Lead Information Packet

Module 2: Wind Turbines
4th 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.

Note: We **highly recommend** teachers give the initial and final procedure assessments outside of SciTrek sessions.

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.

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: Technique/Observations/Variables

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

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

Times if teacher gave assessment prior to SciTrek:
Introduction (SciTrek Lead) – 2 minutes
Module Introduction (SciTrek Lead) – 5 minutes
Technique (SciTrek Lead) – 15 minutes
Observation Discussion (SciTrek Lead) – 2 minutes
Observations (SciTrek Volunteers) – 18 minutes
Variable Discussion (SciTrek Lead) – 5 minutes
Variables (SciTrek Volunteers) – 10 minutes
Wrap-Up (SciTrek Lead) – 3 minutes

Times if SciTrek must give assessment:
Introduction (SciTrek Lead) – 2 minutes
Procedure Assessment (SciTrek Lead) – 10 minutes
Module Introduction (SciTrek Lead) – 5 minutes
Technique (SciTrek Lead) – 12 minutes
Observation Discussion (SciTrek Lead) – 1 minute
Observations (SciTrek Volunteers) – 17 minutes
Variable Discussion (SciTrek Lead) – 5 minutes
Variables (SciTrek Volunteers) – 5 minutes
Wrap-Up (SciTrek Lead) – 3 minutes

Preparation:

1. Get the procedure assessments and put them in the lead box.
2. Make sure volunteers are writing their name, and group color, on the whiteboard.
3. Make sure volunteers are passing out nametags.
4. Make sure volunteers are setting up for the initial observation.
5. Set up the document camera for the wind farm picture (picture packet, page 1), class question (notebook, front cover), and technique activity (notebook, pages 2-3).
6. Have a multimeter ready to show students during the Introduction.
7. Have the hub with one dowel, cardstock blade, and wind turbine protractor available to show students during the technique activity.

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

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

Procedure Assessment: *(10 minutes – Full Class – Given By Classroom Teacher Prior to SciTrek)*

- Question *1*: Have students write in their own words what they think is the definition of a procedure.
- Read step 1 of the directions. Then read the question, changing variable (Ex: the changing variable was nutrient amount), and controls (Ex: the controls were plant type, liquid type, plant mass…). Do not read values of the changing variable or controls.
- Read step 2 of the directions. Then read the statement in question 2 and have students underline controls, circle changing variables, and box information about data collection.
- Read step 3 of the directions. Then have students circle if the statement, in question 2, could be an appropriate procedure step.
- Read the statement in question 3 and have students underline controls, circle changing variables, and box information about data collection.
- Have students circle if the statement, in question 3, could be an appropriate procedure step.
- Repeat the process for questions 4-8
- Collect assessments.

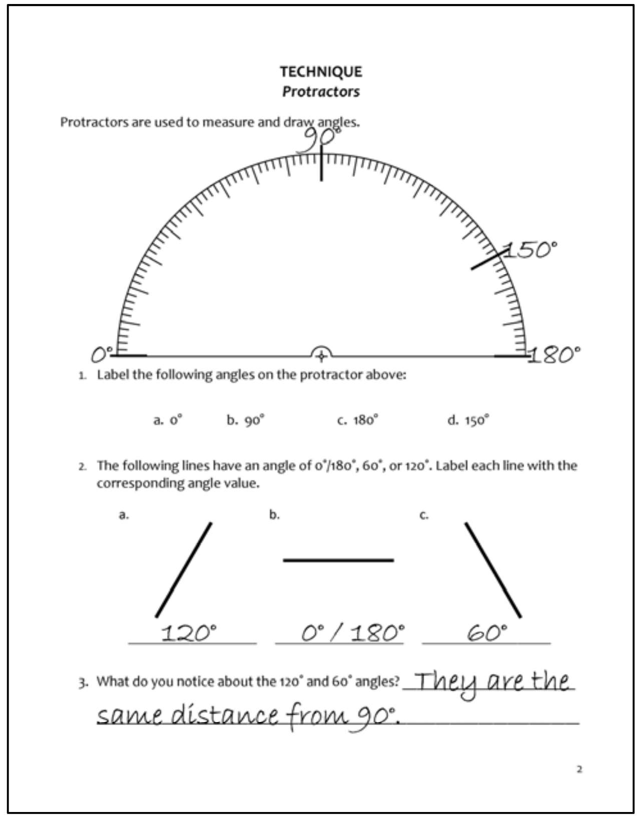
Module Introduction: *(5 minutes – Full Class – SciTrek Lead)*

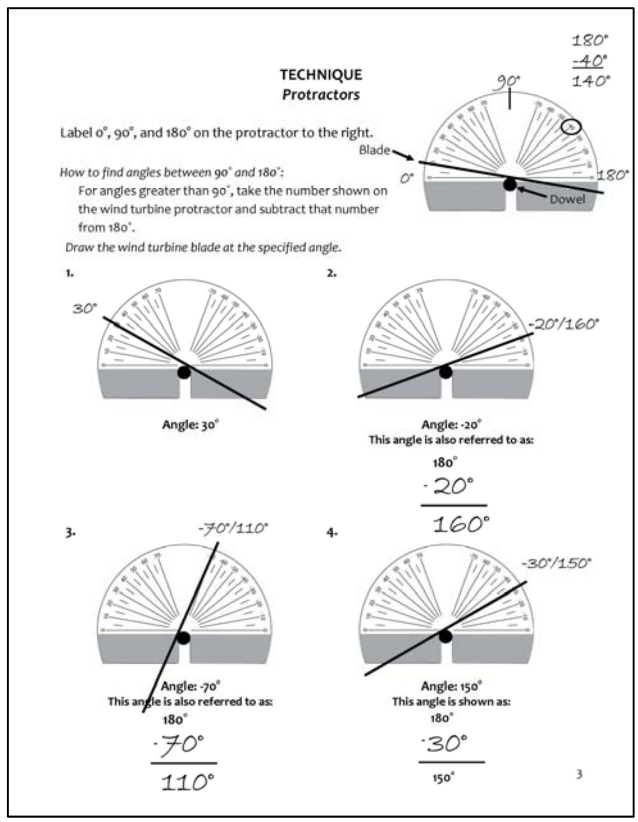
- Have volunteers pass out notebooks.
- Have students fill out the front cover of their notebooks.
    - They will not fill out their subgroup number, or class question.
- Show students the picture of the wind farm (picture packet, page 1).
- Have students identify the wind turbines, and discuss what they are used for (producing electricity).
- Show students a multimeter, and introduce the words: multimeter, current, and milliamp.
- Introduce the class question, "What variables affect the current a wind turbine produces?"
    - Write the class question on the front cover of the class notebook, and have students copy it onto their notebooks.

Picture Packet, Page 1

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

- Show student the hub with one blade attached, and introduce the terms: hub, dowel, and blade.
  Tell students, "Protractors are used to measure angles."
- Have students help you label the angles in question *1*, on the protractor (notebook, page 2).
- Place a blade under the document camera to show students the perspective from which they will be measuring the blade angles.
- Have students help you fill out question *2*, and justify their answers.
- Make sure students notice that 120° and 60° are symmetric, and the same distance away from 90°.
- Shows students the wind turbine protractor and how to use it to measure blade angels.
- On the wind turbine protractor (notebook, page 3, top), have students help you identify and label where 0°, 90°, and 180°, are.
- Tell students, "For angles over 90°, the protractor shows you the number that you would need to subtract from 180° to get the 'real' angle."
- Show students how to get the 'real' angle for -40°.
- As a class, draw in where the blade would be for question *1* and *2* (notebook, page 3), and, if needed, solve for the 'real' angle.
- Have students fill out question *3* by themselves, before reviewing (notebook, page 3).
- As a class, determine the number that needs to be subtracted from 180° to give 150°, then, draw in where the blade would be for question *4* (notebook, page 3).





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

- Review the definition of an observation (a description using your five senses).
- Tell students, "The more electricity the wind turbine produces, the higher the current the multimeter will read, in milliamps."
- Have students move to their groups.
  - o 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.

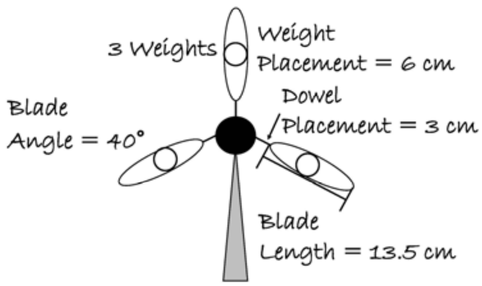
Observations: *(18 minutes – Groups – SciTrek Volunteers)*

- Walk around and help groups who are struggling.
- Make sure groups are moving along and only spending ~13 minutes on the experimental set-up and ~5 minutes recording the current for the two different blade materials.

OBSERVATIONS

Experimental Set-Up:

On the picture below, indicate relevant dimensions of the wind turbine.



Other aspects of the experimental set-up:

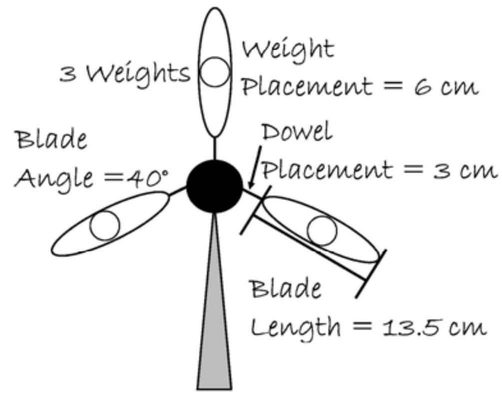
3 Blades
Fan Distance = 60 cm
Cardstock and cardboard blades

2

OBSERVATIONS

Experimental Set-Up:

On the picture below, indicate relevant dimensions of the wind turbine.



