Solar Panel Challenge

Due Date:

Tuesday, April 26, 2022

Learning Goals of this Challenge

1) *Learn about powering a motor from a solar panel.*
2) *Learn the advantages of hooking up the panels in series or in parallel.*
3) *Build two different circuits using two solar panels and a DC motor, then measure the performance of each using a digital tachometer.*
4) *Decide which configuration is better for speed and for carrying more of a load.*

Inventory of your Challenge Kit

Make sure that your kit includes:

- Small hobby motor
- Solar panel
- Digital tachometer
- Five alligator clips
- Cloth tape measure
- Adhesive tape
- Multimeter—borrow from the Electronics kits

You will also need a bright light of some sort. Use the brightest lamp or flashlight you can find.

Document It ~ Extra Credit

Use video or photos to document your work. Get creative. Examples include a time-lapse video of you conducting the challenge, a selfie with the finished product, or a self-

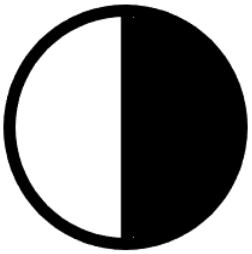
narrated video about your work. Metropolitan may post selected submissions on our social media accounts to promote Solar Cup and the work students are doing. You also may post your videos and photos on your own social media account, or your school's account. Be sure to tag Metropolitan at @mwdh2o and use the hashtag #SolarCup. The more creative your idea, the more points you will earn. Be sure to avoid profanity and inappropriate or copyrighted images or music.

Students that turn in a signed media release and upload their finished product to their school folder can earn up to 100 extra points. For a required media release and upload instructions contact Julie Miller Kalbacher at jamiller@mwdh2o.com.

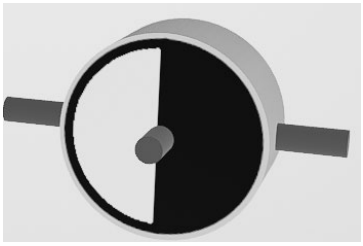
Section One: Building a circuit to power a DC motor using a solar panel

1. **Motor** - Remove the motor from the kit and place it on the tabletop. You will also need some room on the table for your lamp and a multimeter.

2. **Attaching a disk to the front of the motor** - First you need to make a disk about 1" in diameter to attach to the front of your motor. It needs to have a distinct white/dark dividing line to trigger the tachometer. Sample disk looks like this:

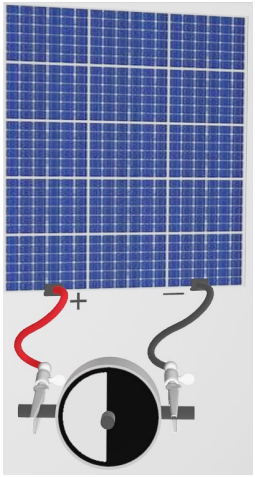


We used a thin piece of cardboard for my disk, cut it out by hand, and filled in the dark half with a black marker pen. If you don't have cardboard, you can print out an extra copy of this page and cut out the one above. Your disk does not have to be perfect, just about anything with a light and dark side should work. You can use the adhesive tape pad in your kit or glue to attach the disk to the plastic pulley on the front of the motor. A sketch of my motor looks like this:



3. **Hooking up the solar panel** – Connect the motor and the solar panel as shown below. You can connect the leads directly from the solar panel to the wires which come out of the motor, or you can use some additional alligator clips to give yourself more room to move the solar panels underneath your light. Make sure that your disk does not fly off as the motor turns. It doesn't make any difference which lead goes to which side of the motor. What happens if you switch the leads?

   _____



4. **Measuring the voltage across the motor -** Now take the multimeter, set it to the voltage range, and measure the voltage across the motor. The picture below shows how to take this measurement. Make sure that your multimeter is set to the Voltage range. If your meter reads 0L you may have to change the range of the multimeter. What happens if you hook up the meter with the leads reversed?

