 mW).

Underline controls, circle changing variables, and box information about data collection.

Variables	Trial A	Trial B	Trial C
Power Source:	*Solar panel* →	→	→
Panel Angle:	30°	75°	45°
Shading Amount:	6/8 →	→	→
Temperature: Room Temp: 22°C	RT	30°C	44°C
Light Height: (other variable)	14 cm →	→	→
Predictions	**Trial A**	**Trial B**	**Trial C**
Put an "S" in the trial that will give the smallest power and an "L" in the trial that will give the largest power.		S	L
Data and Calculations	**Trial A**	**Trial B**	**Trial C**
Measurements: Current (mA):	6.7 mA	0.7 mA	5.3 mA
Measurements: Voltage (V):	2.0 V	1.6 V	2.0 V
Calculations: Power (mW): $P = I \times V$	6.7 mA x 2.0 V =13.4 mW	0.7 mA x 1.6 V =1.1 mW	5.3 mA x 2.0 V = 10.6 mW

The independent variable(s) is(are) the changing variable(s) and the dependent variables are the current and voltage.

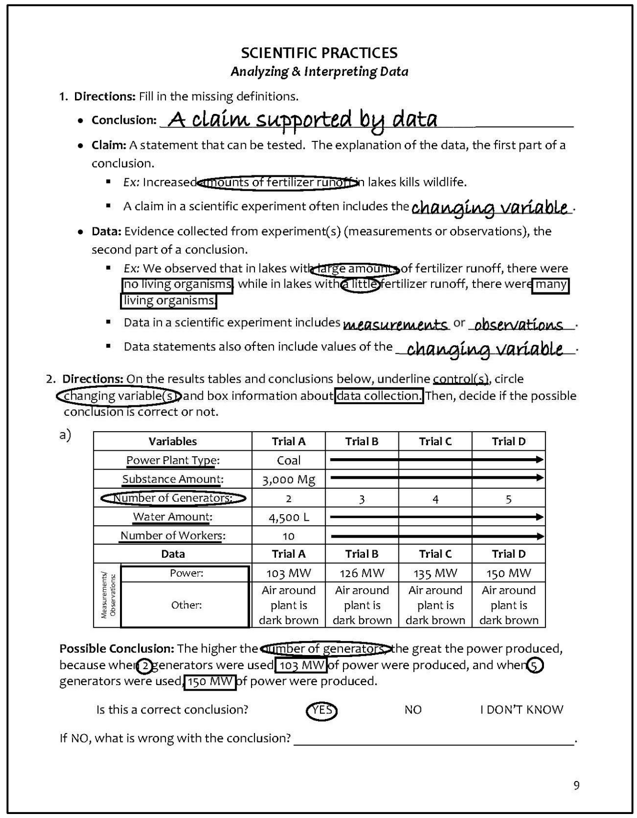
8

- Tell students, "You will only have 20 minutes to do your experiments so make sure you are working efficiently."

Experiment: *(20 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- If needed, make sure students have assigned themselves roles and are rotating roles between each trial.
- Give students a five-minute warning 15 minutes into experiment time and then at 20 minutes, no matter where students are in their experiments move on to the analysis activity.

Analysis Activity: *(30 minutes – Full Class – SciTrek Lead)*



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

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:* Increased amounts of fertilizer runoff in lakes kills wildlife.
     - A claim in a scientific experiment often includes the changing variable.
   - **Data:** Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion.
     - *Ex:* We observed that in lakes with large amounts of fertilizer runoff, there were no living organisms, while in lakes with a little fertilizer runoff, there were many living organisms.
     - Data in a scientific experiment includes measurements or observations.
     - Data statements also often include values of the changing variable.
2. **Directions:** On the results tables and conclusions below, underline control(s), circle changing variable(s) and box information about data collection. Then, decide if the possible conclusion is correct or not.

a)

Variables	Trial A	Trial B	Trial C	Trial D
Power Plant Type:	Coal	→	→	→
Substance Amount:	3,000 Mg	→	→	→
Number of Generators:	2	3	4	5
Water Amount:	4,500 L	→	→	→
Number of Workers:	10	→	→	→
Data	**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/ Observations: Power:	103 MW	126 MW	135 MW	150 MW
Measurements/ Observations: Other:	Air around plant is dark brown	Air around plant is dark brown	Air around plant is dark brown	Air around plant is dark brown

Possible Conclusion: The higher the number of generators, the great the power produced, because when 2 generators were used 103 MW of power were produced, and when 5 generators were used, 150 MW of power were produced.

Is this a correct conclusion? YES NO I DON'T KNOW

If NO, what is wrong with the conclusion? ________________.

9

- **Make sure to start the analysis activity at least 30 minutes before the end of the session.**
- Question *1*: Review the definition of a conclusion (claim supported by data; notebook, page 9).
- Review the definition of a claim (a statement that can be tested).
- Read the example claim and have students tell you the changing variable (amounts of fertilizer runoff), then circle it.
  - Discuss and fill in what claims include (changing variable).
- Review the definition of data (evidence collected from experiments).
- Read the example data statement and have students tell you the changing variable values and circle them (large amount and a little) as well as the data values and box them (no living organisms and many living organisms).
  - Discuss and fill in types of data (measurements and observations).
  - Discuss and fill in what is also in data statements (changing variables).
- Question *2*: Read the directions aloud to the class.
  - Annotate the results table and possible conclusion by underlining controls, circling changing variables, and boxing information about data collection.
    - Annotate sections *a* and *b* as a class, then, have students try *c*-*e* on their own, while you do them off to the side of the document camera.
  - Help students decide whether the conclusion is correct or incorrect by using the following questions:
    - What type of statement is before the 'because' and how do you know?
      - If the statement is *data* (contains measurements or observations)
        - Is this a correct conclusion? (No)
        - What is wrong with the conclusion? (Claim and data switched)
        - Move onto next conclusion
      - If the statement is a *claim* (can be tested)
        - What is the changing variable in this claim?
        - Is this a changing variable in this experiment? (Yes)
        - Is the claim consistent with the results table?
          - If No
            - Is this a correct conclusion? (No)
            - What is wrong with the conclusion? (Incorrect claim)
            - Move onto next conclusion.
          - If Yes and *one changing variable*
            - What type of statement is after the 'because' and how do you know? (Data, because it contains a measurement or an observation)
            - Is the data consistent with the results table? (Yes)
            - Is this a correct conclusion? (Yes)
            - Move onto next conclusion.

- If Yes and *two changing variables*
  - What type of statement is after the 'because' and how do you know? (Data, because it contains measurements or observations.)
  - Is the data consistent with the results table? (Yes)
  - Is this a fair conclusion? (No, because the change could be due to the other changing variable.)
  - Is this a correct conclusion? (No)
  - What is wrong with the conclusion? (More than one changing variable)

- For question *3*, make sure students understand, they can only have one changing variable in order to make a conclusion, and write *1* on the line.
- Tell students, "You will now analyze your data to determine if you can make a conclusion for your first experiment."

SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

b)

Variables	Trial A	Trial B	Trial C	Trial D
Power Plant Type:	Natural Gas	→	→	→
Substance Amount:	3,200 Mg	→	→	→
Number of Generators:	3	→	→	→
Water Amount:	4,200 L	→	→	→
Number of Workers:	8	10	12	14
Data	**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/Observations: Power:	140 MW	139 MW	140 MW	141 MW
Other:	Air around plant is clear	Air around plant is clear	Air around plant is clear	Air around plant is clear

Possible Conclusion: The more people working (# of workers) at the power plant, the more power produce, because when 8 people were working, 140 MW of power were produced, and when 14 people were working, 141 MW of power were produced.

Is this a correct conclusion? YES (NO) I DON'T KNOW

If NO, what is wrong with the conclusion? Incorrect claim.

c)

Variables	Trial A	Trial B	Trial C	Trial D
Power Plant Type:	Coal	→	→	→
Substance Amount:	2,700 Mg	3,100 Mg	3,600 Mg	4,200 Mg
Number of Generators:	3	→	→	→
Water Amount:	4,500 L	→	→	→
Number of Workers:	10	→	→	→
Data	**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/Observations: Power:	131 MW	140 MW	147 MW	155 MW
Other:	Air around plant is light brown	Air around plant is brown	Air around plant is brown	Air around plant is dark brown

Possible Conclusion: The greater the amount of coal (Substance amount) burned in the power plant, the more polluted the air, because we observed when 2,700 Mg of coal were burned, the air was light brown, and when 4,200 Mg of coal were burned, the air was dark brown.

Is this a correct conclusion? (YES) NO I DON'T KNOW

If NO, what is wrong with the conclusion? ________________.

10

SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

d)

Variables	Trial A	Trial B	Trial C	Trial D
Power Plant Type:	Natural Gas	→	→	→
Substance Amount:	3,100 Mg	→	→	→
Number of Generators:	3	→	→	→
Water Amount:	4,200 L	4,400 L	4,600 L	4,800 L
Number of Workers:	10	→	→	→
Data	**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/Observations: Power:	155 MW	147 MW	140 MW	128 MW
Other:	Air around plant is clear	Air around plant is clear	Air around plant is clear	Air around plant is clear

Possible Conclusion: When 4,200 L of water were used, 155 MW of power were produced, and when 4,800 L of water were used, 128 MW of power were produced, because the greater the water amount the smaller the amount of power produced.

Is this a correct conclusion? YES (NO) I DON'T KNOW

If NO, what is wrong with the conclusion? Claim and data switched.

e)

Variables	Trial A	Trial B	Trial C	Trial D
Power Plant Type:	Coal	→	→	→
Substance Amount:	2,800 Mg	3,200 Mg	3,600 Mg	4,000 Mg
Number of Generators:	3	→	→	→
Water Amount:	4,000 L	4,200 L	4,500 L	4,700 L
Number of Workers:	8	→	→	→
Data	**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/Observations: Power:	130 MW	139 MW	145 MW	155 MW
Other:	Air around plant is brown	Air around plant is brown	Air around plant is brown	Air around plant is brown

Possible Conclusion: The greater the water amount used in the power plant, the more power produced, because when 4,000 L of water were used 130 MW of power were produced, and when 4,700 L of water were used, 155 MW of power were produced.

Is this a correct conclusion? YES (NO) I DON'T KNOW

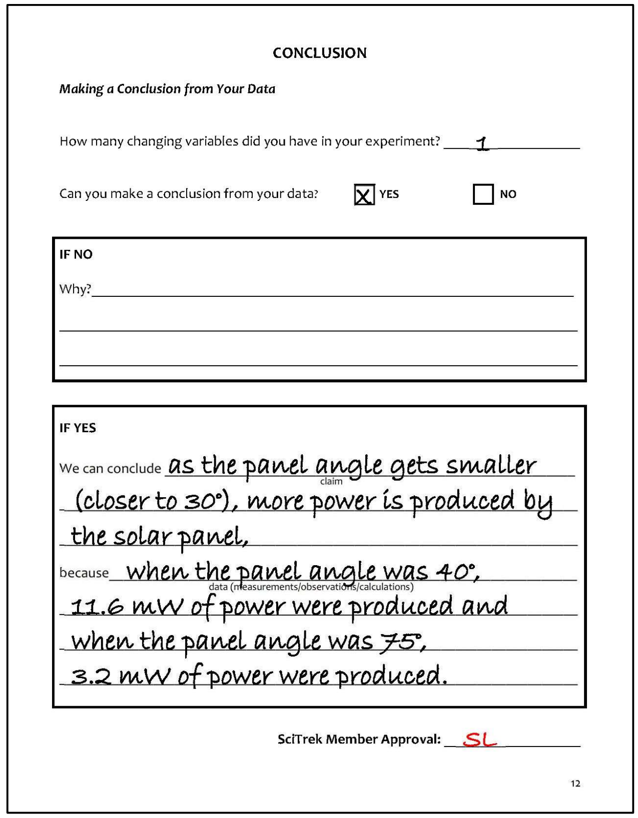
If NO, what is wrong with the conclusion? More than 1 changing variable.

3. How many changing variables can you have in order to make a conclusion? 1

11

Conclusion: *(6 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Subgroups who can make a conclusion will need more help than those who cannot.
    - If a subgroup can make a conclusion, make sure they are making a claim and using specific data to support that claim.


CONCLUSION

Making a Conclusion from Your Data

How many changing variables did you have in your experiment? 1

Can you make a conclusion from your data? [X] YES [ ] NO

IF NO

Why?

IF YES

We can conclude as the panel angle gets smaller (closer to 30°), more power is produced by the solar panel, (claim)

because when the panel angle was 40°, 11.6 mW of power were produced and when the panel angle was 75°, 3.2 mW of power were produced. (data (measurements/observations/calculations))

SciTrek Member Approval: SL

12

Wrap-Up: *(1 minutes – Full Class – SciTrek Lead)*

- Go over what students will do next session.