Other aspects of the experimental set-up:

3 Blades
Fan Distance =60 cm
Cardstock and Cardboard Blades

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OBSERVATIONS

	Cardstock Blades	Cardboard Blades
Current (mA):	2.0 mA	2.3 mA
Similarities:	Size, shape, both have plastic around them	
Differences:	Thickness, color, cardboard is less bendy	

Other Observations:

3 Blades evenly spaced on hub

3

OBSERVATIONS

	Cardstock Blades	Cardboard Blades
Current (mA):	2.0 mA	2.3 mA
Similarities:	size, shape, both have plastic around them	
Differences:	thickness, color, cardboard is less bendy	

Other Observations:

3 Blades evenly spaced on hub

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

- Have groups share what they did and learned.
    - They tested the current produced by cardstock and cardboard blades. Both blades gave similar currents.
- 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 they believe this variable might affect the current a wind turbine produces.

Variables: *(10 minutes – Groups – SciTrek Volunteers)*

- **If there are less than 5 minutes left, do this section 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 four possible variables, as well as how and why these variables might affect the current a wind turbine produces.
- Make sure students are generating at least one additional variable by themselves.

VARIABLES

Variable	How will changing this variable affect the current?
Blade Angle	The larger the blade angle, the __more/less__ current.
Dowel Placement	The closer the blade is to the hub, the __more/less__ current.
Weight Number	The more weights on the blade, the __more/less__ current.
Fan Distance	The larger the fan distance, the __more/less__ current.
Choose your own!!!	

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VARIABLES

Variable	How will changing this variable affect the current?
Blade Angle	The larger the blade angle, the more current.
Dowel Placement	The closer the blade is to the hub, the more current.
Weights Number	The more weights on the blade, the less current.
Fan Distance	The larger the fan distance, the more current.
Blade Length	The longer the blades, the more current.

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Wrap-Up: *(3 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 current a wind turbine produces.
- Go over what students will do next session.

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

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

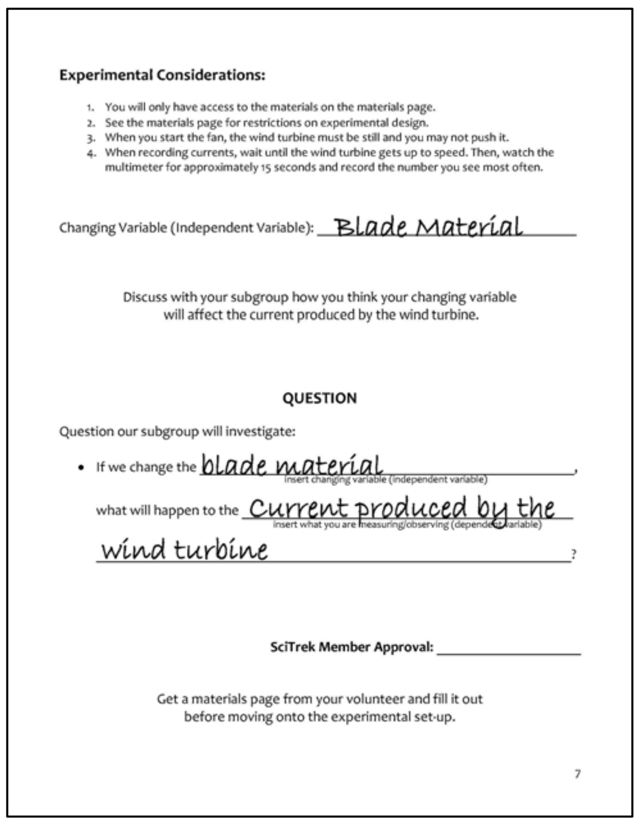
Introduction (SciTrek Lead) – 15 minutes
Question (SciTrek Volunteers) – 5 minutes
Materials Page (SciTrek Volunteers) – 5 minutes
Experimental Set-Up (SciTrek Volunteers) – 10 minutes
Procedure Activity (SciTrek Lead) – 23 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

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 Day 1 experimental set-up picture (picture packet, page 2), question (notebook, page 7), lead materials page (picture packet, page 3), experimental set-up (picture packet, page 4), and procedure activity (notebook, pages 10-11).

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

- Review the class question, as well as what students did and learned last session.
- Review the terms: **wind turbine**, **multimeter**, **current**, and **milliamp**.
- Review experimental considerations with the class (notebook, page 7, top):
    - *You will only have access to the materials on the materials page.*
    - *See the materials page for restrictions on experimental design.*
    - *When you start the fan, the wind turbine must be still and you may not push it.*
    - *When recording currents, wait until the wind turbine gets up to speed. Then, watch the multimeter for approximately 15 seconds and record the number you see most often.*
- Design an example experiment with the class.
    - For the changing variable, pick **blade material** (notebook, page 7).
    - Show students how to write the question.
        - If we change the <u>blade material,</u> what will happen to the <u>current produced by the wind turbine</u>?


Experimental Considerations:

1. You will only have access to the materials on the materials page.
2. See the materials page for restrictions on experimental design.
3. When you start the fan, the wind turbine must be still and you may not push it.
4. When recording currents, wait until the wind turbine gets up to speed. Then, watch the multimeter for approximately 15 seconds and record the number you see most often.

Changing Variable (Independent Variable): Blade Material

Discuss with your subgroup how you think your changing variable will affect the current produced by the wind turbine.

QUESTION

Question our subgroup will investigate:

- If we change the blade material (insert changing variable (independent variable)), what will happen to the Current produced by the wind turbine (insert what you are measuring/observing (dependent variable))?

SciTrek Member Approval: ________________

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

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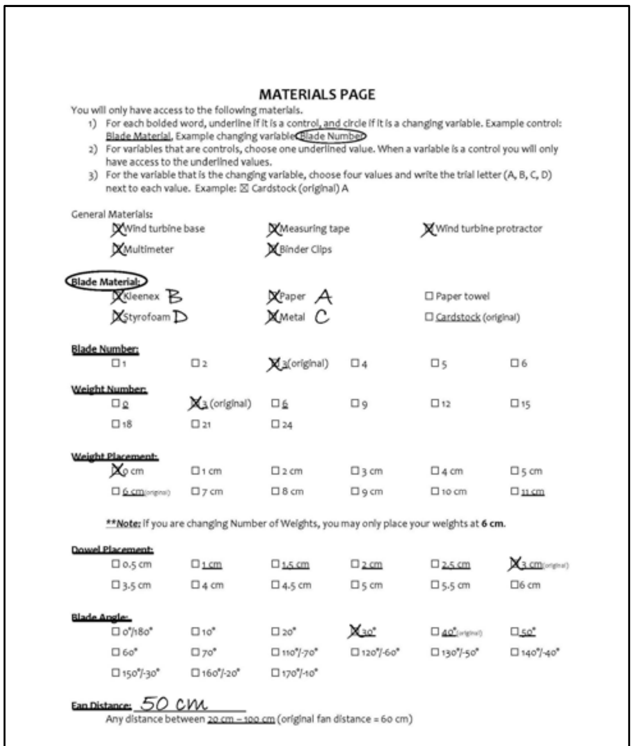
- Fill out the materials page for the example experiment (picture packet, page 3).
  - Read step 1 and have students tell you what to do for each bolded word (underline controls and circle the changing variable).
  - Go through the list of general materials and check them off.
  - Read steps 2 and 3. You should choose the control values, but let students choose the four changing variable values.
    - Tell students, "If the variable is a control, you are only allowed to select a single underlined value."
    - Remind students to pick changing variable values that are spread out.
      - Make sure students pick blade materials that are both flexible (Kleenex), as well as not flexible (metal).
    - Write trial letters next to changing variable values (Ex: Cardstock A).
- Fill out the experimental set-up for the example experiment (picture packet, page 4).
  - There will be one additional blank for controls. Lead students to come up with fan speed/3 (high).
- Tell students, "Since the class is changing blade material, no other subgroup will be able to have blade material as a changing variable and the only blade material you will have access to is cardstock."


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. Example control: Blade Material. Example changing variable: Blade Number
2) For variables that are controls, choose one underlined value. When a variable is a control you will only have access to the underlined values.
3) For the variable that is the changing variable, choose four values and write the trial letter (A, B, C, D) next to each value. Example: ☒ Cardstock (original) A

General Materials:
☒ Wind turbine base ☒ Measuring tape ☒ Wind turbine protractor
☒ Multimeter ☒ Binder Clips

Blade Material:
☒ Kleenex B ☒ Paper A ☐ Paper towel
☒ Styrofoam D ☒ Metal C ☐ Cardstock (original)

Blade Number:
☐ 1 ☐ 2 ☒ 3 (original) ☐ 4 ☐ 5 ☐ 6

Weight Number:
☐ 0 ☒ 3 (original) ☐ 6 ☐ 9 ☐ 12 ☐ 15
☐ 18 ☐ 21 ☐ 24

Weight Placement:
☒ 0 cm ☐ 1 cm ☐ 2 cm ☐ 3 cm ☐ 4 cm ☐ 5 cm
☐ 6 cm (original) ☐ 7 cm ☐ 8 cm ☐ 9 cm ☐ 10 cm ☐ 11 cm

Note: If you are changing Number of Weights, you may only place your weights at **6 cm.