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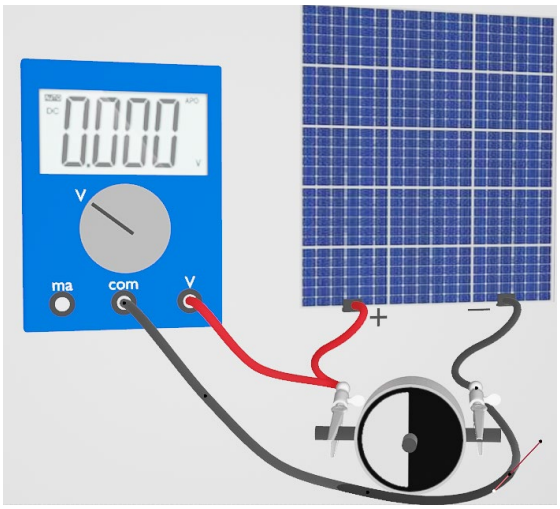
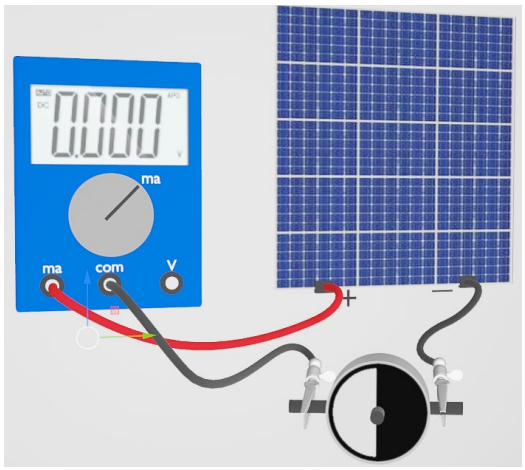
   _____



5. **Measuring the speed of the motor** – Move the light source above the solar panel close enough so that the motor begins to turn. Point the tachometer at the rotating disk and press the measurement button. Give the meter a second to settle and then take a reading. You will notice that the numbers on the meter jump around a bit across a short range. Do your best to figure out the “midpoint” of the range and record the number. The units will be in revolutions per minute, abbreviated RPM.

6. **Connecting the ammeter** – To measure current, it will be necessary to change the multimeter to the correct function and range. Turn the dial on the front of the meter to the **20ma** range to measure the current coming from the panel. Also remove the leads between the solar panel and the motor, and insert the multimeter as shown in the sketch below. Make sure that you change the leads **and** the dial of the meter so that you are measuring current.



7. **Taking a current reading** – Move the light source close enough to the solar panel so that the motor begins to turn. You will see that the multimeter gives a reading.

Move the light source closer and further away from the panels and note how the current reading changes as you do so. You may have the change the current range to get a good reading. What happens to the motor as you move the light?

_____

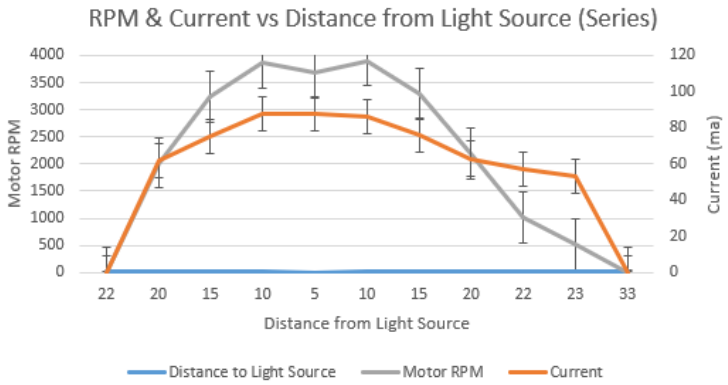
_____

8. **Taking some measurements** – Now it is time to take some real data.

    a. You will need to raise your lamp up high enough so that the motor does not turn when the solar panel is put directly underneath it.
        i. You can set the lamp on a stack of books so that the distance between the light and the solar panel does not change while you are taking the meter readings.
        ii. Once you complete the readings, you will lower the lamp by removing a book or two and measure that height. You have a tape measure in your kit to measure the distance the light is from the solar panel.

    b. Lower the lamp slowly until the motor just barely starts to turn (remove a book or two)
    c. You will need to take three data points:
        i. The distance of the light above the solar panel
        ii. The current reading on the multimeter
        iii. The RPM reading from the tachometer
    d. Now lower the light source a bit (2-3 cm, or one book width) and take readings. Make sure the motor does not stop turning as you adjust the light height.
    e. Continue reducing the distance and taking readings until the light is touching the solar panel
    f. Now move the light source back up in small increments (book widths) and take additional readings every 2-3 cm as you move the light source back up. As before, make sure the motor does not stop turning as you raise the light.
    g. Continue taking readings until the light source is too dim to make the motor turn.
    h. **Appendix A** shows a sample table of data which I took when doing this experiment, although your table should have more data points than mine.

9. **Plotting your data** – Put your data into an Excel or Google Sheets showing the Current and RPM vs Distance of the light source. It should look something like my graph below:



1. Do your best to make your graphs look professional, it doesn't have to look identical to mine. Make sure you label your axis and include error bars.