Day 4: Technique/Analysis Activity

Schedule: *You are responsible for* ***BOLD*** *sections*

Introduction (SciTrek Lead) – 3 minutes
Findings Discussion (SciTrek Lead) – 10 minutes
Technique (SciTrek Lead) – 15 minutes
Analysis Activity (SciTrek Lead) – 30 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Preparation:

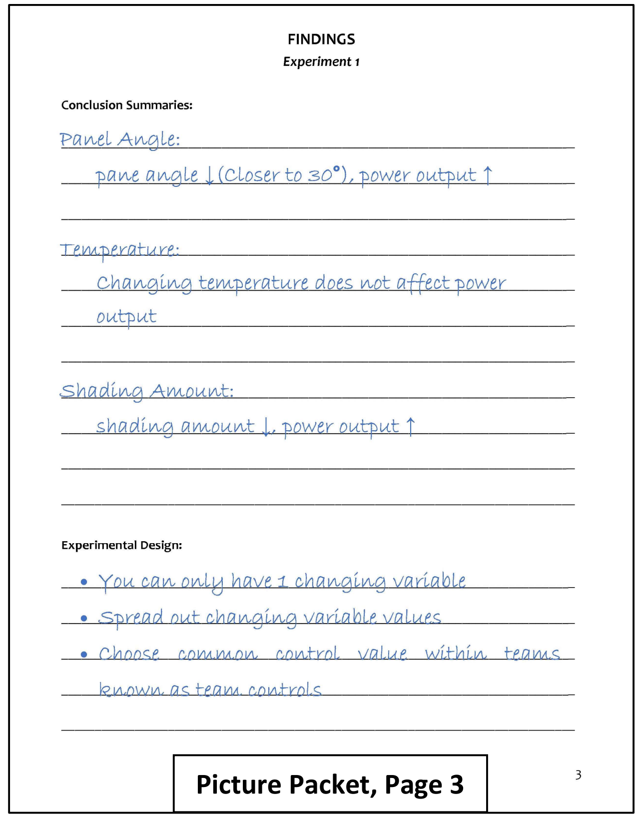
1. Make sure volunteers are setting out notebooks.
2. Set up the document camera for the findings discussion (picture packet, page 3), technique activities (notebook, pages 13-14), and analysis activity (notebook, pages 15-18).
3. Make sure that volunteers know that they have extra copies of the notebook pages for the technique and analysis activities in their boxes and they know to fill them out with the class. Volunteers should sit next to students that might need extra help.

Introduction: *(3 minutes – Full Class – SciTrek Lead)*

- Review the class question, as well as what students did and learned last session.
- Review what they learned about conclusions.
    - What is a conclusion?
        - A claim supported by data
    - What is a claim and what does it usually include?
        - A statement that can be tested, which includes the changing variable
    - What type of information can be used for data?
        - Measurements or observations
    - What else do we often see in a data statement?
        - Values of the changing variable
    - Can the claim and data statements be in any order for a conclusion?
        - No, the claim must come first, followed by the data that supports it.
    - How many changing variables can we have, in order to make a conclusion, and why?
        - One, if we test more than one changing variable at the same time, there is no way of telling which variable affected the data.
- Remind students that last time they wrote conclusions about their first experiment if their data allowed.

Findings Discussion: *(10 minutes – Full Class – SciTrek Lead)*

- Put the *Findings* page (picture packet, page 3) under the document camera.
- Have subgroups share out what they learned from their first experiment, and record it.
  - Make sure to record "only change one variable" under *Experimental Design*.



FINDINGS

Experiment 1

Conclusion Summaries:

Panel Angle:

pane angle ↓(Closer to 30°), power output ↑

Temperature:

Changing temperature does not affect power output

Shading Amount:

shading amount ↓, power output ↑

Experimental Design:

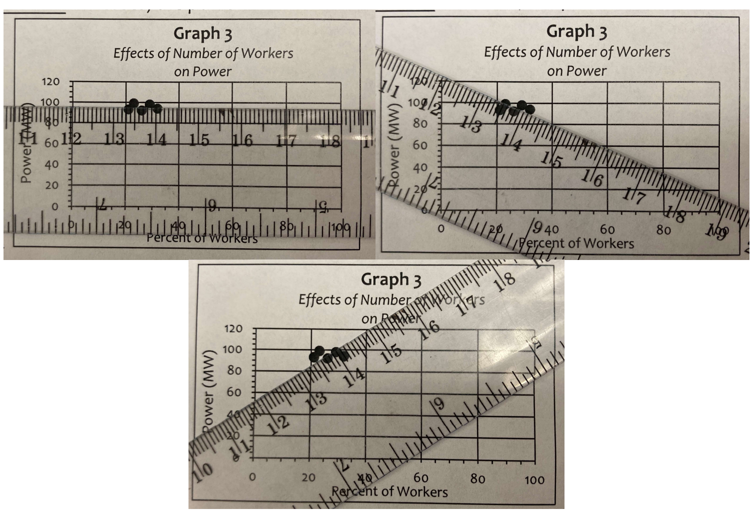
- You can only have 1 changing variable
- Spread out changing variable values
- Choose common control value within teams known as team controls

Picture Packet, Page 3

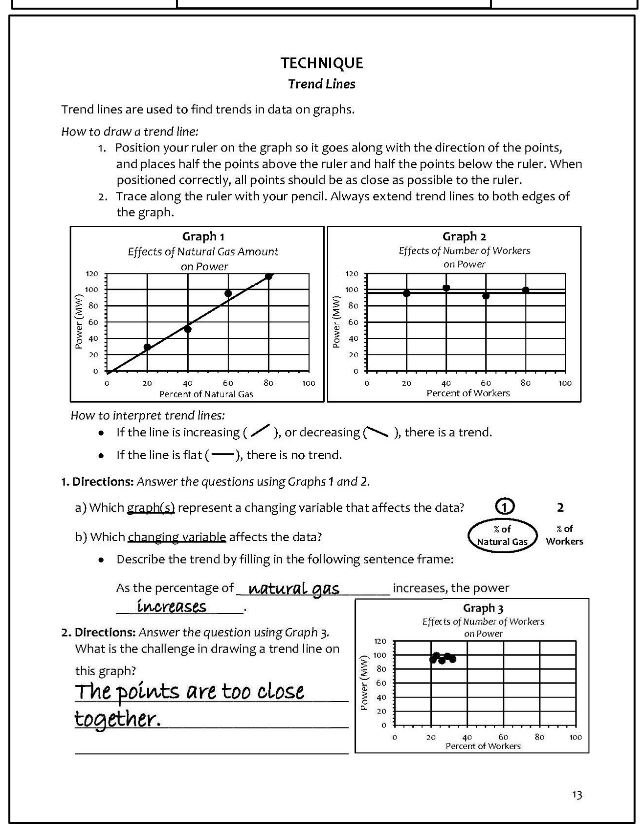
3

Technique: *(15 minutes – Full Class – SciTrek Lead)*

- Have volunteers pass out clear rulers then get their extra copies of notebook pages 13 through 18 and sit next to a student that might need extra help and fill them out along side of them.
- Go through the instructions for how to draw trend lines; draw trend lines for both graphs with students.
- Read, and discuss, the directions for how to interpret trend lines, and then fill in the lines in question *1*.
  - Make sure to use the word 'flat,' rather than 'straight,' when describing trend lines that show no trend, because all lines are straight.
- Answer question *1* as a class.
- Show students the challenge with drawing a trend line on graph *3*.
  - Put the ruler along with the points in three different ways (showing three potentially correct trend lines) and ask students, "Which placement is correct?" (see examples below)



- Lead students to understand it is impossible to tell which way is correct because the points are too close together (answer question *2*).
- Add "spread out changing variable values" to the *Findings* page (picture packet, page 3) under *Experimental Design*.



TECHNIQUE

Trend Lines

Trend lines are used to find trends in data on graphs.

How to draw a trend line:

1. Position your ruler on the graph so it goes along with the direction of the points, and places half the points above the ruler and half the points below the ruler. When positioned correctly, all points should be as close as possible to the ruler.
2. Trace along the ruler with your pencil. Always extend trend lines to both edges of the graph.

Graph 1 — *Effects of Natural Gas Amount on Power* (Power (MW) vs. Percent of Natural Gas)

Graph 2 — *Effects of Number of Workers on Power* (Power (MW) vs. Percent of Workers)

How to interpret trend lines:

- If the line is increasing (/), or decreasing (\ ), there is a trend.
- If the line is flat (—), there is no trend.

1. Directions: *Answer the questions using Graphs 1 and 2.*

a) Which graph(s) represent a changing variable that affects the data? ① 2

b) Which changing variable affects the data? (% of Natural Gas) % of Workers

- Describe the trend by filling in the following sentence frame:

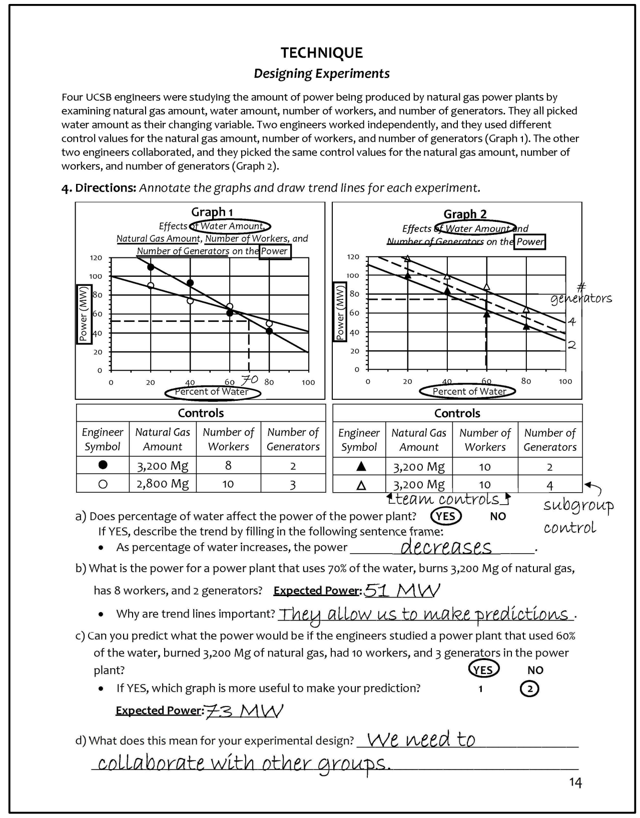
As the percentage of natural gas increases, the power increases.

2. Directions: *Answer the question using Graph 3.* What is the challenge in drawing a trend line on this graph?

The points are too close together.

Graph 3 — *Effects of Number of Workers on Power* (Power (MW) vs. Percent of Workers)

13



TECHNIQUE

Designing Experiments

Four UCSB engineers were studying the amount of power being produced by natural gas power plants by examining natural gas amount, water amount, number of workers, and number of generators. They all picked water amount as their changing variable. Two engineers worked independently, and they used different control values for the natural gas amount, number of workers, and number of generators (Graph 1). The other two engineers collaborated, and they picked the same control values for the natural gas amount, number of workers, and number of generators (Graph 2).

4. Directions: *Annotate the graphs and draw trend lines for each experiment.*

Controls			
Engineer Symbol	*Natural Gas Amount*	*Number of Workers*	*Number of Generators*
●	3,200 Mg	8	2
○	2,800 Mg	10	3

Controls			
Engineer Symbol	*Natural Gas Amount*	*Number of Workers*	*Number of Generators*
▲	3,200 Mg	10	2
△	3,200 Mg	10	4

team controls — subgroup control

a) Does percentage of water affect the power of the power plant? YES NO
If YES, describe the trend by filling in the following sentence frame:
- As percentage of water increases, the power decreases.

b) What is the power for a power plant that uses 70% of the water, burns 3,200 Mg of natural gas, has 8 workers, and 2 generators? **Expected Power:** 51 MW
- Why are trend lines important? They allow us to make predictions.

c) Can you predict what the power would be if the engineers studied a power plant that used 60% of the water, burned 3,200 Mg of natural gas, had 10 workers, and 3 generators in the power plant? YES NO
- If YES, which graph is more useful to make your prediction? 1 2

Expected Power: 73 MW

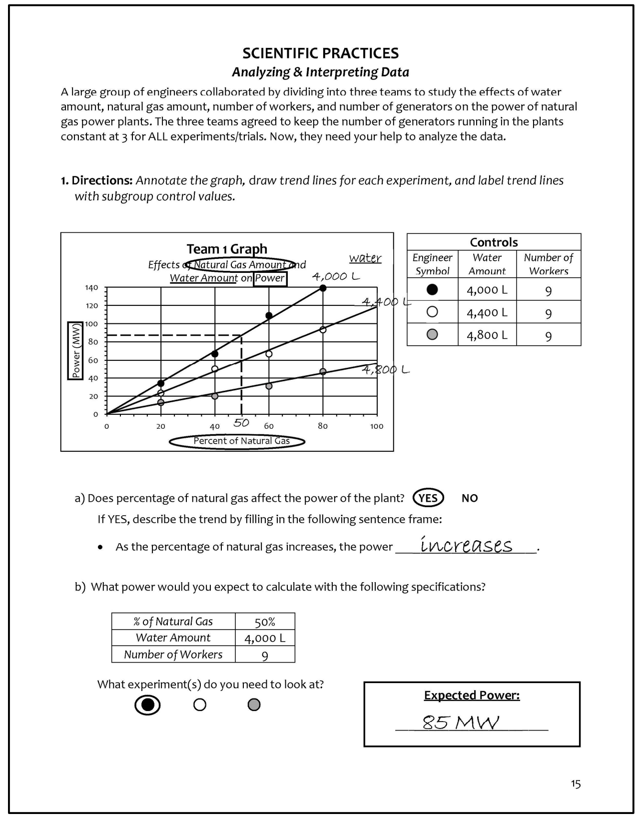
d) What does this mean for your experimental design? We need to collaborate with other groups.