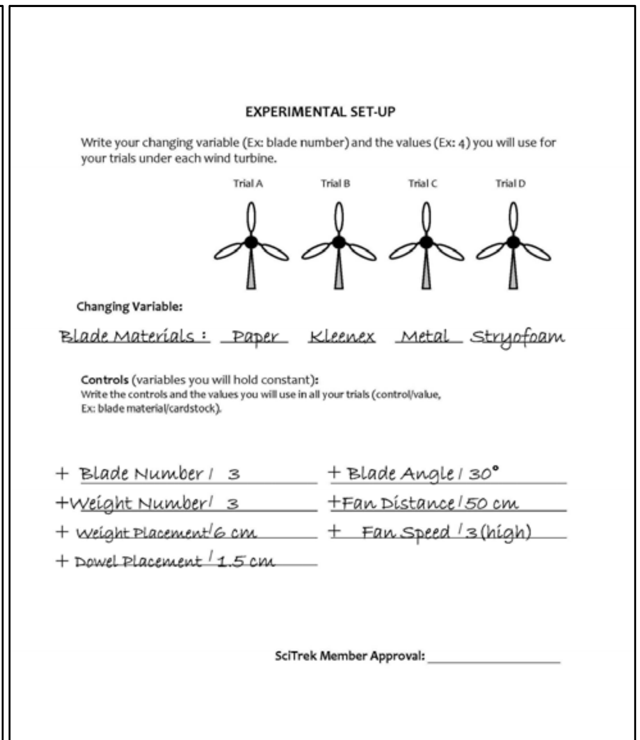
Dowel Placement:
☐ 0.5 cm ☐ 1 cm ☐ 1.5 cm ☐ 2 cm ☐ 2.5 cm ☒ 3 cm (original)
☐ 3.5 cm ☐ 4 cm ☐ 4.5 cm ☐ 5 cm ☐ 5.5 cm ☐ 6 cm

Blade Angle:
☐ 0°/180° ☐ 10° ☐ 20° ☒ 30° ☐ 40° (original) ☐ 50°
☐ 60° ☐ 70° ☐ 110°/-70° ☐ 120°/-60° ☐ 130°/-50° ☐ 140°/-40°
☐ 150°/-30° ☐ 160°/-20° ☐ 170°/-10°

Fan Distance: 50 cm
Any distance between 20 cm – 100 cm (original fan distance = 60 cm)

3

Picture Packet, Page 3


EXPERIMENTAL SET-UP

Write your changing variable (Ex: blade number) and the values (Ex: 4) you will use for your trials under each wind turbine.

Trial A Trial B Trial C Trial D

Changing Variable:
Blade Materials: Paper Kleenex Metal Stryofoam

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

+ Blade Number / 3
+ Weight Number / 3
+ Weight Placement / 6 cm
+ Dowel Placement / 1.5 cm
+ Blade Angle / 30°
+ Fan Distance / 50 cm
+ Fan Speed / 3 (high)

SciTrek Member Approval: ______________

4

Picture Packet, Page 4

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

- Walk around and help subgroups who are struggling.
- Encourage subgroups to pick different changing variables.
- Make sure, for the second part of the question (what you are measuring/observing), students are specific (they should write, "the current produced by the wind turbine" not just "the wind turbine" or "the current").

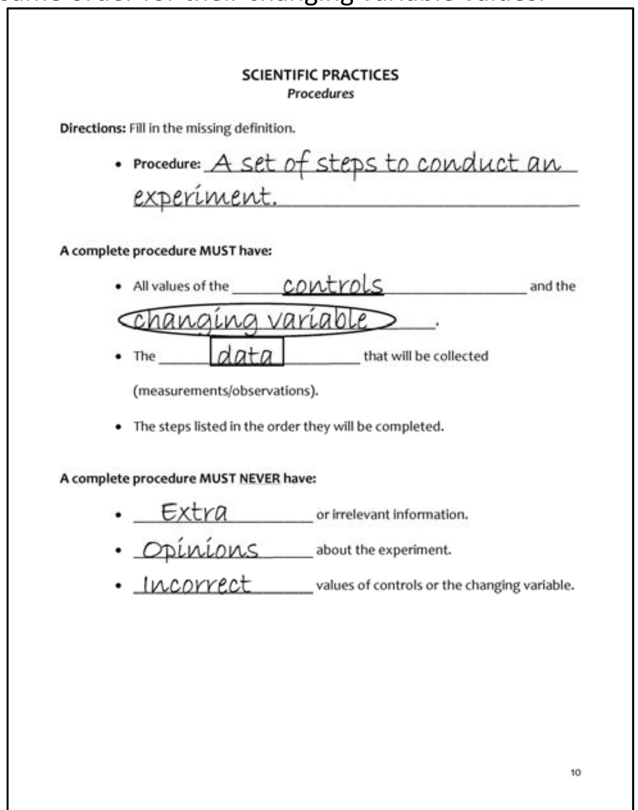
Materials Page: *(5 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Make sure subgroups are underlining their controls and circling their changing variable.
- Make sure subgroups are filling out the materials page correctly and completely.
  - Make sure for controls subgroups only choose from the underlined values.

Experimental Set-Up: *(10 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 values.
- Make sure all control blanks are filled out.

Procedure Activity: *(23 minutes – Full Class – SciTrek Lead)*


SCIENTIFIC PRACTICES
Procedures

Directions: Fill in the missing definition.

- **Procedure:** A set of steps to conduct an experiment.

A complete procedure MUST have:

- All values of the controls and the changing variable.
- The data that will be collected (measurements/observations).
- The steps listed in the order they will be completed.

A complete procedure MUST NEVER have:

- Extra or irrelevant information.
- Opinions about the experiment.
- Incorrect values of controls or the changing variable.

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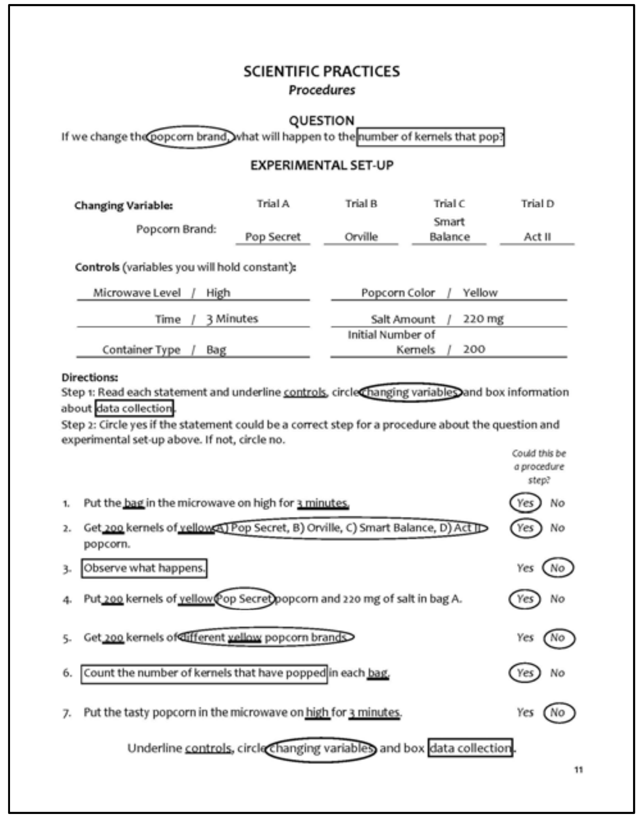
- Review the definition of a procedure (a set of steps to conduct an experiment) (notebook, page 10).
- Go over what procedures should include:
  - *All values of the <u>controls</u> and the <u>changing variable</u>.*
  - *The <u>data</u> will be collected (measurements/observations).*
  - *The steps listed in the order they will be completed.*
- Go over what procedures should not include:
  - *<u>Extra</u> or irrelevant information.*
  - *<u>Opinions</u> about the experiment.*
  - *<u>Incorrect</u> values of controls or the changing variable.*
- Tell students, “We will underline controls, circle changing variables, and box information about data collection.” Then do each of these actions, to these words that were filled in.
- Tell students, “On page 11 there is a scientist’s question and experimental set-up, you will annotate each possible procedural step, then determine if it could be correct. These steps are not a full procedure for the experiment, and are therefore, not in any order.”
- Read the question.
  - Have students circle *popcorn brand* and box *number of kernels that pop*.
- Read the changing variable and control values.
- Read each statement.
- Ask students, “What should be underlined, circled, and/or boxed”
  - Have students underline controls, circle changing variables, and box data collection.
- Ask students, “Are there any opinions, incorrect, or extra/irrelevant information in this statement?”
  - If yes
    - Ask them, “Could this be a correct procedural step?”
  - If no
    - Ask them, “What is this step about?”
    - Followed by, “Is there any other information which should have been included in this step?”
    - Conclude by asking, “Could this be a correct procedural step?”

- *1. Put the bag in the microwave on high for 3 minutes.*
  - Correct
- *2. Get 200 kernels of yellow A) Pop Secret, B) Orville, C) Smart Balance, D) Act II popcorn.*
  - Correct
- *3. Observe what happens.*
  - Incorrect
- *4. Put 200 kernels of yellow Pop Secret popcorn and 220 mg of salt in bag A.*
  - Correct
- *5. Get 200 kernels of different yellow popcorn brands.*
  - Incorrect
- *6. Count the number of kernels that have popped in each bag.*
  - Correct
- *7. Put the tasty popcorn in the microwave on high for 3 minutes.*
  - Incorrect


SCIENTIFIC PRACTICES
Procedures

QUESTION
If we change the popcorn brand, what will happen to the number of kernels that pop?

EXPERIMENTAL SET-UP

Changing Variable:	Trial A	Trial B	Trial C	Trial D
Popcorn Brand:	Pop Secret	Orville	Smart Balance	Act II

Controls (variables you will hold constant):

Microwave Level / High	Popcorn Color / Yellow
Time / 3 Minutes	Salt Amount / 220 mg
Container Type / Bag	Initial Number of Kernels / 200

Directions:
Step 1: Read each statement and underline controls, circle changing variables and box information about data collection.
Step 2: Circle yes if the statement could be a correct step for a procedure about the question and experimental set-up above. If not, circle no.

	Could this be a procedure step?	
1. Put the bag in the microwave on high for 3 minutes.	Yes	No
2. Get 200 kernels of yellow A) Pop Secret, B) Orville, C) Smart Balance, D) Act II popcorn.	Yes	No
3. Observe what happens.	Yes	No
4. Put 200 kernels of yellow Pop Secret popcorn and 220 mg of salt in bag A.	Yes	No
5. Get 200 kernels of different yellow popcorn brands.	Yes	No
6. Count the number of kernels that have popped in each bag.	Yes	No
7. Put the tasty popcorn in the microwave on high for 3 minutes.	Yes	No

Underline controls, circle changing variables and box data collection.