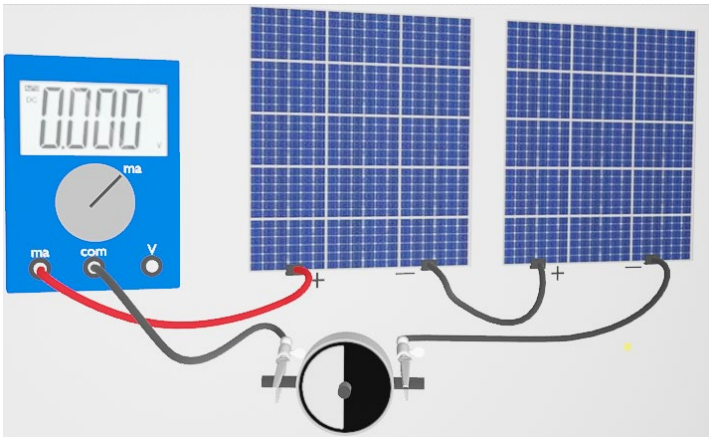
2. My plot was generated as a standard line plot using the data table shown in Appendix A. Your data should be different, so your plot will naturally be slightly different.

3. More information on how to create a plot graph is in Appendix B

Section Two: Solar Panels in a Series Circuit

For this Section and Section Three, you will need to borrow a solar panel from another kit or from the Zero Emission Vehicle kit that was sent to the school. You can return the solar panel to the kit you borrowed it from after Section Three.

This next circuit you will build will use your DC motor along with two solar panels wired in **series**. In this configuration, the positive output (+) of one panel is connected to the negative (-) output of the other panel. Your set-up should be as shown below:



Taking Measurements

After you hook up the circuit, repeat the measurements you took in the Section One experiment, although the distances may be different. Report your data in a table like you did for Section One.

It may help to do the experiment a few times, at least three would be good. You can then either average the data or use the trial run which you feel is the best. Averaging multiple trials is probably the best, however if you have one trial run which is very different than the others, examine why the difference occurred before averaging the data. As a rule, the more trial runs, the better the data.

Create Graph

Put your data into an Excel or Google Sheets showing the Current and RPM vs Distance of the light source as you did in Section One.

Do your best to make your graphs look professional. Make sure you label your axis and include error bars.

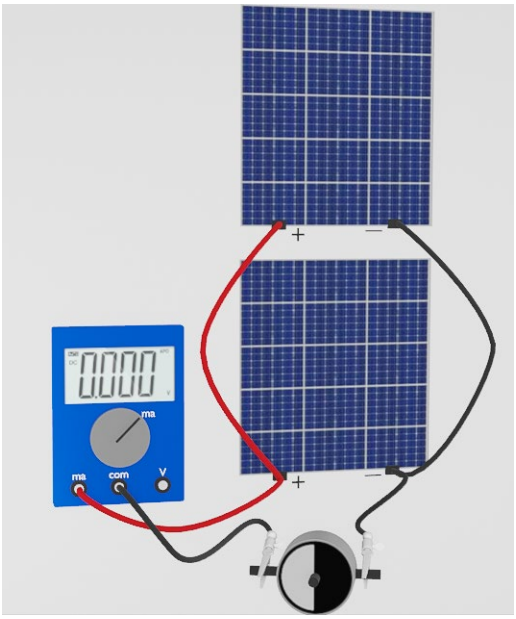
Section Two Questions:

1) Why did the ammeter give a reading at a distance that was too far away to make the motor turn? _____
   _____

2) As you moved the light away from the panel, the motor still turned at a distance greater than it was in question 2. How is this possible? _____
   _____

Section Three: Solar Panels in a Parallel Circuit

The next circuit you will build will have your DC motor along with two solar panels wired in **parallel**. In this configuration, the positive outputs (+) of each panel are connected and the negative (-) outputs of the panels are also connected. Your set-up should be as shown below:



Taking Measurements

After you hook up the circuit, take and record your data as you did in the first two sections. As before, doing multiple trial runs will give you better data.

Create Graph

Put your data into an Excel or Google Sheets showing the Current and RPM vs Distance of the light source as you did in Section One.

Do your best to make your graphs look professional. Make sure you label your axis and include error bars.

Section Three Questions:

1) As you brought the light closer to the solar panels, at what distance did the motor start turning? _____

2) Why is this distance different from the distance you got with the panels wired in series? _____

At the end of the Challenge you should have three sets of data and three graphs:

1. Motor and a single solar panel
2. Motor and two solar panels wired in series
3. Motor and two solar panels wired in parallel

Section Four: Making Conclusions

Use your data and the graphs you have printed to answer the following questions.