14

- Turn to page 14 in the notebook and read the scenario aloud to the students.
- Show students how to annotate the graph titles.
  - Do not underline natural gas amount, number of workers, or number of generators, yet.
- Have students draw trend lines for graphs *1* and *2,* independently, while you do the same off to the of the document camera. Let them check their work after approximately 1 minute.
- Lead students to identify and underline the three controls in the title of graph *1* and the one control in the title of graph *2*.
- Discuss with students that these graph titles are different because the engineers in graph *1* all picked different control values, while the engineers in graph *2* collaborated to choose two of the control values.
  - Introduce vocabulary:
    - **Class Control:** A control that everyone in the class has the same value for.
      - For this example, there is no class control.
    - **Team Control:** A control that everyone in a team has the same value for, but values vary for different teams within a class.
      - Graph *2*: number of workers and natural gas amount
    - **Subgroup Control:** A control that everyone in a subgroup has the same value for, but values vary for different subgroups within a team
      - Graph *1*: natural gas amount, number of workers, and number of generators
      - Graph *2*: number of generators
  - Label the controls under graph *2* as either "subgroup control," or "team control."
  - Label the trend lines on graph *2* with their subgroup control values.
- Answer question *a* as a class.
- Discuss with students which trend line they should use to answer question *b* and why.
  - Walk students through using the black circle trend line to determine the expected power output. You should predict approximately 51 MW. Tell students, "Your prediction should be within 2 MW of the class's prediction."
  - Discuss that trend lines allow us to make predictions from our graphs, making them an important tool. Write this for question *b*.
- Discuss which graph is more useful for making predictions and answer question *c*.
  - Walk students through using graph 2 to determine the expected power output (~73 MW).
  - Make sure students understand their predicted trend line should fall exactly halfway between the 2 and 4 generator trend lines.
- Ask students, "What did the engineers do, that made graph 2 more useful in making predictions?" Add "choose common control values within teams" to the *Findings* page (picture packet, page 3) under *Experimental Design* and use this to answer question *d* on page 14 of the notebook.

Analysis Activity: *(30 minutes – Full Class – SciTrek Lead)*

- Read the scenario at the top of page 15 of the notebook aloud, and point out that the engineers collaborated by making the number of generators a class control.
- As a class annotate and draw/label trend lines on the team 1 graph on their own.
- Fill out question *1a* as a class.
- As a class, complete question *1b,* which allows students to make a prediction using one trend line.
  - Help students identify that the trend line they are interested in is the black circles.
  - Then find the changing variable value you are interest in (50%) and label it if it is not already on the x-axis. Then, use a ruler to draw a dashed vertical line up to the trend line or interest. Rotate the ruler by 90° and use it to draw a horizontal dashed line over to the y-axis to determine the expected power.
  - Student predictions can be off from the value in the class notebook by up to 2 MW and still be considered correct. This is true for all predictions within the scientific practice activity.
- Repeat this process for question *2* (notebook, page 16).
  - Make sure students understand, that number of workers does not affect the power output, and this is a valid and important finding (not a mistake).
  - This time you will need to draw in a predicted trend line halfway between the white and gray diamonds, using a dashed line.
    - Do this by drawing two dots, one dot on each vertical axis, halfway between the white and grey trend lines, then use a ruler to connect them with a dotted line.
  - Because number of workers do not affect power, **do not** draw dashed line up from the changing variable value of interested. Just identify where the predicted trend line crosses the y-axis.


SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

A large group of engineers collaborated by dividing into three teams to study the effects of water amount, natural gas amount, number of workers, and number of generators on the power of natural gas power plants. The three teams agreed to keep the number of generators running in the plants constant at 3 for ALL experiments/trials. Now, they need your help to analyze the data.

1. **Directions:** *Annotate the graph, draw trend lines for each experiment, and label trend lines with subgroup control values.*

Controls		
Engineer Symbol	Water Amount	Number of Workers
●	4,000 L	9
○	4,400 L	9
◍	4,800 L	9

a) Does percentage of natural gas affect the power of the plant? YES NO

If YES, describe the trend by filling in the following sentence frame:

- As the percentage of natural gas increases, the power increases.

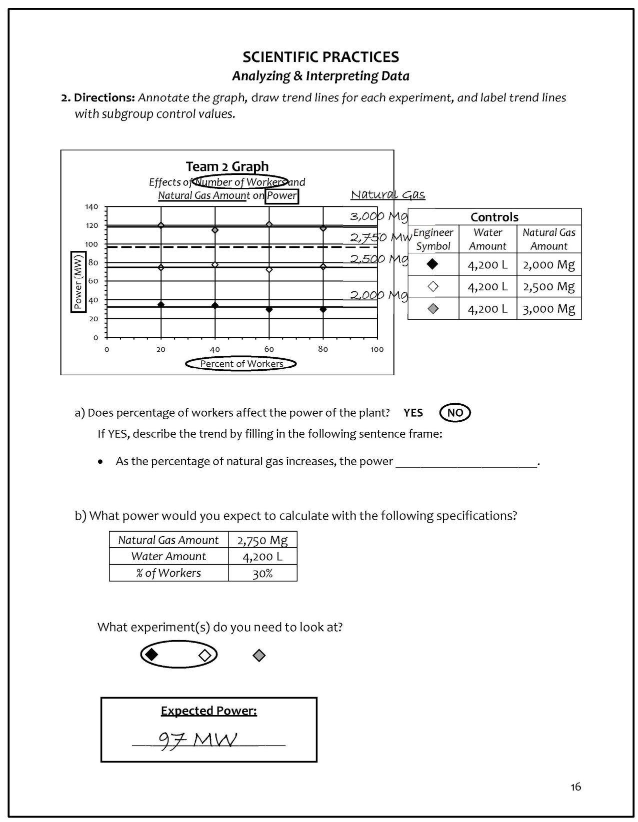
b) What power would you expect to calculate with the following specifications?

% of Natural Gas	50%
Water Amount	4,000 L
Number of Workers	9

What experiment(s) do you need to look at?

Expected Power: 85 MW

15


SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

2. **Directions:** *Annotate the graph, draw trend lines for each experiment, and label trend lines with subgroup control values.*

Controls		
Engineer Symbol	Water Amount	Natural Gas Amount
◆	4,200 L	2,000 Mg
◇	4,200 L	2,500 Mg
◈	4,200 L	3,000 Mg

a) Does percentage of workers affect the power of the plant? YES NO

If YES, describe the trend by filling in the following sentence frame:

- As the percentage of natural gas increases, the power ____________.

b) What power would you expect to calculate with the following specifications?

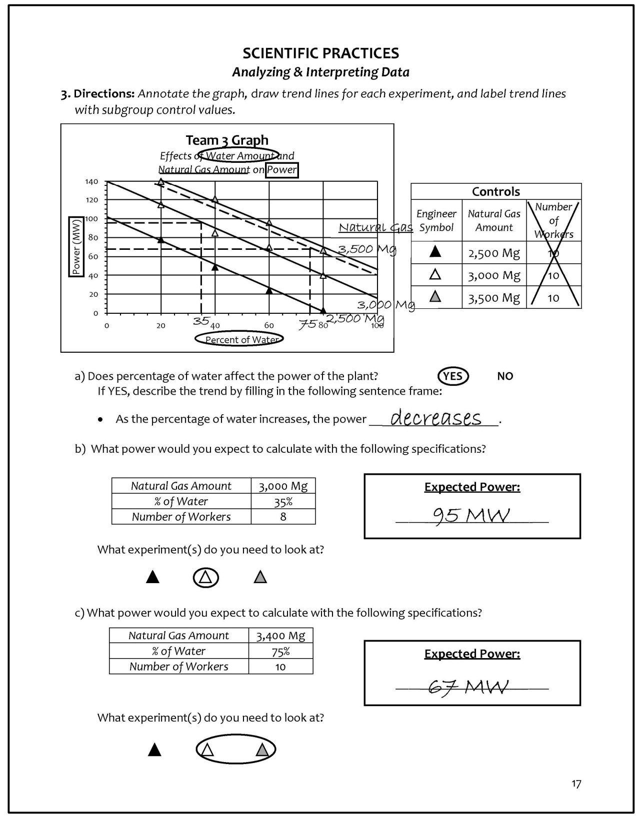
Natural Gas Amount	2,750 Mg
Water Amount	4,200 L
% of Workers	30%

What experiment(s) do you need to look at?

Expected Power: 97 MW

16

- Repeat this process for question *3* (notebook, page 17).
    - This time have students annotate and draw/label tread lines on the team 3 graph on their own. Give them approximately 1 minute, while you do so to the side of the document camera, then let them check their work.
    - Show students they can cross out number of workers, since it does not affect the power output.
    - As a class, complete question *3b,* which allows students to make a prediction using one trend line. Following the procedure laid out for question *1*.
    - As a class, complete question *3c,* which allows students to make a prediction using an estimated trend line. Following the procedure laid out for question 2.
        - To get the expected power find the changing variable value of interest (75%), write it in and draw a vertical dashed line up to the estimated trend tine. Rotate the ruler by 90° and use it to draw a horizontal dashed line over to the y-axis to determine the expected power.



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

3. Directions: *Annotate the graph, draw trend lines for each experiment, and label trend lines with subgroup control values.*

Controls		
Engineer Symbol	Natural Gas Amount	Number of Workers
▲	2,500 Mg	10
△	3,000 Mg	10
△ (shaded)	3,500 Mg	10

a) Does percentage of water affect the power of the plant? YES NO
If YES, describe the trend by filling in the following sentence frame:
- As the percentage of water increases, the power decreases.

b) What power would you expect to calculate with the following specifications?

Natural Gas Amount	3,000 Mg
% of Water	35%
Number of Workers	8

Expected Power: 95 MW

What experiment(s) do you need to look at?
▲ △ △

c) What power would you expect to calculate with the following specifications?

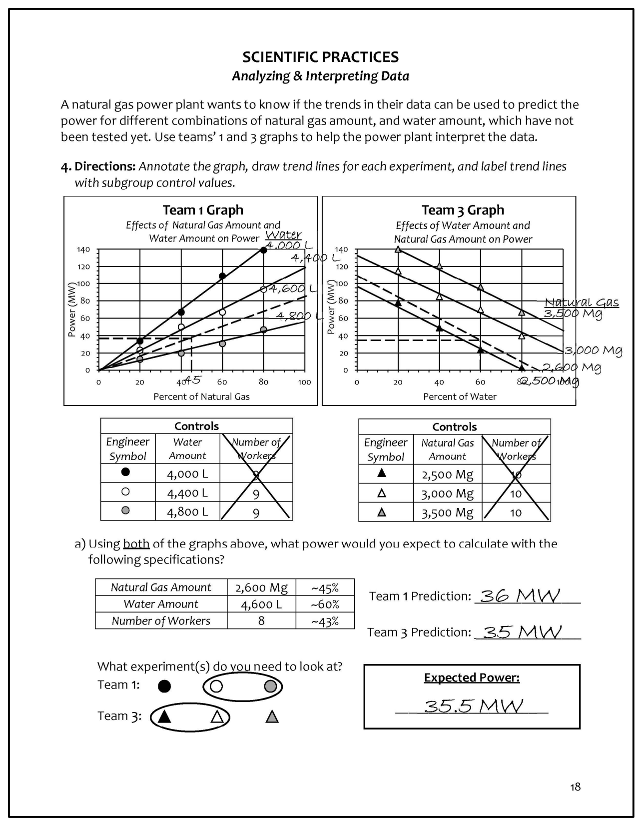
Natural Gas Amount	3,400 Mg
% of Water	75%
Number of Workers	10

Expected Power: 67 MW

What experiment(s) do you need to look at?
▲ △ △

17

- Turn to page 18 of the notebook and tell students, “We will now put all of the teams’ data together to make a prediction.”
    - Have students draw/label trend lines on both graphs, on their own, while you do so off to the side; then let them check their work.
        - They do not need to annotate the graph because they did this already on the previous pages, but they can if they would like.
    - Ask students, “Why has team 2’s graph been left out?” Possible student response: number of workers does not affect the power output.
        - Cross off number of workers in both control charts.
    - Find the estimated power form team 1’s graph
        - As a class identify the trend lines that they will use.
        - Have students determine the estimated power on their own.
        - Once the majority of them are done, on the class notebook under the document camera show them how to draw in the trend line and find the estimated power.
    - Repeat the process for team 2’s graph.
- Show students how to average their two predictions to find the final expected power (for the class notebook, this value should be 35.5 MW).



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

A natural gas power plant wants to know if the trends in their data can be used to predict the power for different combinations of natural gas amount, and water amount, which have not been tested yet. Use teams’ 1 and 3 graphs to help the power plant interpret the data.

4. Directions: *Annotate the graph, draw trend lines for each experiment, and label trend lines with subgroup control values.*

Controls		
Engineer Symbol	Water Amount	Number of Workers
●	4,000 L	9
○	4,400 L	9
● (grey)	4,800 L	9

Controls		
Engineer Symbol	Natural Gas Amount	Number of Workers
▲	2,500 Mg	10
△	3,000 Mg	10
△ (shaded)	3,500 Mg	10

a) Using both of the graphs above, what power would you expect to calculate with the following specifications?

Natural Gas Amount	2,600 Mg	~45%
Water Amount	4,600 L	~60%
Number of Workers	8	~43%

Team 1 Prediction: 36 MW

Team 3 Prediction: 35 MW

What experiment(s) do you need to look at?
Team 1: ● ○ ●
Team 3: ▲ △ △

Expected Power: 35.5 MW

18

Wrap-Up: *(2 minutes – Full Class – SciTrek Lead)*

- Go over what students will do next session.