11

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

- Go over what students will do next session.

Day 3: Procedure Activity/Procedure

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

Introduction (SciTrek Lead) – 3 minutes
Procedure Activity (SciTrek Lead) – 25 minutes
Procedure Discussion/Procedure (SciTrek Lead/SciTrek Volunteers) – 30 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Preparation:

1. Make sure volunteers are passing out notebooks.
2. Set up the document camera for the procedure activity (notebook, pages 12-13) and procedure (notebook, page 9).
3. Have a hub with one dowel, cardstock blade, and weight, available to show students during the procedure discussion/procedure.

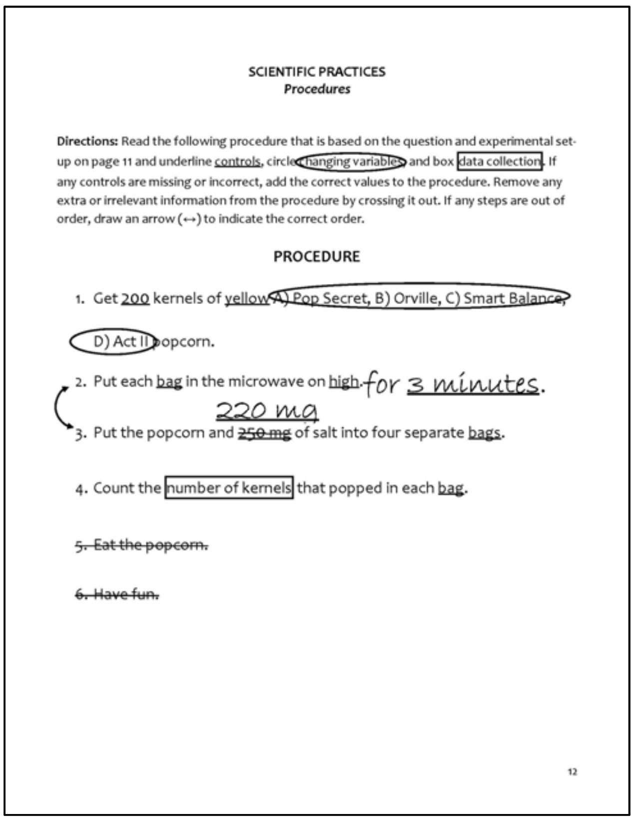
Introduction: *(3 minutes – Full Class – SciTrek Lead)*

- Review the class question, as well as what students did and learned last session.
- Review the definition of a procedure (set of steps to conduct an experiment).
- Review what should and should not be in a procedure.

Procedure Activity: *(25 minutes – Full Class – SciTrek Lead)*

- Tell students, "Last session, you were given a scientist's question and experimental set-up then you decided whether statements represented possible procedural steps for the given set-up. Today, we will examine a full procedure for the same question and experimental set-up then determine whether it represents a possible procedure" (notebook, page 12).

- Have students open their notebook, so they can see both pages 11 and 12.
- Read through the procedure, and have students underline controls, circle changing variables, and box information about data collection.
  - o After each step, have students tell you what they underlined/circled/boxed, and fill out the class notebook with this information.
- Have students tell you what should and should not be in a procedure, and correct the procedure accordingly.
- Tell students, "Now, we are going to look at a procedure we do not have a question or experimental set-up for and determine the changing variable, controls, and data collection" (notebook, page 13).
- Read each step of the procedure. Once a step has been read have students identify whether anything should be underlined, circled, or boxed and complete the action on the procedure.
- Tell students, "From the procedure I know the question the scientists were investigating is: If we change the ball mass, what will happen to the time it takes the ball to complete 1 swing?"



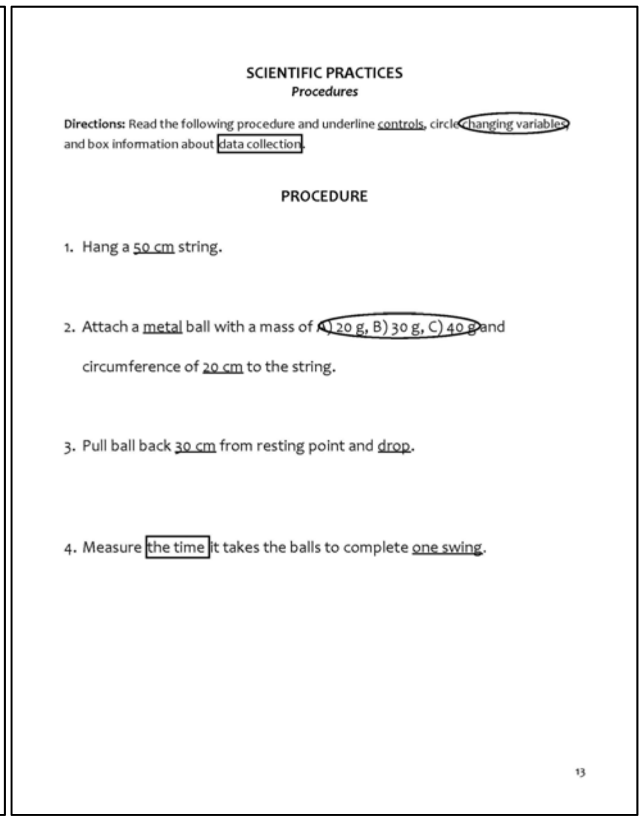
SCIENTIFIC PRACTICES
Procedures

Directions: Read the following procedure that is based on the question and experimental set-up on page 11 and underline controls, circle changing variables and box data collection. If any controls are missing or incorrect, add the correct values to the procedure. Remove any extra or irrelevant information from the procedure by crossing it out. If any steps are out of order, draw an arrow (↔) to indicate the correct order.

PROCEDURE

1. Get 200 kernels of yellow A) Pop Secret, B) Orville, C) Smart Balance, D) Act II popcorn.
2. Put each bag in the microwave on high. for 3 minutes.
3. Put the popcorn and ~~250 mg~~ 220 mg of salt into four separate bags.
4. Count the number of kernels that popped in each bag.
5. ~~Eat the popcorn.~~
6. ~~Have fun.~~

12



SCIENTIFIC PRACTICES
Procedures

Directions: Read the following procedure and underline controls, circle changing variables and box information about data collection.

PROCEDURE

1. Hang a 50 cm string.
2. Attach a metal ball with a mass of A) 20 g, B) 30 g, C) 40 g and circumference of 20 cm to the string.
3. Pull ball back 30 cm from resting point and drop.
4. Measure the time it takes the balls to complete one swing.

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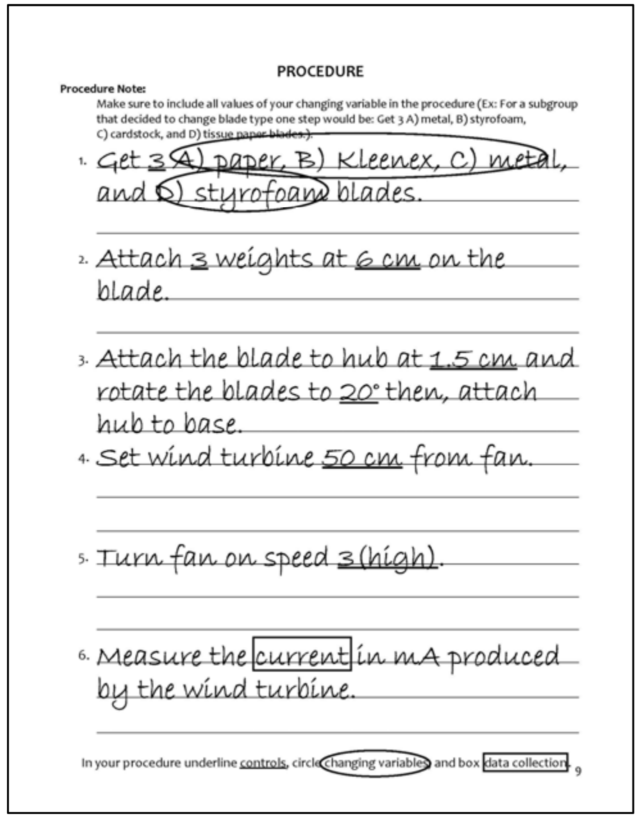
Procedure Discussion/Procedure: *(30 minutes – Full Class/Subgroups – SciTrek Lead/SciTrek Volunteers)*

- Remind students of the experimental set-up for the class question: If we change the blade material, what will happen to the current produced by a wind turbine?
- Show students the blade, hub with one dowel, and weight, and tell them, "This is how you will receive your materials."
- Have students determine step one for the class experiment and write it in the class notebook, remembering to underline controls, circle changing variables, and box information about data collection. Once each step is done, allow students to write that step for their experiment, in their notebook.
    - Volunteers should make sure students do not get ahead of you.
- Repeat this process for each procedure step.
    - Step 1: Information about number of blades and blade material.
    - Step 2: Information about number of weights and weight placement.
    - Step 3: Information about dowel placement and blade angle.
    - Step 4: Information about fan distance.
    - Step 5: Information about fan speed.
    - Step 6: Information about data collection.
- When writing each procedure step, make sure volunteers are helping their subgroups who have a changing variable in the step, before helping subgroups who only have controls in the step.


PROCEDURE

Procedure Note:
Make sure to include all values of your changing variable in the procedure (Ex: For a subgroup that decided to change blade type one step would be: Get 3 A) metal, B) styrofoam, C) cardstock, and D) tissue paper blades.).