1) How did the performance of the circuit with only a single solar panel compare to the circuits with two panels? _____
_____

2) Which configuration made the motor turn fastest? _____

3) Can you explain why? _____
_____

4) Examine the graphs for current vs distance. What is the major difference between the current graphs for the series and parallel configurations? _____
_____

5) What does this tell you about the best way to hook up the panels? _____
_____

6) Which configuration is better to make the car go faster? _____

7) Why? _____

8) Which configuration is better to make the car carry a heavier load? _____

9) Why? _____

10) How can you test your answers to questions 5 and 6 without building the car?
_____
_____

11) Why does the configuration with the solar panels in parallel turn slower no matter how close you move the light source? _____
_____

12) Why does the motor slow down when the light comes the closest (touching) the solar panels? _____
_____

13) A big part of doing any experiment is knowing how accurate your data is. What are the major sources of errors in doing this experiment?

_____

_____

Submissions and Grading

Data Charts are worth 50 points each for a total of 150 points
Graphs are worth 50 points each for a total of 150 points
Responses to questions on the Challenge worksheets are a total of worth 100 points

Email graphs, data tables and question responses to Julie Miller Kalbacher jamiller@mwdh2o.com by **Tuesday April 26, 2022.**

Use the correct format when emailing the work

a. Your name
b. The name of your school
c. Title the data tables and graphs:
    i. Single solar panel
    ii. Two solar panels in series circuit
    iii. Two solar panels in parallel circuit
d. Your question responses can be handwritten on the Challenge worksheets or on notebook paper. If you use notebook paper, make sure to identify the Section and question number for each response.

Appendix A

Create Sample Table

Below is a sample table of data using a single solar panel. Your data should look different than the data below.

You will need to make three tables of data during this Challenge

- Single solar panel table
- Two solar panels in series circuit
- Two solar panels in parallel circuit

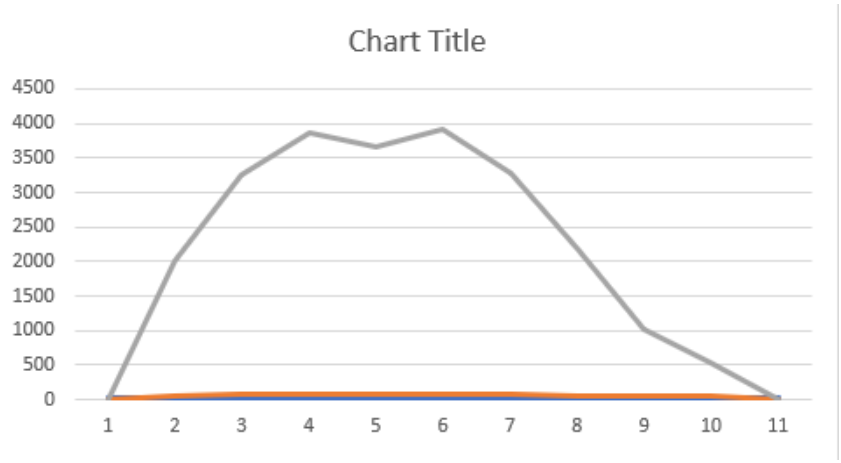
Distance	Current	RPM
22	0	0
20	62	2020
15	75	3249
10	88	3858
5	88	3685
10	86	3905
15	76	3290
20	63	2185
22	57	1012
23	53	525
33	0	0

Appendix B

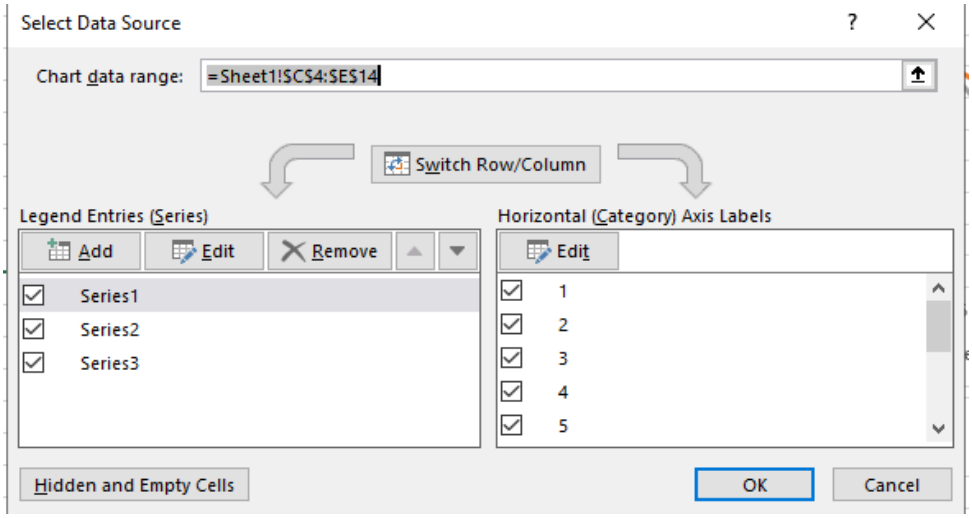
Creating Line Plot Graph

You will be creating three graphs for this Challenge using the data tables you created.