Day 5: Technique/Question/Experimental Set-Up/Procedure/Results Table

Schedule: *You are responsible for* ***BOLD*** *sections*

Introduction (SciTrek Lead) – 2 minutes
Technique (SciTrek Lead) – 8 minutes
Class Plan Discussion (SciTrek Lead) – 15 minutes
Team Plan Discussion (SciTrek Volunteer) – 7 minutes
Question (SciTrek Volunteers) – 5 minutes
Experimental Set-Up (SciTrek Volunteers) – 5 minutes
Procedure (SciTrek Volunteers) – 11 minutes
Results Table (SciTrek Volunteers) – 5 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Preparation:

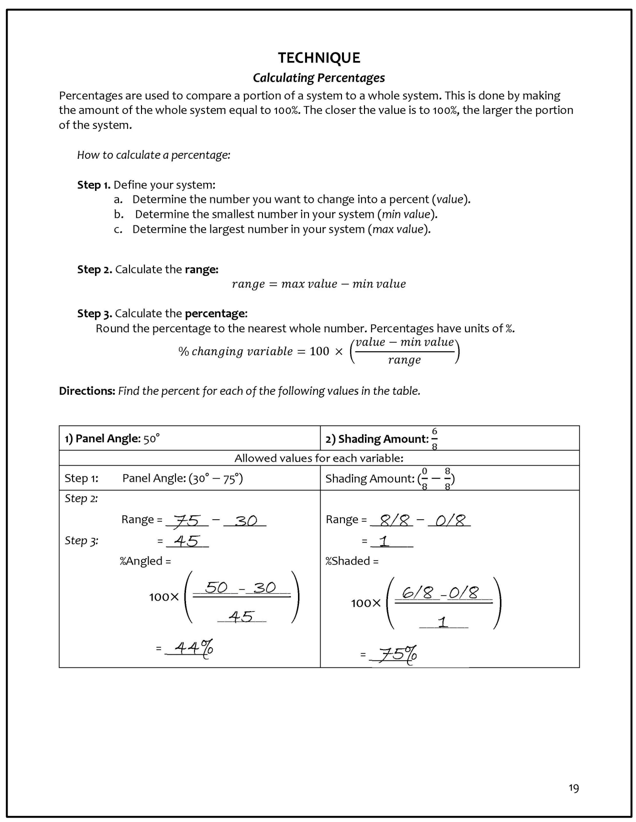
1. Make sure volunteers know what team they will work with once students form teams.
2. Make sure volunteers are passing out notebooks and rulers.
3. Set up the document camera for the technique activity (notebook, pages 19) and class plan discussion (picture packet, page 4).

Introduction: *(2 minutes – Full Class – SciTrek Lead)*

- Review the class question, as well as what students did and learned last session.
- Tell students, "Today we will learn a technique that will make it easier for us to compare data between subgroups in our next experiment. Then, we will redesign our next experiment."

Technique: *(8 minutes – Full Class – SciTrek Lead)*

- Have volunteers pass out calculators.
- Have students tell you the units for each variable (panel angle (degrees), shading amount (fraction), temperature (degrees Celsius).
- Go over how to change a variable into a percentage (notebook, page 19, top).
- Complete number *1* as a class.
    - When you get to step 3 show students how to use their calculator.
        - To enter fractions into the calculator, you must press the "$\frac{n}{d}$" button.
        - To change an improper fraction into a decimal, press the "←→" button.



TECHNIQUE

Calculating Percentages

Percentages are used to compare a portion of a system to a whole system. This is done by making the amount of the whole system equal to 100%. The closer the value is to 100%, the larger the portion of the system.

How to calculate a percentage:

Step 1. Define your system:
a. Determine the number you want to change into a percent (*value*).
b. Determine the smallest number in your system (*min value*).
c. Determine the largest number in your system (*max value*).

Step 2. Calculate the **range:**

$$range = max\ value - min\ value$$

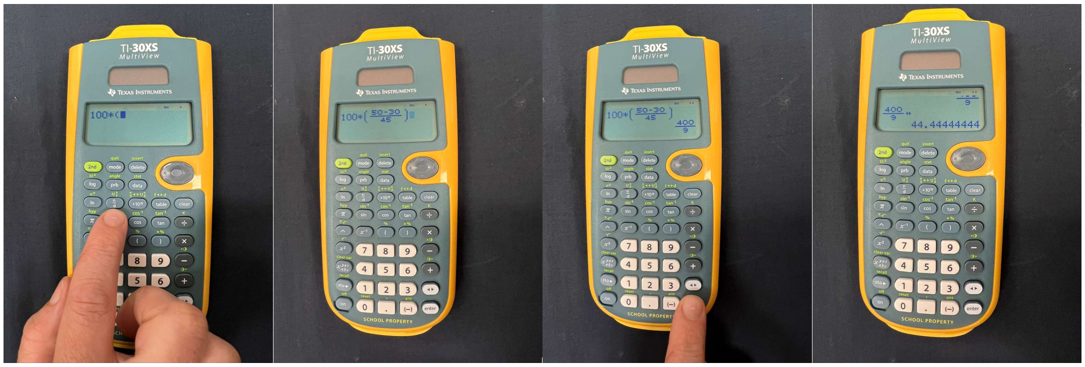
Step 3. Calculate the **percentage:**
Round the percentage to the nearest whole number. Percentages have units of %.

$$\%\ changing\ variable = 100 \times \left(\frac{value - min\ value}{range}\right)$$

Directions: *Find the percent for each of the following values in the table.*

1) Panel Angle: 50°	**2) Shading Amount:** $\frac{6}{8}$
Allowed values for each variable:	
Step 1: Panel Angle: (30° – 75°)	Shading Amount: $(\frac{0}{8} - \frac{8}{8})$
Step 2: Range = 75 – 30 = 45 *Step 3:* %Angled = $100 \times \left(\frac{50 - 30}{45}\right)$ = 44%	Range = 8/8 – 0/8 = 1 %Shaded = $100 \times \left(\frac{6/8 - 0/8}{1}\right)$ = 75%

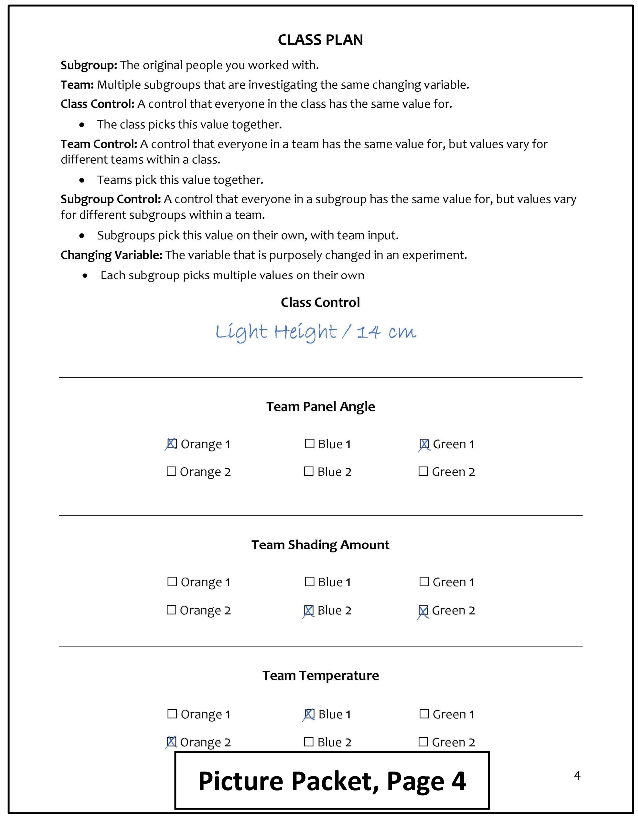
19



- Have students round the answer to the nearest whole number, and remind students that percentages are unitless.
- Repeat this process for number *2*. (**Note**: For this problem you will have to input a fraction inside a fraction in step 3.)

Class Plan Discussion: *(15 minutes – Full Class – SciTrek Lead)*

- Review the *Finding, Experimental Design* (picture packet, page 3) and what this means for the next experiment that subgroups design.
- Tell students, "We are going to break into teams to investigate each changing variable."
- Have students identify the changing variable that will be investigated (panel angle, shading amount, or temperature) as well as the class controls (light height).
- Record class control and its value (Light Height/ 14 cm) on the *Class Plan* (picture packet, page 4).
- Have subgroups rank their top 3 choices for their changing variable. Use the subgroup fair sticks (lead box) to allow them to select their team. Record these on the *Class Plan*, and have students record their team on page 20 of their notebook. **<u>Make sure to have two subgroups per team.</u>**



CLASS PLAN

Subgroup: The original people you worked with.
Team: Multiple subgroups that are investigating the same changing variable.
Class Control: A control that everyone in the class has the same value for.

- The class picks this value together.

Team Control: A control that everyone in a team has the same value for, but values vary for different teams within a class.

- Teams pick this value together.

Subgroup Control: A control that everyone in a subgroup has the same value for, but values vary for different subgroups within a team.

- Subgroups pick this value on their own, with team input.

Changing Variable: The variable that is purposely changed in an experiment.

- Each subgroup picks multiple values on their own

Class Control

Light Height / 14 cm

Team Panel Angle

☒ Orange 1	☐ Blue 1	☒ Green 1
☐ Orange 2	☐ Blue 2	☐ Green 2

Team Shading Amount

☐ Orange 1	☐ Blue 1	☐ Green 1
☐ Orange 2	☒ Blue 2	☒ Green 2

Team Temperature

☐ Orange 1	☒ Blue 1	☐ Green 1
☒ Orange 2	☐ Blue 2	☐ Green 2

4

Picture Packet, Page 4

- Tell students, “Before we get into our teams, you are going to select the values of your changing variable. Then, you will then turn these values into percentages.”
- Have subgroups determine the range for their changing variable.
    - Panel Angle Range: 45, Shading Amount Range: $\frac{8}{8}$ (1), and Temperature Range: 25
- Have students select values for their changing variables and change these into percentages.

Our subgroup is on team: Shading amount

Variables	Min Value	Max Value
Panel Angle:	30°	75°
Shading Amount:	$\frac{0}{8}$	$\frac{8}{8}$
Temperature:	19°C	44°C

The range for our changing variable is:

$range = max\ value - min\ value$

8/8-0/8=8/8=1

1. As a subgroup select and record the values of your changing variable in the table below.
   Team Temperature: Choose any whole number temperatures between 25°C and 44°C. You may also choose room temperature (ranges from 19°C - 24°C) as one of your four values. If you select this value, write “RT” on the line; you will record the numerical value of the room temperature and determine the percent temperature on the experiment day.
2. Use the following equation to calculate the percent of your change variable values.

$$\%\ changing\ variable = 100 \times \left(\frac{value - min\ value}{range}\right)$$

1) Changing Variable Value 1: 0/8	**2) Changing Variable Value 2:** 4/8
% Changing Variable = $100 \times \left(\frac{0/8 - 0/8}{1}\right) =$ 0%	% Changing Variable = $100 \times \left(\frac{4/8 - 0/8}{1}\right) =$ 50%
3) Changing Variable Value 3: 6/8	**4) Changing Variable Value 4:** 8/8
% Changing Variable = $100 \times \left(\frac{6/8 - 0/8}{1}\right) =$ 75%	% Changing Variable = $100 \times \left(\frac{8/8 - 0/8}{1}\right) =$ 100%

20

Team Plan Discussion: *(7 minutes – Teams – SciTrek Volunteers)*

- Walk around and help teams who are struggling.
- Make sure volunteers have students write their team and subgroup symbol on the front covers of their notebooks.
- Make sure volunteers fill out the team plan correctly and have students pick subgroup control values that are spread out.

TEAM SHADING AMOUNT
TEAM PLAN

1) Write each subgroups’ color and number (found on notebook cover) next to one of the symbols (O or Δ).

Subgroup Symbol:

O Blue 2 (Subgroup) Δ Green 2 (Subgroup)

2) On the front cover of your notebook for Team/Subgroup Symbol, fill in “Shading”/ the symbol for your subgroup from 1.

3) Your **subgroup control** will be panel angle. As a subgroup, select the values you will use.

Panel Angle: Choose any panel angle between 30° and 75° (original = 45°).

O 30°C Δ 75°C

4) Your teams’ **team control** will be temperature. The value you will use will be room temperature (RT). This will be a temperature between 19°C - 26°C. You will record the numerical value of room temperature on experiment day.

Temperature: RT

5) The **class control** will be light height.

Light Height: 14 cm

TEAM PANEL ANGLE
TEAM PLAN

1) Write each subgroups’ color and number (found on notebook cover) next to one of the symbols.

Subgroup Symbol:

O Orange 1 (Subgroup) Δ Green 1 (Subgroup)

2) On the front cover of your notebook for Team/Subgroup Symbol, fill in “Panel Angle”/ the symbol for your subgroup from 1.

3) Your **subgroup control** will be temperature. As a subgroup, select the values you will use.

Temperature: Choose any whole number temperature between 26°C and 44°C. You may also choose room temperature (ranges from 19°C - 26°C). If you select this value, write “RT” on the line. You will record the numerical value of room temperature on experiment day.

O RT Δ 40°C

4) Your teams’ **team control** will be shading amount. As a team, select the value you will use.

Shading Amount: Choose any fraction from $\frac{0}{8}$ to $\frac{7}{8}$. (original = $\frac{2}{8}$)

$\frac{0}{8}$

5)The **class control** will be light height.

Light Height: 14 cm

Team Plans

TEAM TEMPERATURE
TEAM PLAN

1) Write each subgroups’ color and number (found on notebook cover) next to one of the symbols.

Subgroup Symbol:

O Orange 2 (Subgroup) Δ Blue 1 (Subgroup)

2) On the front cover of your notebook for Team/Subgroup Symbol, fill in “Temp”/ the symbol for your subgroup from 1.