1. Get 3 A) paper, B) Kleenex, C) metal, and D) styrofoam blades.
2. Attach 3 weights at 6 cm on the blade.
3. Attach the blade to hub at 1.5 cm and rotate the blades to 20° then, attach hub to base.
4. Set wind turbine 50 cm from fan.
5. Turn fan on speed 3(high).
6. Measure the current in mA produced by the wind turbine.

In your procedure underline controls, circle changing variables and box data collection. 9

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

- Go over what students will do next session.

Day 4: Results Table/Experiment/Graph

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

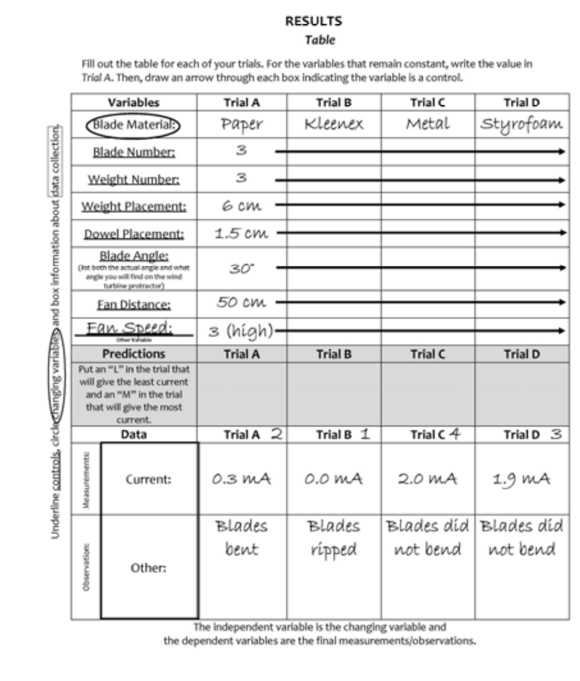
Introduction (SciTrek Lead) – 15 minutes
Results Table (SciTrek Volunteers) – 5 minutes
Experiment (SciTrek Volunteers) – 28 minutes
Graph (SciTrek Volunteers) – 10 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

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 filled-out results table (picture packet, page 5) and graph (notebook, page 15).
4. Have hub with one dowel, cardstock blade, binder clip, and wind turbine protractor, available to show students during the Introduction.

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

- Review the class question as well as what students did and learned last session.
- Show students how to fill out the results table (picture packet, page 5).
- Show students how to attach the weights to the blades.
- Show students the tape card, and which piece of tape to take first and second. Attach a weight to one blade.
- Show students how to attach the blade to the dowel with the binder clip. Then, tell them, "You will use the wind turbine protractor to adjust the blade angle."
  - o The protractor should be inserted from the front of the hub (where the knob is).
  - o When adjusting the blade angle, students should have their thumb on the binder clip, and fingers on the front of the blade. The flat slide of the blade should be facing out (straw to the back of the hub).
    - ▪ If blade angle is less than 90˚, turn the blade so that it passes 0˚, 10˚, etc., until you reach the desired angle.
    - ▪ If the angle is greater than 90˚, turn the blade so that it passes 0˚, -10˚, etc., until you reach the desired angle.
- Tell students, "Once you have your hub set up, you will gently put it on the wind turbine base. The hub must be still before you turn on the fan, and you cannot push the blades to make them spin. You will then record the current in mA."
- Use the checklist (notebook, page 15, top) to go over how to graph results.
  - o Use the filled-out results table (picture packet, page 5) to fill out the graph (notebook, page 15).
  - o Stress the importance of step 3 to ensure students' graphs are in increasing order.



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.

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

Variables	Trial A	Trial B	Trial C	Trial D
Blade Material:	Paper	Kleenex	Metal	Styrofoam
Blade Number:	3	→	→	→
Weight Number:	3	→	→	→
Weight Placement:	6 cm	→	→	→
Dowel Placement:	1.5 cm	→	→	→
Blade Angle: (list both the actual angle and what angle you will find on the wind turbine protractor)	30˚	→	→	→
Fan Distance:	50 cm	→	→	→
Fan Speed: (Other Variable)	3 (high)	→	→	→
Predictions	**Trial A**	**Trial B**	**Trial C**	**Trial D**
Put an "L" in the trial that will give the least current and an "M" in the trial that will give the most current.				
Data	**Trial A** 2	**Trial B** 1	**Trial C** 4	**Trial D** 3
Measurements: Current:	0.3 mA	0.0 mA	2.0 mA	1.9 mA
Observation: Other:	Blades bent	Blades ripped	Blades did not bend	Blades did not bend

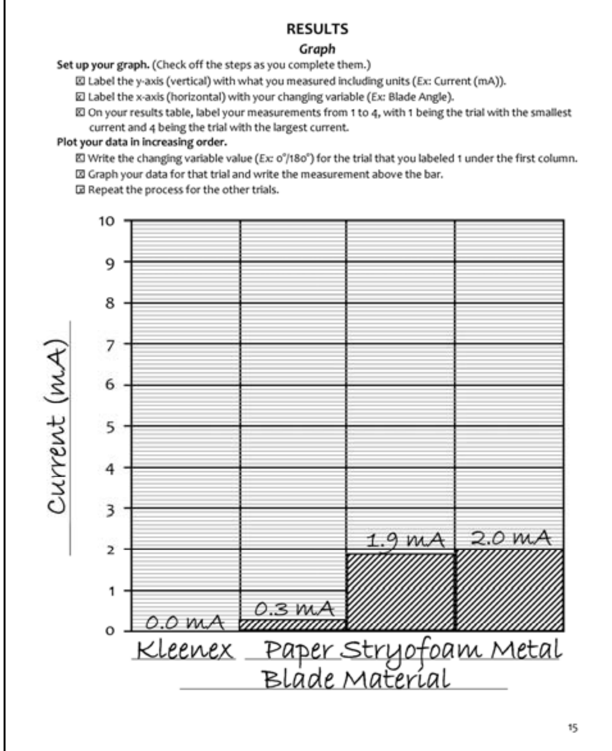
The independent variable is the changing variable and the dependent variables are the final measurements/observations.

5

Picture Packet, Page 5

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 A* 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 least (L), and most (M), current.



Experiment: *(28 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- As soon as groups finish making any of their hub set-ups, have them start making measurements. Do not wait until all hubs are made to make measurements.
- Groups changing weight number or weight placement, will take the most time. Make sure volunteers are helping these groups first.
- For groups changing blade number, have them make and run the trial with the largest number of blades first. Then, reuse those blades for the trials with less blades.
- Make sure students have their blade angles correct.

Graph: *(10 minutes – Subgroups – SciTrek Volunteers)*

- Walk around and help subgroups who are struggling.
- Make sure students are graphing their data from smallest current, to largest current.
- Make sure students have their changing variable values (Ex: 3), not the trial letters (Ex: trial A), on the x-axis.
- Make sure students are writing the numerical value of the current on top of each column.

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

- Go over what students will do next session.

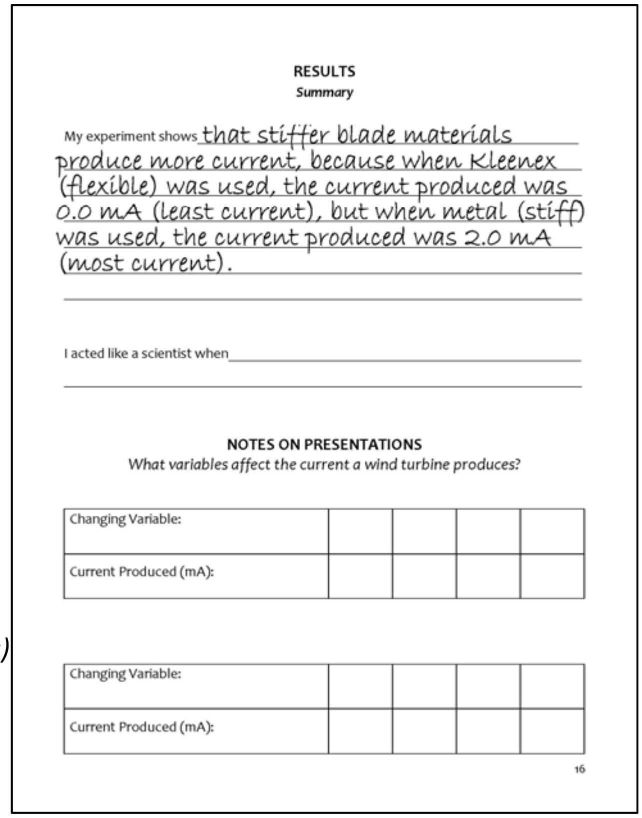
Day 5: Results Summary/Poster Making

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

Introduction (SciTrek Lead) – 10 minutes
Results Summary (SciTrek Volunteers) – 15 minutes
Poster Making (SciTrek Volunteers) – 30 minutes
Wrap-Up (SciTrek Lead) – 5 minutes

Preparation:

1. Make sure volunteers are setting out notebooks.
2. Find a place to leave student posters.
3. Set up the document camera for the results graph (notebook, page 15) and results summary (notebook, page 16).


RESULTS
Summary

My experiment shows that stiffer blade materials produce more current, because when Kleenex (flexible) was used, the current produced was 0.0 mA (least current), but when metal (stiff) was used, the current produced was 2.0 mA (most current).

I acted like a scientist when

NOTES ON PRESENTATIONS
What variables affect the current a wind turbine produces?

Changing Variable:				
Current Produced (mA):				

Changing Variable:				
Current Produced (mA):				

16

Introduction: *(10 minutes – Full Class – SciTrek Lead)*

- Review the class question as well as what students did and learned last session.
- Review the class experimental question.
- Have students generate a results summary from the graph (notebook, page 15).
    - My experiment shows stiffer blade materials will produce more current, because when Kleenex (flexible) was used, the current produced was 0.0 mA (least current), but when metal (stiff) was used the current produced was 2.0 mA (most current).
- Tell students, "Once you finish your results summary, you will make posters."