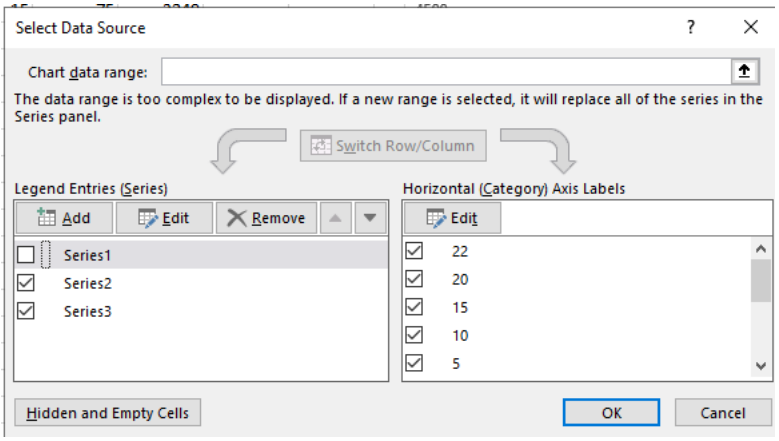
1. Create a spreadsheet with the three columns of data similar as explained above in Appendix A
2. Highlight all three columns of numbers
3. From the main menu, click on “Insert” then click on “Line Graph”. You should get a graph like the one below:



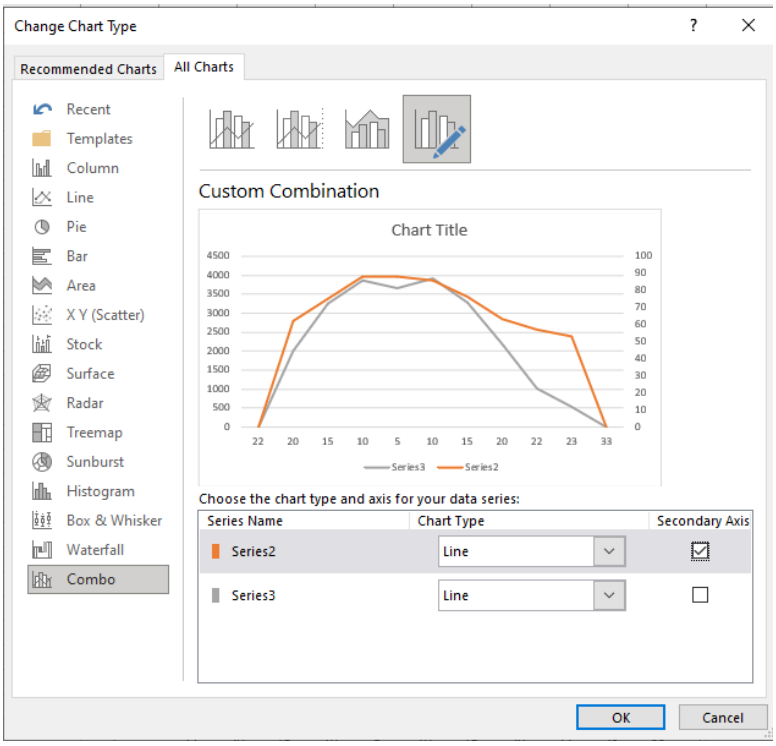
4. Right click in the graph area and select “Select Data” from the drop-down menu. You should get a box like this:



5. On the right side click on the “Edit button and select the first row of data from the table as the horizontal axis. Also click on the check box to the right of “Series 1” on the left side to unselect it. Your screens should now look like this:



6. Click the “OK” button to accept these changes
7. Now right click on the graph again and select “Change chart type” from the drop-down menu.
8. Select “Combo” from the left column selections. Change both of the “Chart Types” to Line, the check the “Secondary Axis” box at the end of the Series 2 line
9. Your screen should look something like this:



10. Click on the “OK” button to accept the changes
11. Now add the titles, error bars and axis labels to your graph
12. Now take a screen shot of you graph, add it to the documents you will send to Julie Kalbacher for evaluation