3) Your **subgroup control** will be shading amount. As a subgroup, select the values you will use.

Shading Amount: Choose any fraction from $\frac{0}{8}$ to $\frac{7}{8}$. (original = $\frac{2}{8}$)

O $\frac{6}{8}$ Δ $\frac{0}{8}$

4) Your teams’ **team control** will be panel angle. As a team, select the value you will use.

Panel Angle: Choose any angle between 30° and 75°. (original = 45°)

45°

5) The **class control** will be light height.

Light Height: 14 cm

Question: *(5 minutes – Teams – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Make sure for the second part of the question (what you are calculating) students are specific (they should write, "the power produced by the solar panel" and not just "the power").

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

- Walk around and help subgroups who are struggling.
- Make sure within one subgroup all students have the same order for their changing variable values.
- Make sure all control blanks are filled out.

Procedure: *(11 minutes – Teams – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Make sure procedures are concise, but still include all values of the controls and changing variable, as well as the data that will be collected and the calculation that will be performed.
  - Students within each subgroup can vary the wording in their procedures, as long as the steps are in the same order and correct values are included.

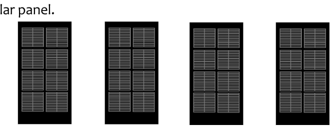
QUESTION

Question our subgroup will investigate:

- If we change the shading amount (insert each changing variable (independent variable)), what will happen to the power produced by the solar panel (insert what you are calculating)?

EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: panel angle) and the values (Ex: 45°) you will use for your trials under each solar panel.



Changing Variable(s):	D	E	F	G
1) Shading Amount:	0/8	4/8	6/8	8/8
2) :				

Why did your subgroup choose these values of the changing variable? We spread out our changing variable values so our data points will also be spread out.

Controls (variables you will hold constant):
Write your controls and the values you will use in all your trials (control/value, Ex: power source/solar panel).

Class and Team Controls: (same vlaues between subgroups)	Subgroup Control: (differnet values between subgroups)
Power Source / Solar Panel	Panel Angle / 30°
Temperature / RT	
Light Height / 14 cm	

SciTrek Member Approval: SL

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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 panel angle one step would be: Place the panel at an angle of D) 30°, E) 45°, F) 60°, and G) 75°.

1. Set up lamp using the spacing tool 14 cm above panel.
2. Place shading tool on solar panel at D) 0/8, E) 4/8, F) 6/8, and G) 8/8 shaded.
3. Place the panel at an 30° angle.
4. Position panel directly under lamp, and turn lamp on.
5. Do not heat the solar panel, leave at RT.
6. Use multimeter to measure the current (mA) and voltage (V).
7. Calculate the power by multiplying current and voltage.
8.

SciTrek Member Approval: SL

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RESULTS

Table

Check the box of your subgroup control and write your subgroup symbol on the line. Then, fill out the table for each of your trials. For the variables that remain constant, write the value in *Trial D*. Then, draw an arrow through each box indicating the variable is a control. Remember to record measurements to the nearest tenth (Ex. 4.1 mA), calculate power to the nearest tenth (Ex. 13.2 mW), and percentages to the nearest whole number (Ex. 75%).

Subgroup Control: ☒ Panel Angle ☐ Shading Amount ☐ Temperature **Subgroup Symbol:** o

Underline controls, circle changing variables, and box information about data collection.

Variables	Trial D	Trial E	Trial F	Trial G
Power Source:	*Solar panel*	→	→	→
Panel Angle:	30°	→	→	→
Shading Amount:	0/8	4/8	6/8	8/8
Temperature: Room Temp: 22°C	RT	→	→	→
Light Height: (other variable)	14 cm	→	→	→
Predictions	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Put an "S" in the trial that will give the smallest power and an "L" in the trial that will give the largest power.	L			S
Data and Calculations	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Measurements: Current (mA):				
Measurements: Voltage (V):				
Calculations: Percent Changing Variable: (get values from pg. 20)				
Calculations: Power (mW): $P = I \times V$				

The independent variable is the changing variable and the dependent variables are the current and voltage.

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Results Table: *(5 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Make sure students are underlining controls, circling the changing variable, and boxing data collection boxes.
- Make sure control values are written in the *Trial D* box with an arrow through the rest of the trials' boxes, while changing variable values are written in each trial's box.
- Make sure students are making predictions for which trial they think will produce the smallest (S) and largest (L) power.

Wrap-Up: *(2 minutes – Full Class – SciTrek Lead)*

- Go over what students will do next session.

Day 6: Experiment/Graph/Conclusion

Schedule: *You are responsible for* ***BOLD*** *sections*

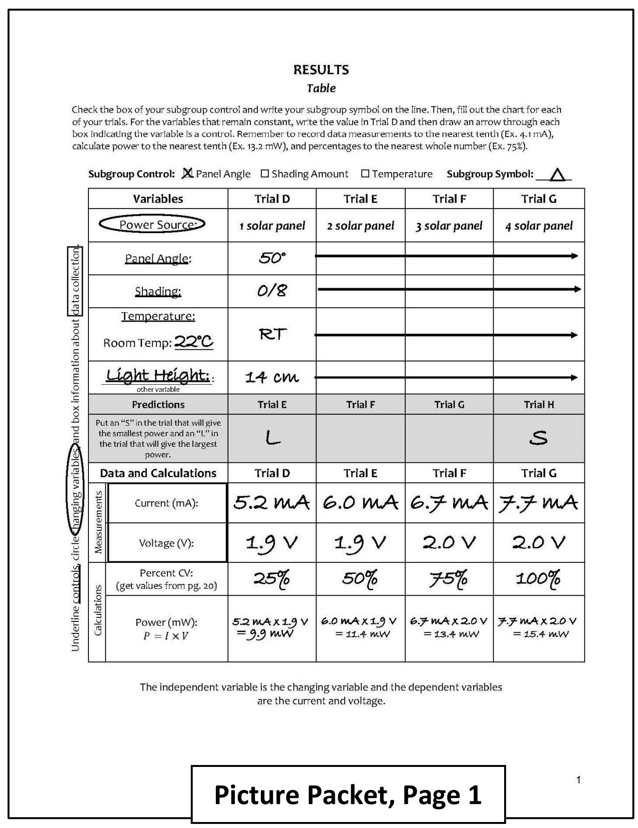
Introduction (SciTrek Lead) – 9 minutes
Experiment (SciTrek Volunteers) – 20 minutes
Graph (SciTrek Volunteers) – 20 minutes
Conclusion (SciTrek Volunteers) – 9 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Preparation:

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 Introduction (picture packet, pages 1, 5, and 6; notebook, page 25).

Introduction: *(9 minutes – Full Class – SciTrek Lead)*

- Review the class question, as well as what students did and learned last session.
- Use the checklist (picture packet, page 5, top) to go over how to graph results.
    - The filled-out results table used to make the graph is on page 1 of the picture packet.
    - Talk students through the process of completing their graphs (picture packet, page 5)
    - Show what the completed team graph should look like (picture packet, page 6)


RESULTS

Table

Check the box of your subgroup control and write your subgroup symbol on the line. Then, fill out the chart for each of your trials. For the variables that remain constant, write the value in Trial D and then draw an arrow through each box indicating the variable is a control. Remember to record data measurements to the nearest tenth (Ex. 4.1 mA), calculate power to the nearest tenth (Ex. 13.2 mW), and percentages to the nearest whole number (Ex. 75%).

Subgroup Control: ☒ Panel Angle ☐ Shading Amount ☐ Temperature **Subgroup Symbol:** △

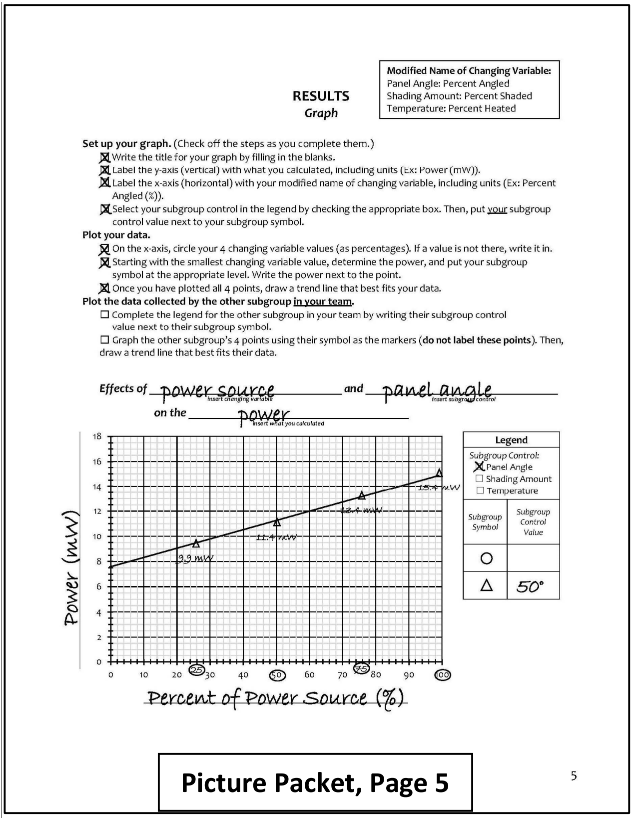
Underline controls, circle changing variables, and box information about data collection.

Variables	Trial D	Trial E	Trial F	Trial G
Power Source:	*1 solar panel*	*2 solar panel*	*3 solar panel*	*4 solar panel*
Panel Angle:	50°	→	→	→
Shading:	0/8	→	→	→
Temperature: Room Temp: 22°C	RT	→	→	→
Light Height: (other variable)	14 cm	→	→	→
Predictions	**Trial E**	**Trial F**	**Trial G**	**Trial H**
Put an "S" in the trial that will give the smallest power and an "L" in the trial that will give the largest power.	L			S
Data and Calculations	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Measurements: Current (mA):	5.2 mA	6.0 mA	6.7 mA	7.7 mA
Measurements: Voltage (V):	1.9 V	1.9 V	2.0 V	2.0 V
Calculations: Percent CV: (get values from pg. 20)	25%	50%	75%	100%
Calculations: Power (mW): $P = I \times V$	5.2 mA x 1.9 V = 9.9 mW	6.0 mA x 1.9 V = 11.4 mW	6.7 mA x 2.0 V = 13.4 mW	7.7 mA x 2.0 V = 15.4 mW

The independent variable is the changing variable and the dependent variables are the current and voltage.

1

Picture Packet, Page 1


Modified Name of Changing Variable:
Panel Angle: Percent Angled
Shading Amount: Percent Shaded
Temperature: Percent Heated

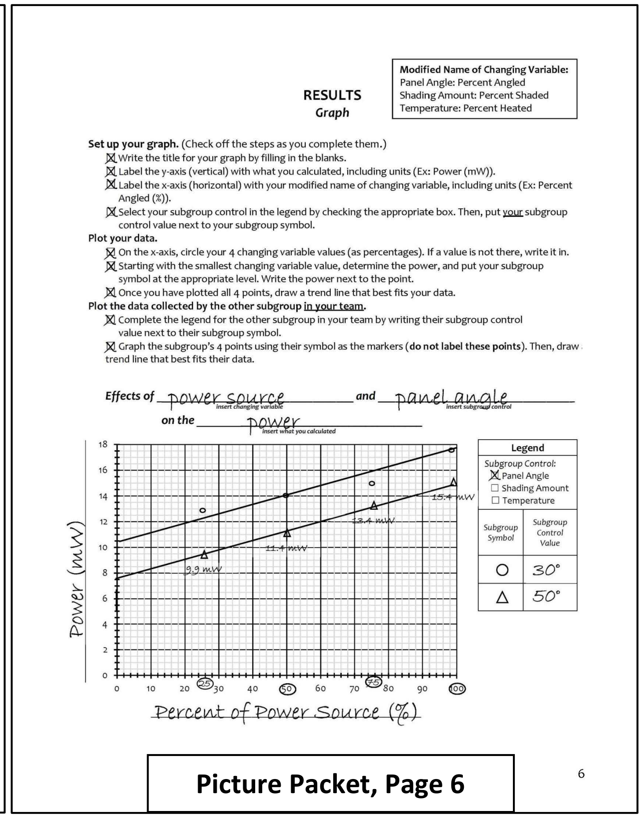
RESULTS
Graph

Set up your graph. (Check off the steps as you complete them.)
☒ Write the title for your graph by filling in the blanks.
☒ Label the y-axis (vertical) with what you calculated, including units (Ex: Power (mW)).
☒ Label the x-axis (horizontal) with your modified name of changing variable, including units (Ex: Percent Angled (%)).
☒ Select your subgroup control in the legend by checking the appropriate box. Then, put your subgroup control value next to your subgroup symbol.
Plot your data.
☒ On the x-axis, circle your 4 changing variable values (as percentages). If a value is not there, write it in.
☒ Starting with the smallest changing variable value, determine the power, and put your subgroup symbol at the appropriate level. Write the power next to the point.
☒ Once you have plotted all 4 points, draw a trend line that best fits your data.
Plot the data collected by the other subgroup in your team.
☐ Complete the legend for the other subgroup in your team by writing their subgroup control value next to their subgroup symbol.
☐ Graph the other subgroup's 4 points using their symbol as the markers (**do not label these points**). Then, draw a trend line that best fits their data.