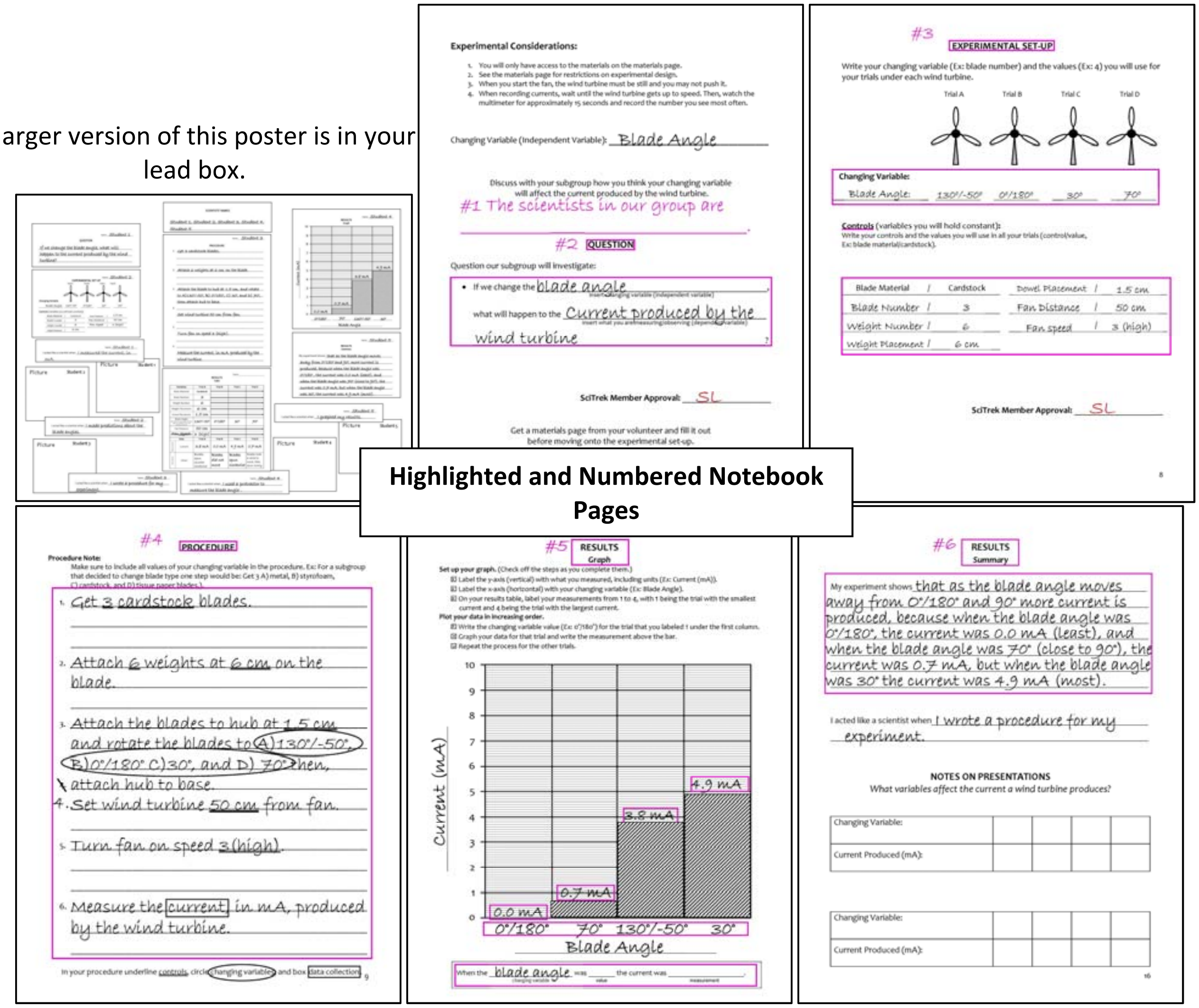
Results Summary: *(15 minutes – Subgroups – SciTrek Volunteers)*

- 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 use at least two specific data points to support it.
    - Since this is an engineering activity, make sure students are making claims that focus on the value of their changing variable that produces the largest amount of current.
    - Subgroups will be using measurements as their data; make sure they are including numerical values in their data statement.
    - Do not let subgroup reference trial letters in their results summary.
- Volunteers struggle with results summaries, so you should check at least one results summary from each group.
- Make sure students fill out the sentence *I acted like a scientist when* (notebook, page16, bottom).

Poster Making: *(30 minutes – Subgroups – SciTrek Volunteers)*

- 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.
- Make sure the student in each subgroup who is presenting the results graph, has a sentence frame sticker in their notebook and a volunteer has gone over how to present the four sentences with the student several times.
- Each student should have the part(s) they are presenting highlighted and numbered in their notebook: 1) scientists' names, 2) question, 3) experimental set-up, 4) procedure, 5) results graph, and 6) results summary (see pictures below).
    - Remind volunteers if a student is presenting multiple parts, they should have multiple sections highlighted and numbered in their notebook, and the sections should be paperclipped together.
- Volunteers often forget to highlight notebooks, so make sure this gets done before Day 6.

A larger version of this poster is in your lead box.



Highlighted and Numbered Notebook Pages

Wrap-Up: *(5 minutes – Full Class – SciTrek Lead)*

- Ask students the following questions:
    - How did you act like a scientist during this project?
    - What did you do that scientists do?

Day 6: Poster Presentations

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

Introduction (SciTrek Lead) – 2 minutes
Practice Posters (SciTrek Volunteers) – 10 minutes
Poster Presentations (SciTrek Volunteers/SciTrek Lead) – 46 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Preparation:

1. Make sure volunteers are passing out notebooks.
2. Set up the document camera for the *Notes on Presentations* (picture packet, pages 6 and 7).
3. Organize posters so experiments featuring the same changing variable will be presented back-to-back and posters are presented from simplest to understand, to most difficult to understand (suggested order: fan distance, blade angle, dowel placement, weight placement, weight number, and blade number).

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

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

Practice Posters: *(10 minutes – Subgroups – SciTrek Volunteers)*

- **Do not give students more than 10 minutes to practice or you will run out of time for presentations.**
- Make sure students are reading from their notebooks and practicing the posters in the following order: 1) scientists' names, 2) question, 3) experimental set-up, 4) procedure, 5) results graph, and 6) results summary. They will **not** read the *I acted like a scientist when* or results tables from their posters.

Poster Presentations: *(46 minutes – Full Class – SciTrek Volunteers/SciTrek Lead)*

- Have students present their posters.
- While posters are being presented, record each subgroup's changing variable values, and their data (picture packet, pages 6 and 7), while students do the same (notebook, pages 16 and 17).
    - After a subgroup reads their question, stop the presentation and have the class identify the changing variable. Then, record it in the picture packet.
    - When a subgroup reads their results graph, record the values of the changing variable and their measurements.
- After each presentation, ask students:
    - What questions do you have for this subgroup?
- 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, pages 6 and 7). Students will not record the summary in their notebooks.
- Ask students, "Which trial produced the largest current for the cheapest cost?" Then, circle this trial(s).
- Students will not record information about their own subgroup's poster presentation.
- After all presentations are over, have students tell you the variable values they would select to produce the most current, for the cheapest price.

NOTES ON PRESENTATIONS

What variables affect the current a wind turbine produces?

Subgroup 1

Changing Variable: Fan Distance (cm)	100	70	45	20
Current (mA):	4.0	4.6	5.0	5.3

Summary: As the turbine gets closer to the fan, more current is produced.

Subgroup 2

Changing Variable: Weight Placement (cm)	0	11	2	7
Current (mA):	3.2	3.3	3.3	3.4

Summary: Weight placement does not affect the current.

Subgroup 3

Changing Variable: Weight Number	21	6	0	12
Current (mA):	0.0	6.3	6.4	6.5

Summary: The weight number does not affect the current, until the weight number becomes too large.

Subgroup 4

Changing Variable: Blade Number	1	5	4	2
Current (mA):	0.0	0.8	6.7	7.0

Summary: Blades that are evenly spaced on the hub (balanced), will produce more current.

6

Picture Packet, Page 6

Group 5

Cheapest (2) · Slightly more current (3)

Changing Variable: Blade Number	1	4	2	3
Current (mA):	0.0	5.5	5.8	6.1

Summary: Agrees with group 4

Group 6

Changing Variable: Blade Angle (°)	0/180	70	130/-50	30
Current (mA):	0.0	0.7	3.8	4.9

Summary: As the blade angle moves away form 0°/180° and 90°, ~~more current is produced.~~ Blade angles on either side of 90°, will spin in different directions.

Pages 16 and 17 in the notebooks look similar to these pages but they do not have summaries.

7

Picture Packet, Page 7

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 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 7: Draw a Scientist/Tie to Standards/Content Assessment

Note: We **highly recommend** teachers give the procedure assessment prior to Day 7 of the module. The suggested times in the lesson plan below are assuming students completed the procedure assessment prior to SciTrek's arrival.