Effects of power source (insert changing variable) *and* panel angle (insert subgroup control) *on the* power (insert what you calculated)

Picture Packet, Page 5

5


Modified Name of Changing Variable:
Panel Angle: Percent Angled
Shading Amount: Percent Shaded
Temperature: Percent Heated

RESULTS
Graph

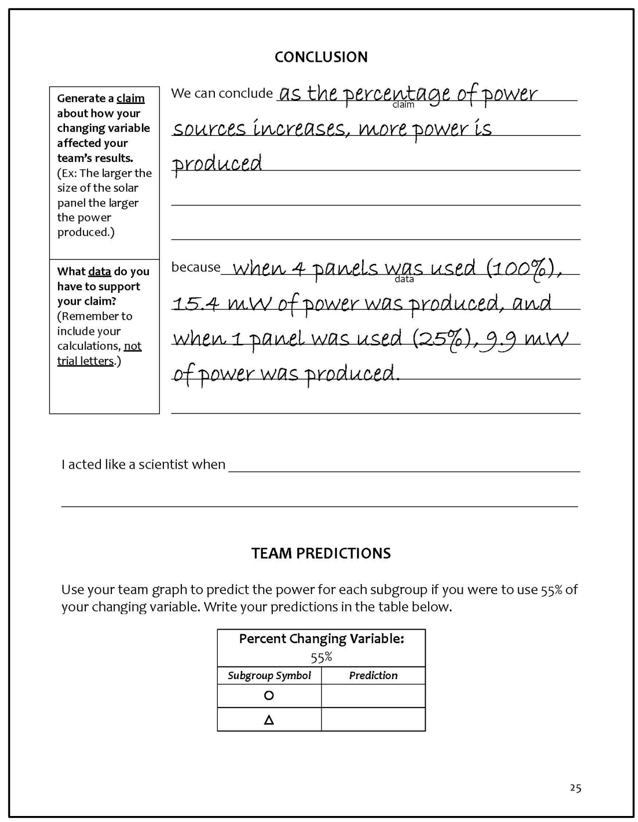
Set up your graph. (Check off the steps as you complete them.)
☒ Write the title for your graph by filling in the blanks.
☒ Label the y-axis (vertical) with what you calculated, including units (Ex: Power (mW)).
☒ Label the x-axis (horizontal) with your modified name of changing variable, including units (Ex: Percent Angled (%)).
☒ Select your subgroup control in the legend by checking the appropriate box. Then, put your subgroup control value next to your subgroup symbol.
Plot your data.
☒ On the x-axis, circle your 4 changing variable values (as percentages). If a value is not there, write it in.
☒ Starting with the smallest changing variable value, determine the power, and put your subgroup symbol at the appropriate level. Write the power next to the point.
☒ Once you have plotted all 4 points, draw a trend line that best fits your data.
Plot the data collected by the other subgroup in your team.
☒ Complete the legend for the other subgroup in your team by writing their subgroup control value next to their subgroup symbol.
☒ Graph the subgroup's 4 points using their symbol as the markers (**do not label these points**). Then, draw a trend line that best fits their data.

Effects of power source (insert changing variable) *and* panel angle (insert subgroup control) *on the* power (insert what you calculated)

Picture Packet, Page 6

6

- Review the definition of a conclusion (a claim supported by data).
- Have students generate a conclusion from the data, using subgroup (Δ) data (picture packet, page 6).
  - We can conclude as the percentage of power source increases, more power is produced, because when 4 solar panels was used (100%), 15.4 mW of power were produced and when 1 solar panel was used (25%) 9.9 mW of power were produced.
  - Tell students, "When you make your conclusions you, will use your entire team's graph to come up with a claim, but you will use two specific data points, from your own subgroup data, to support the claim."
- Remind students of the following things before allowing them to start:
  - When connecting the multi meter to the solar panel connect the red wire with the red wire and the black wire with the black wire and the red and black wires should not touch.
  - Shading amount increases from the bottom of the solar panel ($\frac{0}{8}$) to the top of the solar panel ($\frac{8}{8}$).
  - Use the clear scale of the protractor.
  - Thermometers should only be pointed at solar panel set up.
  - Take and record the room temperature before starting experiments.


CONCLUSION

Generate a claim about how your changing variable affected your team's results. (Ex: The larger the size of the solar panel the larger the power produced.)	We can conclude as the percentage of power sources increases, more power is produced (claim)
What data do you have to support your claim? (Remember to include your calculations, not trial letters.)	because when 4 panels was used (100%), 15.4 mW of power was produced, and when 1 panel was used (25%), 9.9 mW of power was produced. (data)

I acted like a scientist when

TEAM PREDICTIONS

Use your team graph to predict the power for each subgroup if you were to use 55% of your changing variable. Write your predictions in the table below.

Percent Changing Variable: 55%	
Subgroup Symbol	Prediction
O	
Δ	

25

  - To heating the solar panel, hold the hair dry on high about 6 inches from the panel and move back and forth for about 10 seconds then check the temperature. If needed, repeat the process until the solar panel is about 2°C above their target temperature and then let the panel cool to the target temperature.
  - For Team Temperature, if there is a trial at room temperature, do that first, followed by the trial with the hottest temperature, and finishing with the trial with the coolest temperature, no matter the trial letters.
  - Start with their multimeter on the setting boxed in black to measure the current, then flip to the setting boxed in silver to measure the voltage.
  - Multiple the current and the voltage to get power and record it to the nearest tenths place.

Experiment: *(20 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- If needed, make sure students have assigned themselves roles and are rotating roles between each trial.
- Make sure students are copying their percent changing variable from page 20 of their notebook into the results table.
- Allow subgroups to leave their set-up at their station until they have finished their graph. They can go back and repeat any trials they think have inconsistent data, as long as there is still time.

Graph: *(20 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Make sure students are writing the percentage value above the points for their own subgroup's data.
- If one subgroup finishes before the other subgroup on the team have the volunteer use their phone to take a picture of the other subgroups data for the subgroup to graph.
- Make sure students are graphing the data for the other subgroup in their team (do not let them label these points).
- Make sure students are drawing trend lines for each set of points.

Conclusion: *(9 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Make sure subgroups are generating a claim (ideally the claim will allow them to make a prediction about future experiments) and using two specific data points to support it.
  - Since this is an engineering activity, make sure students are making a claim that focus on the value of their changing variable which produces the largest power.
  - Subgroups will be using calculations as their data; make sure they are including numerical values in their data statements.
  - Do not let subgroups reference trial letters in their conclusions.
- Volunteers struggle with conclusions, so you should check at least one conclusion from each team.
- Make sure students fill out the sentence frame (notebook, page 25), *I acted like a scientist when*.
- If there is time, students should use their team graphs to fill out the *Team Predictions* (notebook, page 25).

Wrap-Up: *(2 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?

Day 7: Poster Making/Poster Presentations

Schedule: *You are responsible for **BOLD** sections*

> **Introduction (SciTrek Lead) – 2 minutes**
> Poster Making (SciTrek Volunteers) – 25 minutes
> Practice Posters (SciTrek Volunteers) – 5 minutes
> **Poster Presentations (SciTrek Volunteers/SciTrek Lead) – 26 minutes**
> **Wrap-Up (SciTrek Lead) – 2 minutes**

Note: Timing is tight on this day. It is possible the class will only get through two of the three presentations during the allotted time. In this case, the teacher will need to lead the third poster presentation, outside of SciTrek time, before the next SciTrek session.

Preparation:

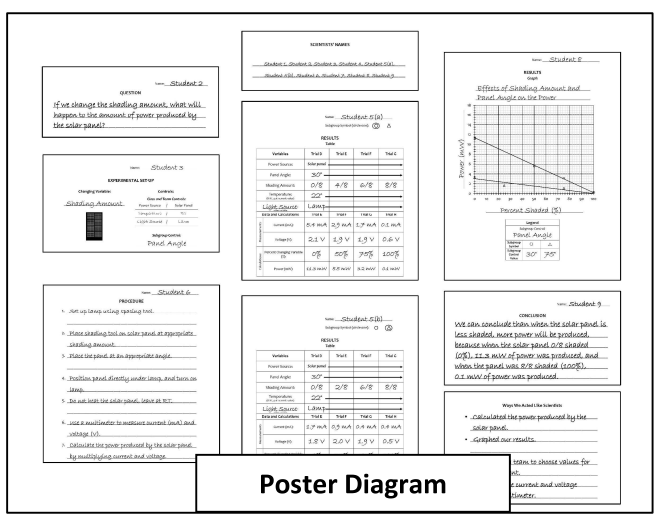
1. Make sure notebooks have been highlighted, stickered, and numbered. If not, use the poster diagram page to have volunteers do this before starting SciTrek.
2. Make sure volunteers are setting out notebooks.
3. Set up the document camera to use for the *Notes on Presentations* (picture packet, page 7).

Introduction: *(2 minutes – Full Class – SciTrek Lead)*

- Review the class question, what students did and learned last session, as well as what they will do today.

Poster Making: *(25 minutes – Subgroups – SciTrek Volunteers)*

- Notebooks will have already been highlighted, numbered, and stickered. If a student is absent have the volunteer give that student's notebook to another student to fill out the part. During the presentation the present student will have two notebooks to read out of.
- Make sure the students in each subgroup who are presenting a results table, has completely filled out the sentence frame sticker in their notebook.
- Make sure the students on each team who are presenting the *Experimental Set-Up: Specific* and *Graph: General*, have fill out the sheet stapled in their notebooks.
- Make sure the student presenting the *Results Graph: Specific* knows how to orally fill in the sentence frame with their data points.
- The *Ways we Acted Like Scientists* poster part can be filled out by one or multiple, student(s), as long as they have finished their assigned poster part first.
- Help volunteers glue poster pieces onto the posters. When gluing, make sure **you** or the **volunteers** (not the students) are gluing the poster in the **exact** order that is shown on the diagram and the poster has a landscape orientation.



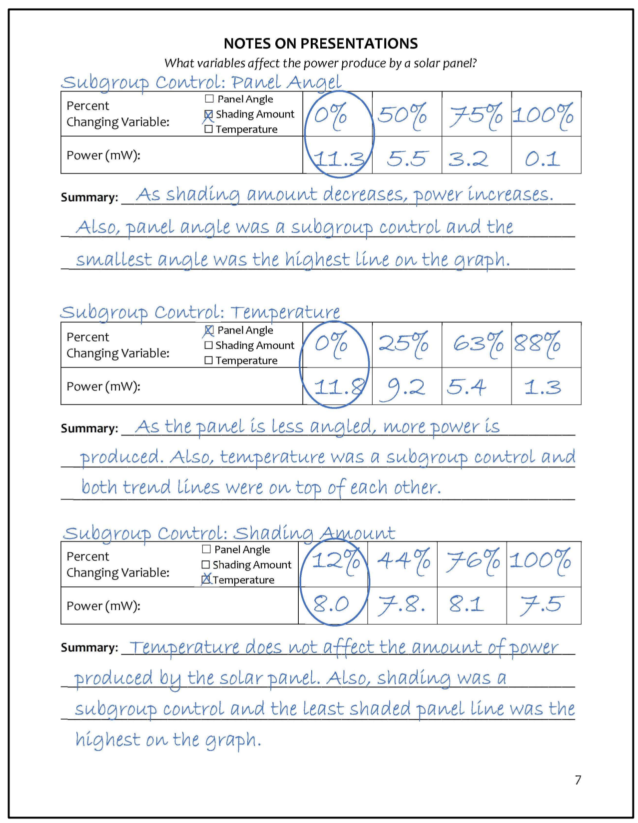
Poster Diagram

Practice Posters: *(5 minutes – Subgroups – SciTrek Volunteers)*

- **Do not give students more than 5 minutes to practice or you will run out of time for presentations.**
- Organize posters so they are presented from easiest to understand, to hardest to understand (**suggested order: shading amount, panel angle, and temperature**).
- Make sure students are reading from their notebooks and practicing the poster in order: 1) scientists' names, 2) question, 3) experimental set-up: general, 4) experimental set-up: specific (staple sheet), 5a) results table ○ (sticker), 5b) results table Δ (sticker), 6) procedure (staple sheet), 7) graph: general (staple sheet), 8) graph: specific (sticker), and 9) conclusion. They will **not** read the *Ways we Acted Like Scientists* from their posters.

Poster Presentations: *(31 minutes – Full Class – SciTrek Volunteers/SciTrek Lead)*

- Inform students if they ask a scientific question (a question that helps summarize what the team did/learned or requires them to make a prediction based on their data) they will receive a SciTrek pencil after the presentations are done.
- Have students present their posters.
- While posters are being presented, record the following (picture packet, page 7), while students do the same (notebook, page 26):
    - After a team reads their question, stop the presentation and have the class identify the changing variable. Then, record it in the picture packet while students do the same in their notebooks.
    - After the team presents their Experimental set up Specific, stop the presentation and have the class identify the subgroup control. Then, record it in the picture pack Students do not have to record this if they do not want to.
    - After the first team's presentation stop the presentation after the team has read their procedure and have the class predict what trend they think the team saw both within their trend lines and between trend lines, if possible.
    - When a team reads their results graph: specific, record the values of the changing variable and their measurements.
- After each presentation, ask students:
    - What questions do you have for this team?
        - Have students take approximately 30 seconds to write down one scientific question to ask this team. Then allow them to ask questions.
    - Once students have asked their questions (make sure each student answers a question; you should ask at least one question per presentation), have students summarize what they learned and record it (picture packet, page 7), while students also record the summary (notebook, page 26).



NOTES ON PRESENTATIONS

What variables affect the power produce by a solar panel?