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

<u>Times if teacher gave assessment prior to SciTrek:</u>
Draw a Scientist (SciTrek Lead) – 5 minutes
Tie to Standards (SciTrek Lead) – 45 minutes
Content Assessment (SciTrek Lead) – 10 minutes

<u>Times if SciTrek must give assessment:</u>
Procedure Assessment (SciTrek Lead) – 10 minutes
Draw a Scientist (SciTrek Lead) – 5 minutes
Tie to Standards (SciTrek Lead) – 35 minutes
Content Assessment (SciTrek Lead) – 10 minutes

Preparation:

1. Get the procedure assessments and put them in the lead box.
2. If the teacher is not leading the tie to standards activity, do the following:
    a. Ask the teacher if they completed the SciTrek final survey. If not, give them the QR code from the lead box, and ask them to go to the website (at a later time), and fill out the evaluation of the program.
    b. Give the teacher an extra notebook and have them fill it out with their students to follow along during the tie to standards activity.
    c. Collect the teacher's lab coat, and put it in the lead box.
3. If you are a teacher, and have not completed the SciTrek final survey, take the QR code from the lead box, and fill out the evaluation of the program, at a later time.
4. Pass out notebooks.
5. Set up the document camera for the tie to standards activity (notebook, pages 18-20; picture packet, pages 8-11).
6. Assemble the tie to standards set-up.
    a. Verify the blades on the hub are at a **dowel placement = 0.5 cm**, and a **blade angle = 10**°, then attach the hub to the wind turbine base.
    b. Roll out the tape measure, set the **fan distance = 60 cm**, and position the wind turbine so the head is pointing at the fan.
    c. Connect the multimeter to the wind turbine base, making sure the red and black wires do not touch. The red clamp should be connected to the red wire **after** the resistor (on the loose end of the wire).
    d. Leave the multimeter, and fan, off.
    e. Set the radiometer on a flat surface, where students will be able to see it. It is important it is not moved once it is set down, because it takes a long time for the blades to come to rest.
7. Put your lab coat in the lead box at the end of the day.

Procedure Assessment: *(10 minutes – Full Class – Given By Classroom Teacher Prior to SciTrek)*

- Page 1 (Question *1)*: Have students write in their own words what they think is the definition of a procedure.
- Page 1 (Question 2): Have students fill in the missing word about what a complete procedure should have.
- Page 2: Read step 1 of the directions. Then read the question, changing variable (Ex: the changing variable was nutrient amount), and controls (Ex: the controls were plant type, liquid type, plant mass…). Do not read values of the changing variable or controls.
- Read step 2 of the directions. Then read the statement in question 3 and have students underline controls, circle changing variables, and box information about data collection.
- Read step 3 of the directions. Then have students circle if the statement, in question 3, could be an appropriate procedure step.
- Read the statement in question 4 and have students underline controls, circle changing variables, and box information about data collection.
- Have students circle if the statement, in question 3, could be an appropriate procedure step.
- Repeat the process for questions 5-9
- Page 3 and 4: have student answer the *Attitudes Towards Science* questions.
- Collect assessments.

Draw a Scientist: *(5 minutes – Full Class – SciTrek Lead)*

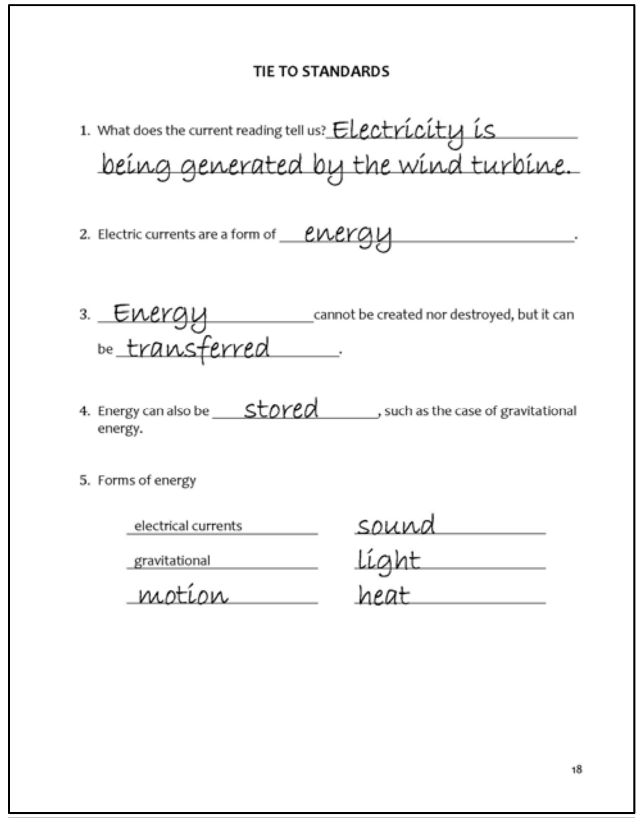
- Pass out the Draw a Scientist page.
- Give students exactly 4 minutes to draw a picture of a scientist.

- If the students drew a specific person, have them write who they drew on the line at the bottom of the page. Have them leave it blank if it is just a general person/picture.
- Collect assessments.

Tie to Standards: *(45 minutes – Full Class – SciTrek Lead)*

Energy (20 minutes)

- Review, students were measuring current and found the greater the current the more electricity the wind turbine produces.
- Fill in question *1* (notebook, page 18).
- Have students give you a few examples of things which need electricity.
- Tell students, "Electricity is a form of energy."
- Fill in question *2*.
- Tell students, "Energy cannot be created or destroyed, but it can be transferred from one form to another."
- Fill in question *3*.
- Show students the picture of the girl with the ball (picture packet, page 8), and discuss energy transfer.
    - Talk about what happens when the ball hits a wall (the wall is so large, you do not see the wall move, even though energy was transferred to it).
- Hold the eraser up, and ask students, "Does the eraser have energy?"
- Have a student hold the clipboard out at arm's length, while you drop the eraser on it.
- Ask the student who was holding the clipboard what they observed.
    - They felt their hand move, and heard a sound, when the eraser hit the clipboard.
- Lead students to understand the eraser did have energy, in the form of stored energy. Tell students, "Scientists call this type of stored energy 'gravitational energy.'"
- Fill in question *4*.
- Have students generate a list of forms of energy, and record them in question *5*.
    - Types of energy: electrical currents, gravitational, motion, sound, heat, and light.
        - If students do not come up with light, ask them, "Where the energy from a wind turbine would go it if was attached to a light bulb?"
        - Shows students the radiometer, then, show them when light is shined on the device, the blades turn. The blades must get the energy to turn from something. Lead students to understand the energy must come from the light.



TIE TO STANDARDS

1. What does the current reading tell us? Electricity is being generated by the wind turbine.
2. Electric currents are a form of energy.
3. Energy cannot be created nor destroyed, but it can be transferred.
4. Energy can also be stored, such as the case of gravitational energy.
5. Forms of energy

electrical currents	sound
gravitational	light
motion	heat

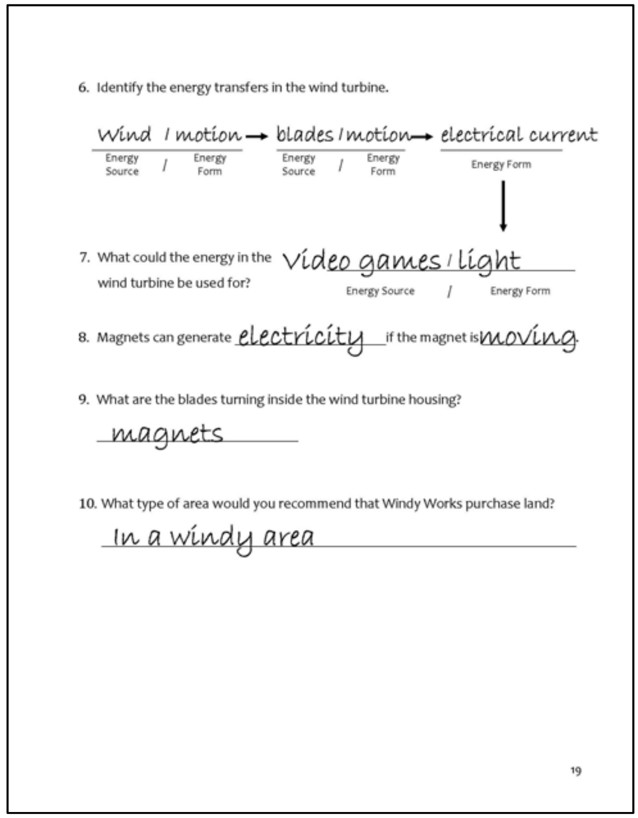
18

Picture Packet, Page 8

8

Energy Transfer (10 minutes)

- Go over the energy transfers that happen for the wind turbine, and record the answers under question *6* (notebook, page 19).
- Have students think of an energy source/energy form that the energy produced by a wind turbine could be used for, and record one possible answer for question *7*.
- Show students the lightbulb device, and explain it is a lightbulb attached to a coil of wire, but it is not plugged into anything.
- Show students if you turn the knob, the light bulb does not light.
- Take one magnet out of the container, and show it can pick up paperclips, proving it is a magnet.
- Put the magnets on either side of the lightbulb device (see picture below), and spin the handle quickly.
- Ask students, "What do you see?" They should reply, "light."
- Ask students, "What does this mean?" Possible student response: we generated electricity, or transferred energy from motion to electrical currents.
- Fill in question *8*.
- Ask students, "What do you think is inside the wind turbine housing?" Student should reply, "Magnets." Then fill in question *9*.


6. Identify the energy transfers in the wind turbine.

Wind / motion → blades / motion → electrical current
Energy Source / Energy Form   Energy Source / Energy Form   Energy Form

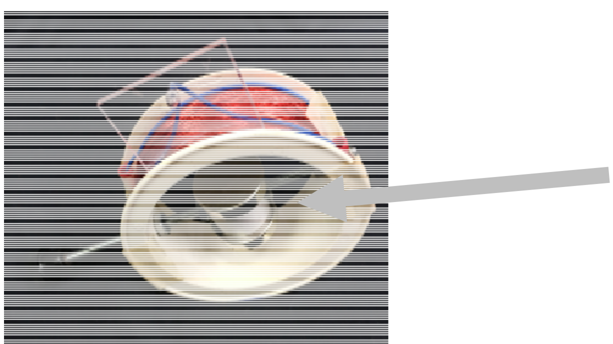
7. What could the energy in the wind turbine be used for? Video games / light
Energy Source / Energy Form

8. Magnets can generate electricity if the magnet is moving

9. What are the blades turning inside the wind turbine housing?
magnets

10. What type of area would you recommend that Windy Works purchase land?
In a windy area

19

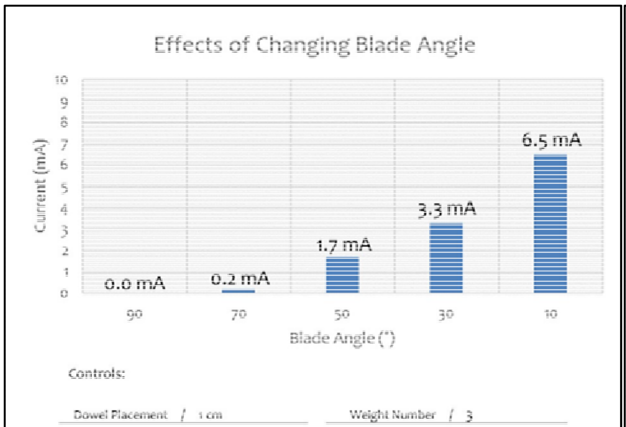


Magnets on either side of the PVC pipe in the center of the lightbulb device.

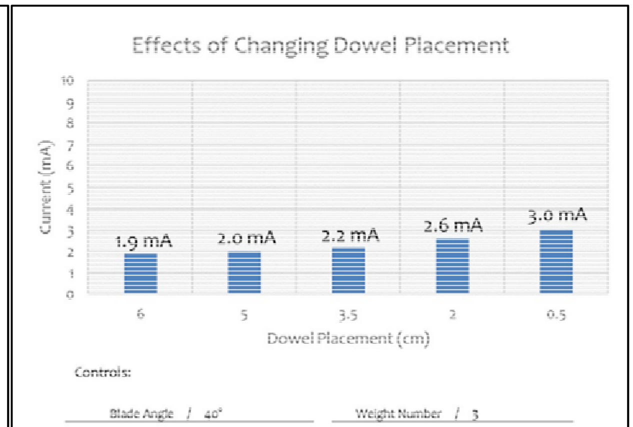
Engineering Extension: Building a Wind Turbine (15 minutes)

- Review, with students, what engineers are.
    - Engineers want to optimize wind turbines, to produce the most current, for the least cost.
- Tell students, "Windy Works, is a wind turbine company which needs our help."
- Ask students, "Where should Windy Works buy land?" Then fill in question *10*.
- Tell students, "You will look at three variables, and predict which value of the variable will produce the most current for the least amount of money."
- Have students circle which blade angle will produce the most current, for the least amount of money.
- Show students the graph of changing blade angle (picture packet, page 9), and have them box what value they would now recommend Windy Works use.

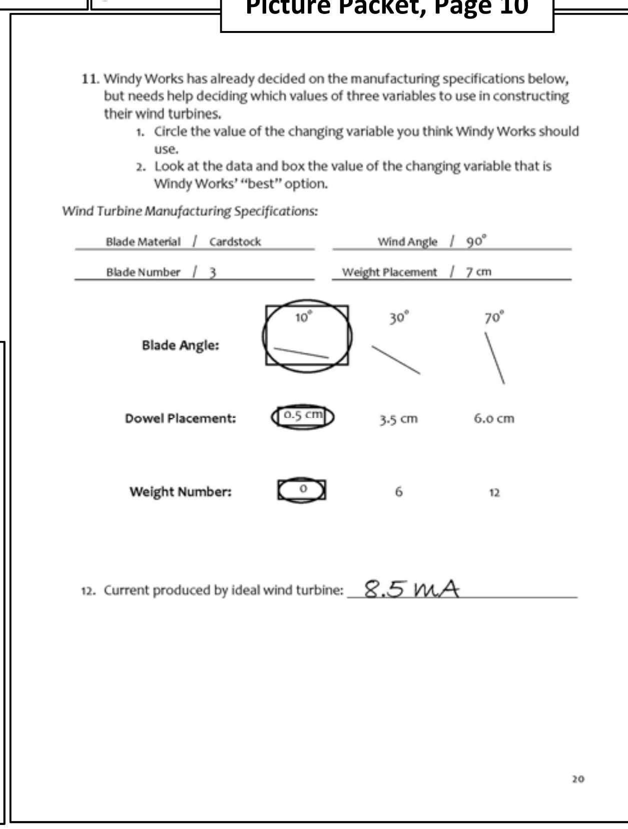
- All blade angles cost the same amount of money, and the graph shows the closer the angle is to 0˚/180˚, the higher the current. Therefore, Windy Works should use a blade angle of 10˚.
- Repeat this process for the other two variables: dowel placement (picture packet, page 10), and weight number (picture packet, page 11).
  - Dowel placements will cost different amounts of money, because the longer the dowel, the more material needed to build the turbine. The graph shows the closer the dowel is to the hub, the more current produced. Therefore, Windy Works should use a dowel placement of 0.5 cm.
  - The greater the weight number, the greater the price, because more material is needed. The graph shows that all weights give approximately the same current. Therefore, Windy Works should use no weights.
- Have subgroups share out the maximum current readings they got in their experiments.
- Tell students, “We will now test the wind turbine they suggested.”
- Turn on the wind turbine, and read the current (~8 mA).
- Tell students, “When we put all our research together, we can build a better device.”



Picture Packet, Page 9



Picture Packet, Page 10


11. Windy Works has already decided on the manufacturing specifications below, but needs help deciding which values of three variables to use in constructing their wind turbines.
    1. Circle the value of the changing variable you think Windy Works should use.
    2. Look at the data and box the value of the changing variable that is Windy Works' "best" option.

Wind Turbine Manufacturing Specifications:

Blade Material / Cardstock — Wind Angle / 90°
Blade Number / 3 — Weight Placement / 7 cm

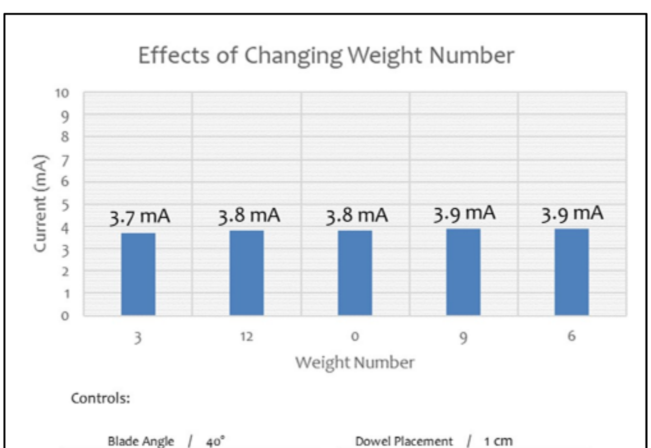
Blade Angle: 10° 30° 70°

Dowel Placement: 0.5 cm 3.5 cm 6.0 cm

Weight Number: 0 6 12

12. Current produced by ideal wind turbine: 8.5 mA

20

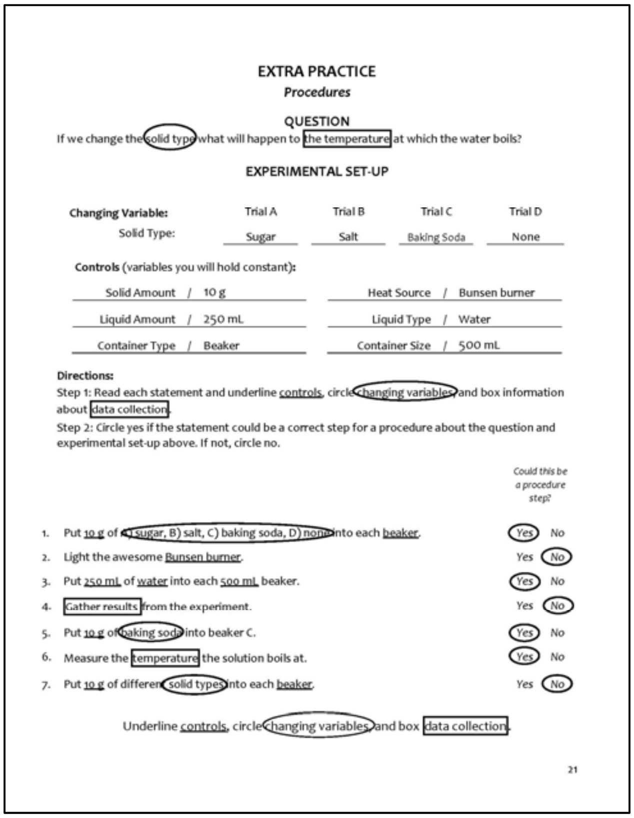


Picture Packet, Page 11

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

- Pass out content assessments.
- Read each question to students.
- Collect content assessments.

Extra Practice Solutions:



EXTRA PRACTICE

Procedures

QUESTION

If we change the solid type what will happen to the temperature at which the water boils?

EXPERIMENTAL SET-UP

Changing Variable:	Trial A	Trial B	Trial C	Trial D
Solid Type:	Sugar	Salt	Baking Soda	None

Controls (variables you will hold constant):

Solid Amount / 10 g	Heat Source / Bunsen burner
Liquid Amount / 250 mL	Liquid Type / Water
Container Type / Beaker	Container Size / 500 mL

Directions:

Step 1: Read each statement and underline controls, circle changing variables, and box information about data collection.

Step 2: Circle yes if the statement could be a correct step for a procedure about the question and experimental set-up above. If not, circle no.

	Could this be a procedure step?	
1. Put 10 g of A) sugar, B) salt, C) baking soda, D) none into each beaker.	Yes	No
2. Light the awesome Bunsen burner.	Yes	No
3. Put 250 mL of water into each 500 mL beaker.	Yes	No
4. Gather results from the experiment.	Yes	No
5. Put 10 g of baking soda into beaker C.	Yes	No
6. Measure the temperature the solution boils at.	Yes	No
7. Put 10 g of different solid types into each beaker.	Yes	No

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

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