Subgroup Control: Panel Angel

Percent Changing Variable: ☐ Panel Angle ☒ Shading Amount ☐ Temperature	0%	50%	75%	100%
Power (mW):	11.3	5.5	3.2	0.1

Summary: As shading amount decreases, power increases. Also, panel angle was a subgroup control and the smallest angle was the highest line on the graph.

Subgroup Control: Temperature

Percent Changing Variable: ☒ Panel Angle ☐ Shading Amount ☐ Temperature	0%	25%	63%	88%
Power (mW):	11.8	9.2	5.4	1.3

Summary: As the panel is less angled, more power is produced. Also, temperature was a subgroup control and both trend lines were on top of each other.

Subgroup Control: Shading Amount

Percent Changing Variable: ☐ Panel Angle ☐ Shading Amount ☒ Temperature	12%	44%	76%	100%
Power (mW):	8.0	7.8.	8.1	7.5

Summary: Temperature does not affect the amount of power produced by the solar panel. Also, shading was a subgroup control and the least shaded panel line was the highest on the graph.

7

   - Have students identify which value is the "best" (most power at the cheapest cost) and circle it.
- Students will not record information about their own team's poster presentation.
- After all presentations are over, have students tell you the variable values they would select that would allow a solar panel produce the most power.

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."
- Have volunteers give students SciTrek pencils.
- 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.

Day 8: Analysis Assessment/Tie to Standards

Schedule: *You are responsible for* ***BOLD*** *sections*

Analysis Assessment (SciTrek Lead) – 10 minutes
Tie to Standards (SciTrek Lead) – 50 minutes

Preparation:

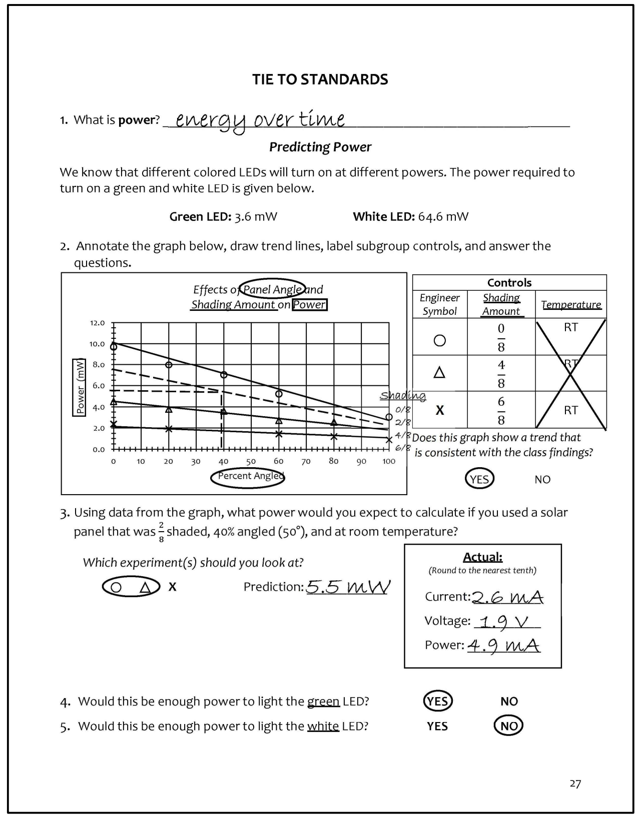
1. If the teacher is not leading the tie to standards activity, do the following:
    a. Give the teacher an extra notebook and have them fill it out with their students, to follow along during the tie to standards activity.
    b. Collect the teacher's lab coat and put it in the lead box.
2. Pass out the analysis assessments and notebooks.
3. Set up the document camera for the tie to standards activity (notebook, pages 27-30).
4. Assemble the tie to standards set-ups accordingly:
    a. Plug an extension cord into the wall and a power strip into the extension cord. We do not want to accidently blow a circuit breaker during the *Bright Choices* section of the tie to standards activity, therefor we must set this up accordingly.
    b. Set up the Solar Panel Set-Up.
        i. Use the shading tool to shade $\frac{2}{8}$ of the panel.
        ii. Place a solar panel in the solar panel holder and turn the angle to 50°.
        iii. Hook the multimeter up to the panel.
        iv. Plug the lamp into the power strip.
        v. Place the entire set-up near the document camera.
    c. Set up the *Bright Choices* Set-Up.
        i. Screw the LED bulb into the hanging lightbulb holder and set it in the tie to standards materials box.
        ii. Have compact florescent and halogen bulbs nearby.
5. Put your lab coat in the lead box at the end of the day.

Analysis Assessment: *(10 minutes – Full Class – SciTrek Lead)*

- Questions *1-3*: Have students underline controls, circle changing variable(s), and box information about data collection on the results tables. Then, have students answer the questions about each results table and possible conclusion.
- Pass out clear rulers to students.

- Question *4*: Have students annotate the graph (you will not help them for this assessment) by underlining the controls, circling the changing variable, and boxing information about data collection in the title, axes titles, and legend.
- Have students answer questions *4b-4f*.
- Collect assessments.
    - Leave clear rulers for students to use during the tie to standards activity.

Tie to Standards: *(50 minutes – Full Class – SciTrek Lead)*


TIE TO STANDARDS

1. What is **power**? energy over time

Predicting Power

We know that different colored LEDs will turn on at different powers. The power required to turn on a green and white LED is given below.

Green LED: 3.6 mW **White LED:** 64.6 mW

2. Annotate the graph below, draw trend lines, label subgroup controls, and answer the questions.

Controls

Engineer Symbol	Shading Amount	Temperature
○	$\frac{0}{8}$	RT
△	$\frac{4}{8}$	RT
X	$\frac{6}{8}$	RT

Does this graph show a trend that is consistent with the class findings? YES NO

3. Using data from the graph, what power would you expect to calculate if you used a solar panel that was $\frac{2}{8}$ shaded, 40% angled (50°), and at room temperature?

Which experiment(s) should you look at? ○ △ X Prediction: 5.5 mW

Actual: *(Round to the nearest tenth)*
Current: 2.6 mA
Voltage: 1.9 V
Power: 4.9 mA

4. Would this be enough power to light the green LED? YES NO
5. Would this be enough power to light the white LED? YES NO

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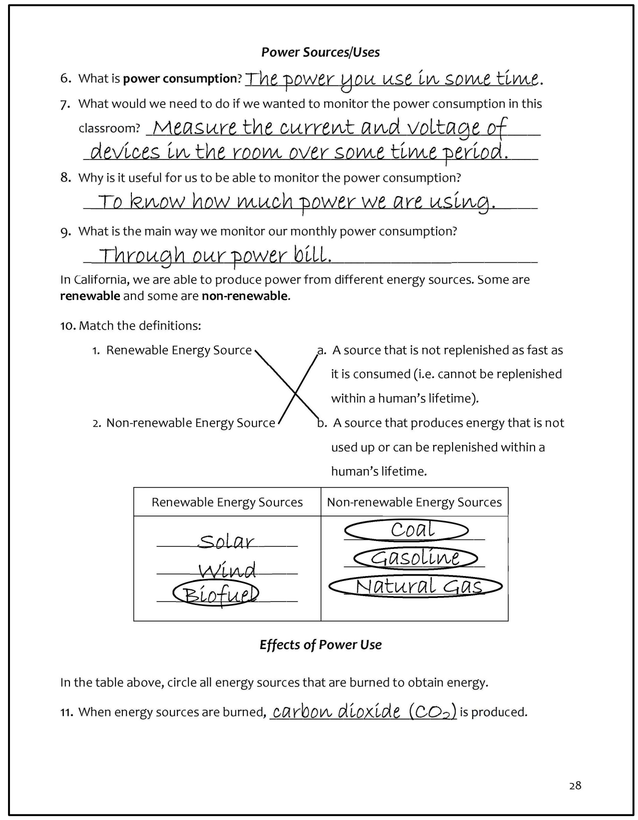
- Review the class question.
- Have student tell you the definition of power, and record this for question *1* (notebook, page 27).
- Discuss with students why we care about answering our class question. Make sure they know that devices operate at different amounts of power and we want to control the amount of power our solar panel produces to power our devices.

Predicting Power (15 minutes)

- Pass out a calculator to each student.
- Show students how much power it takes to turn on each LED (notebook, page 27, top).
- Have students annotate and draw/label trend lines on graph *1* on their own, while you do so off to the side of the document camera. Then let them check their work.
- Discuss what each of the teams found in their experiment and if the graph agrees with the class findings (circle *Yes* to answer the question under the graph *1* controls box).
    - Have students identify which subgroup's data they need to answer question *3*. Have them find the predicted power while you find it off to the side of the document camera. Then let them check their work.
- Test the class prediction using the experimental set-up.
    - Cover the set-up with black cloth so external light does not affect results.
    - Have the multimeter under the document camera.
    - Calculate power and compare with predictions (should be within 0.6 mW).
- Have students identify if the power will be enough to light the green (yes) and white (no) LEDs and then test them.
- If a volunteer is in the classroom, have them take down the solar panel set-up and switch it out for the *Bright Choices* set-up.

Power Sources/Uses (5 minutes)

- Tell students, “We will now think about how much power we use and where it comes from.”
- Go over what power consumption is and answer question *6*.
- Go over what we would need to do to monitor power consumption and answer question *7*.
- Go over why monitoring power consumption is useful and answer question *8*.
- Go over how we monitor our power consumption and answer question *9*.
- Explain to students in California, our energy can come from renewable or non-renewable sources. Then, have students determine the matching term/definition pair (question *10*).
- Have students list renewable and non-renewable energy sources, and record them in the table on page 28.
    - o See full instructions for details on common power sources.



Power Sources/Uses

6. What is **power consumption**? The power you use in some time.
7. What would we need to do if we wanted to monitor the power consumption in this classroom? Measure the current and voltage of devices in the room over some time period.
8. Why is it useful for us to be able to monitor the power consumption? To know how much power we are using.
9. What is the main way we monitor our monthly power consumption? Through our power bill.

In California, we are able to produce power from different energy sources. Some are **renewable** and some are **non-renewable**.

10. Match the definitions:

1. Renewable Energy Source
2. Non-renewable Energy Source

a. A source that is not replenished as fast as it is consumed (i.e. cannot be replenished within a human’s lifetime).
b. A source that produces energy that is not used up or can be replenished within a human’s lifetime.

Renewable Energy Sources	Non-renewable Energy Sources
Solar	Coal
Wind	Gasoline
Biofuel	Natural Gas

Effects of Power Use

In the table above, circle all energy sources that are burned to obtain energy.

11. When energy sources are burned, carbon dioxide (CO_2) is produced.

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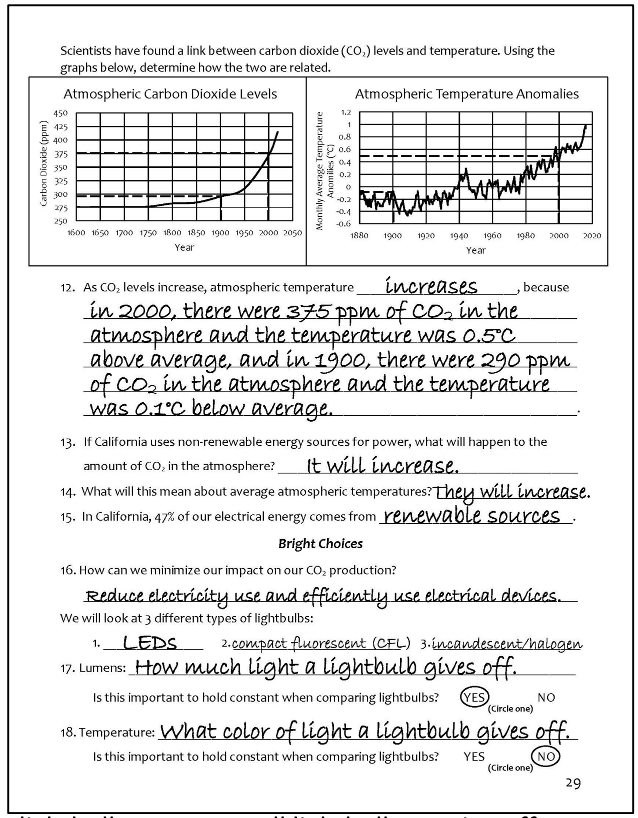
Effects of Power Use (15 minutes)

- Ask students, “What form of energy is our solar panel producing, and what did we have to provide to obtain that energy?” Possible student response: electrical energy/turn on the light.
- Explain that the solar panel is a tool to harness light energy and convert it into electrical energy.
- Ask students, “If we wanted to obtain electrical energy from wind, another renewable energy source, what tool would we have to use?” Possible student response: wind turbine.
- Inform students that some energy sources must be burned to obtain their energy and have them tell you which energy sources in the table this applies to. Circle these in the class notebook and have students do the same in their notebooks.
    - o All non-renewable sources (with the exception of nuclear, if applicable) should be circled. If the students suggested biofuel in the renewables column, you must circle that as well.
- Ask students, “What tool would you have to use to transfer energy from one of the non-renewable energy sources in the table into a useful energy source?” Possible student response: energy source: gasoline, tool: car.
- Tell students, “When energy sources are burned, carbon dioxide (CO_2) is produced.” (question *11*)
- Have student use the graphs on page 29 to determine the link between CO_2 levels and temperature.
    - o Explain that ppm (parts per million) refers to how much of a chemical is in some volume.
    - o Make sure students know an anomaly is something different from the normal.
- Look at each graph with students and ask them:
    - o What is this graph trying to explain?
    - o Does this graph have a trend, and if so, what is it?
- Have students give you the definition of a conclusion and make a conclusion from the graphs (question *12*).
    - o As CO_2 levels increase atmospheric temperature increases, because in 2000 there were 375 ppm of CO_2 in the atmosphere and the temperature was 0.5°C above average, and in 1900 there were 290 ppm of CO_2 in the atmosphere and the temperature was 0.1°C below average.
        - ▪ Other data points can be used, these are just easy to read and extremes.

- Discuss what will happen to the amount of CO_2 in the atmosphere if California uses non-renewable energy sources for power, and how they know (question *13*).
- Discuss how this will affect the average atmospheric temperatures (question *14*).
- Tell students, “In California, 47% of our electrical energy comes from renewable sources.” (question *15*)


Scientists have found a link between carbon dioxide (CO_2) levels and temperature. Using the graphs below, determine how the two are related.

12. As CO_2 levels increase, atmospheric temperature increases, because in 2000, there were 375 ppm of CO_2 in the atmosphere and the temperature was 0.5°C above average, and in 1900, there were 290 ppm of CO_2 in the atmosphere and the temperature was 0.1°C below average.
13. If California uses non-renewable energy sources for power, what will happen to the amount of CO_2 in the atmosphere? It will increase.
14. What will this mean about average atmospheric temperatures? They will increase.
15. In California, 47% of our electrical energy comes from renewable sources.

Bright Choices

16. How can we minimize our impact on our CO_2 production? Reduce electricity use and efficiently use electrical devices.

We will look at 3 different types of lightbulbs:

1. LEDs 2. compact fluorescent (CFL) 3. incandescent/halogen

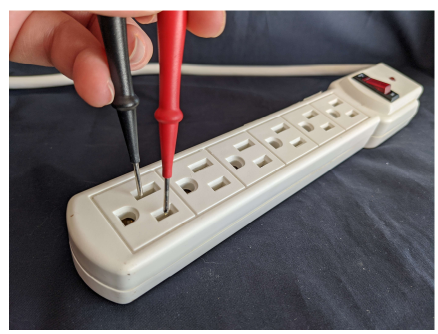
17. Lumens: How much light a lightbulb gives off.
Is this important to hold constant when comparing lightbulbs? (YES) NO (Circle one)

18. Temperature: What color of light a lightbulb gives off.
Is this important to hold constant when comparing lightbulbs? YES (NO) (Circle one)

29

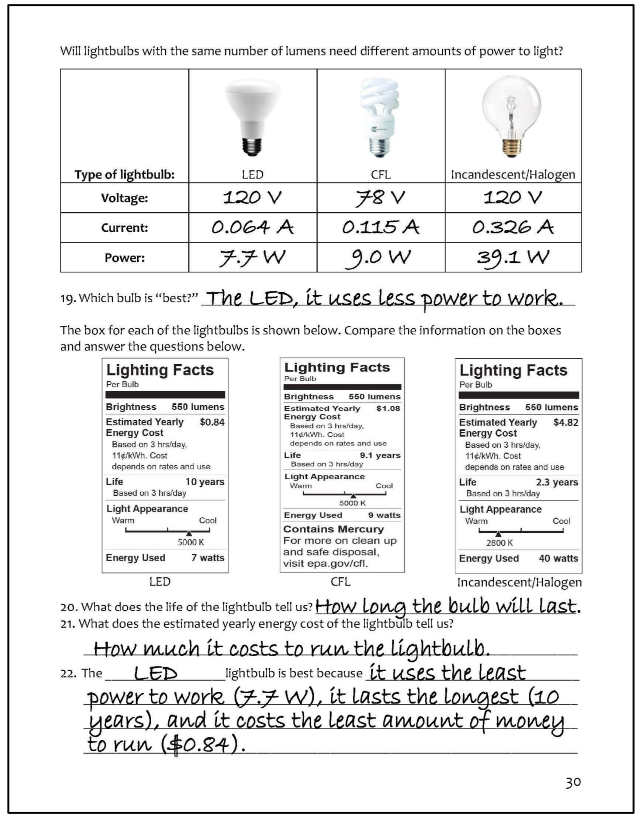
Bright Choices (15 minutes)

- If you do not have a volunteer in the classroom to do this for you, remove the solar panel set-up and replace it with the *Bright Choices* set-up.
- Tell students, “We cannot control what power sources are used for our electricity (renewable vs non-renewable).” Then, discuss how to minimize our impact on CO_2 production (question *16*).
- Introduce the 3 types of lightbulbs (LED, compact fluorescent (CFL), incandescent/halogen) making sure to display each lightbulb for the students.
- Introduce the term **lumens** (a measurement of how much light is given off).
  - Lead students to understand that when comparing lightbulbs, we want all lightbulbs to give off the same amount of light (question *17*).
- Introduce the term temperature (the color of light).
  - Tell students, “The temperature/color of light does not change the energy needed by the bulb.” (question *18*)
- Tell students, “Lightbulbs plug into wall outlets, and all wall outlets produce the same amount of voltage.”
- Demonstrate how to determine the voltage from the power strip.
  - **Note: This step is dangerous for students; emphasize that they should not do this at home.**
  - Turn the multimeter to the **200 V~** setting and place it under the document camera.
  - Place the black and red probes into partner plugs on the power strip (order does not matter).
  - Have students read the voltage and remove the probes.



- Record 120 V in the table for the LED and Incandescent/Halogen bulbs.
- Tell students, “CFLs need a smaller voltage to operate so they have a large base which is called a ballast which steps the voltage down to about 78 V.” Record this in the table for the CFL bulb.
- Introduce the amp meter, which will read current in amps (abbreviated with a capital A).
- Find the current for the lightbulbs starting with the LED.
  - Clamp the amp meter around a single wire in the split portion of the wire.
  - Turn the amp meter on to the **2A** setting.
  - Turn on the lightbulb and have students read and record the current to 3 decimal places.
    - ~0.064 A
  - Then repeat for the CFL and halogen bulbs.
    - ~0.115 A and ~0.326 A respectively

- Have students calculate the power produced by each bulb individually (in W) while you do the same in the class notebook. Then check their answers.
- Have the class decide which bulb is "best" by comparing the power values (question *19*).
- Tell students, "In order to determine all of this information without running an experiment, we can look at the packaging on lightbulbs." Direct their attention to the *Lighting Facts* sheets.
- Compare the calculated power with the value on the facts sheet.
    - Discuss with students what information (lumens and temperature) is needed to describe the light produced by a bulb and where to find this information in the lighting facts.
    - Discuss how the temperature is related to the appearance (warm vs. cool) of the light and explain higher temperatures of lightbulbs produce cooler tones (bluer light) whereas lower temperatures produce warmer tones (yellower light).
- Answer questions *20-21* as a class.
- Have students determine which bulb is "best" and why, using all of the information we obtained from the facts sheet (question *22*).



Will lightbulbs with the same number of lumens need different amounts of power to light?

Type of lightbulb:	LED	CFL	Incandescent/Halogen
Voltage:	120 V	78 V	120 V
Current:	0.064 A	0.115 A	0.326 A
Power:	7.7 W	9.0 W	39.1 W

19. Which bulb is "best?" The LED, it uses less power to work.

The box for each of the lightbulbs is shown below. Compare the information on the boxes and answer the questions below.

	LED	CFL	Incandescent/Halogen
Lighting Facts Per Bulb			
Brightness	550 lumens	550 lumens	550 lumens
Estimated Yearly Energy Cost (Based on 3 hrs/day, 11¢/kWh. Cost depends on rates and use)	$0.84	$1.08	$4.82
Life (Based on 3 hrs/day)	10 years	9.1 years	2.3 years
Light Appearance (Warm – Cool)	5000 K	5000 K	2800 K
Energy Used	7 watts	9 watts	40 watts
Contains Mercury		For more on clean up and safe disposal, visit epa.gov/cfl.	

20. What does the life of the lightbulb tell us? How long the bulb will last.

21. What does the estimated yearly energy cost of the lightbulb tell us?
How much it costs to run the lightbulb.

22. The LED lightbulb is best because it uses the least power to work (7.7 W), it lasts the longest (10 years), and it costs the least amount of money to run ($0.84).

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Only do this section if there is time:

- Have students identify the additional information given on the CFL fact sheet, that does not appear on the LED or incandescent/halogen fact sheets (contains mercury).
- Explain the warning label to students:
    - Mercury is a very toxic gas that can fatally harm people if inhaled.
    - If a CFL breaks open, mercury gas could leak and harm anyone in the room.
    - Disposing of the hazardous waste is dangerous and costly.
    - Failure to dispose of the mercury lightbulbs properly could result in mercury leaking into a local body of water and contaminating the entire water system.
- This contributes to LEDs being the "better" choice of lightbulb.

Last Revised: 8/29/2023

Extra Practice Solutions:

EXTRA PRACTICE

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

1. a. The Nile River is 6,650 km long and the Amazon River is 6,575 km long. — *Claim* — *(Data)* — *Opinion*
   b. McDonalds French fries have more salt than In-N-Out French fries. — *(Claim)* — *Data* — *Opinion*
   c. Dogs weighing over 50 lbs. sleep more than smaller dogs. — *(Claim)* — *Data* — *Opinion*
   d. 30 people used a black pen and 12 people used a blue pen. — *Claim* — *(Data)* — *Opinion*
   e. Peaches are the most delicious fruit. — *Claim* — *Data* — *(Opinion)*
   f. The car door handle was observed to be warmer after sitting in sunlight. — *Claim* — *(Data)* — *Opinion*
   g. The tallest building in the world is in Dubai. — *(Claim)* — *Data* — *Opinion*
   h. The more interesting the story, the longer the student will read. — *Claim* — *Data* — *(Opinion)*

31

Directions for annotating: Underline control(s), circle changing variable(s), and box information about data collection.

2. a) Annotate the following results table.

Variables	Trial 1	Trial 2	Trial 3
Coal Amount:	1,500 Mg	2,500 Mg	3,500 Mg
Number of Generators:	3	→	→
Water Amount:	4,400 L	→	→
Data	**Trial 1**	**Trial 2**	**Trial 3**
Measurements/Observations: Power (MW):	51 MW	67 MW	93 MW
Other:	Air around plant is light brown	Air around plant is brown	Air around plant is dark brown

b) Can this group make a conclusion? (YES) NO I DON'T KNOW

c) Annotate the following possible conclusion.

Possible Conclusion: When less coal is burned in the power plant the air will be less polluted, because when the amount of coal was 1,500 Mg the air around the plant was observed to be light brown, and when the amount of coal was 3,500 Mg the air around the plant was observed to be dark brown.

d) Is this a correct conclusion for the results table? (YES) NO I DON'T KNOW

If NO, what is wrong with the conclusion? __________.

3. a) Annotate the following results table.

Variables	Trial A	Trial B	Trial C
Coal Amount:	2,000 Mg	2,500 Mg	3,000 Mg
Number of Generators:	4	→	→
Water Amount:	4,800 L	4,400 L	4,000 L
Data	**Trial A**	**Trial B**	**Trial C**
Measurements/Observations: Power (MW):	27 MW	60 MW	92 MW
Other:	Air around plant is light brown	Air around plant is light brown	Air around plant is light brown

b) Can this group make a conclusion? YES (NO) I DON'T KNOW

c) Annotate the following possible conclusion.

Possible Conclusion: The less water used in the power plant the higher the power, because when 4,800 L of water were used, 27 MW of power were produced, and when 4, 000 L of water were used, 92 MW of power were produced.

d) Is this a correct conclusion for the results table? YES (NO) I DON'T KNOW

If NO, what is wrong with the conclusion? More than 1 changing variable.

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4. a) Annotate the following results table.

Variables	Trial A	Trial B	Trial C
Coal Amount:	2,500 Mg	→	→
Number of Generators:	4	→	→
Water Amount:	4,800 L	4,400 L	4,400 L
Data	**Trial A**	**Trial B**	**Trial C**
Measurements/Observations: Power (MW):	42 MW	58 MW	75 MW
Other:	Air around plant is light brown	Air around plant is light brown	Air around plant is light brown

b) Can this group make a conclusion? (YES) NO I DON'T KNOW

c) Annotate the following possible conclusion.

Possible Conclusion: When the water amount was 4,400 L the power was 75 MW, and when the water amount was 4,800 L the power was 42 MW, because the more water used in the power plant, the lower the power.

d) Is this a correct conclusion for the results table? YES (NO) I DON'T KNOW

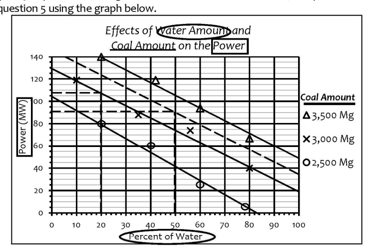
If NO, what is wrong with the conclusion? Claim and data switched.

Directions: Some engineers wanted to know how changing the percentage of water amount would affect the power produced by a power plant. They did 3 experiments, using a different coal amounts each time, and plotted most of their data on a graph. Answer question 5 using the graph below.

5. a) Annotate the graph.

b) Plot the data points from the chart below on the graph using circles (O) as markers.

Coal Amount: 2,500 Mg	
% of Water	Power (MW)
20	80
40	60
60	25
78	5



c) Draw trend lines on the graph for each data set.

d) In general, for all coal amounts, what happens as the percentage of water amount increases?

As percent water amount increases, power decreases

e) What will the power be if a power plant uses 3,000 Mg of coal and 20% water amount?

106 MW

f) What will the power be if a power plant uses 3,250 Mg of coal and 50% water amount?

90 MW

33