

Solar Energy Science Fair Project

Project Guidebook

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By Aurora Lipper

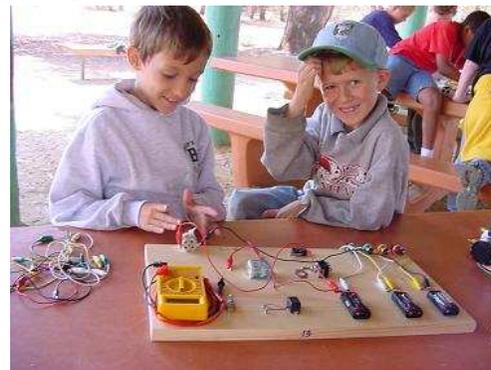
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How to Use This Book:

Welcome to the world of Supercharged Science! In just a moment, you'll be zooming solar racers, taking data, and transforming your great ideas into an outstanding science fair project! Whether you're looking to blow away the competition or happy just get a decent grade, you've got the keys to a successful science fair project in your hands right now. The tools you'll find in this manual answer the basic question: **"How can I create a science fair project and enjoy the process?"**



We're going to walk step-by-step through every aspect of creating a science fair project from start to finish, and we'll have fun doing it. All you need to do is follow these instructions, watch the video, and do the steps we've outlined here. We've taken care of the tricky parts and handed you a recipe for success.

Who am I? My name is Aurora, and I am a mechanical engineer, university instructor, airplane pilot, astronomer, and I worked for NASA during high school and college. I have a BS and MS in mechanical engineering, and for the past decade have toured the country getting kids wildly excited about doing *real* science.



What do the kids I teach learn? After a day or two, my students are building working radios from toilet paper tubes, laser light show from tupperware, and real robots from junk. And they're crazy-wild excited about doing it.

One of the problems kids have, however, is taking their idea and fitting it into something acceptable by science fairs or other technical competitions designed to get kids thinking like a real scientist.

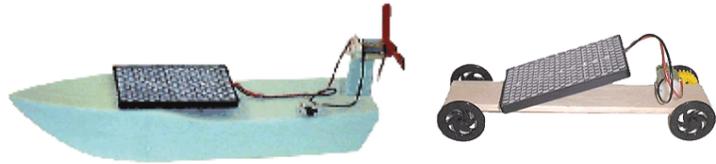
Another problem kids often face is applying the scientific method to their science project. Although the scientific method is not the primary method of investigation by industry, it *is* widely used by formal science academia as well as

scientific researchers. For most people, it's a real jump to figure out not only how to do a decent project, but also how to go about formulating a scientific question and investigate answers methodically like a real scientist. Presenting the results in a meaningful way via "exhibit board" ... well, that's just more of a stretch that most kids aren't really ready for. And from my research, there isn't a whole lot of information available on how to do it by the people who really know how.

This report is designed to show you how to do a cool project, walk you through the steps of theorizing, hypothesizing, experimentation, and iterating toward a conclusion the way a real engineer or scientist does. And we'll also cover communicating your ideas to your audience using a display board *and* the oral presentation using top tips and tricks from real scientists.

For years, Supercharged Science has served as the bridge between the scientific community and the rest of the world. This is yet another step we have taken on to help serve as many families as possible. Thank you for your support and interest... and let's get started!

Materials List



Before we start, you'll need to gather items that may not be around your house right now. Take a minute to take inventory of what you already have and what you'll need.

There are two projects listed here. The **solar boat** is a less expensive project, but the **solar car** doesn't need a bathtub in order to demonstrate.

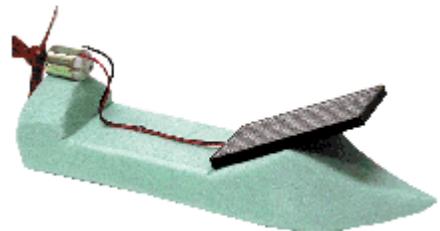
- Solar cell and motor (Radio Shack part #277-1201)
- Digital multi-meter with test leads (Radio Shack part #22-820).
- Protractor with pivoting arm
- Stopwatch or digital counter
- Chalk for marking start and finish lines
- Sunshine OR clear incandescent 100W bulb with socket
- Hot glue gun with extra glue sticks
- Camera to document project
- Composition or spiral-bound notebook to take notes
- Display board (the three-panel kind with wings), about 48" wide by 36" tall
- Paper for the printer (and photo paper for printing out your photos from the camera)
- Computer and printer



For the Solar Car Racer Only, you'll need these additional items:

If you're going to make the **solar car**, you'll need two wooden skewers, one unwrapped plastic straw, four wheels (from an old toy OR use the lids from film canisters), one sheet of foam-core or balsa wood (6" x 2" x 1/2"), and a gear set (gear assortment including a pinion gear can be found at Radio shack part #60-9515 OR pull apart an old motorized toy and use the gears you find inside).

For the Solar Boat only, you'll need these additional items: If you're going to make the **solar boat**, you'll need a block of foam at least 6" x 2" x 1" and a water trough to run your tests. You can use rain gutters sealed with silicone and filled with water, or visit your local swimming pool.



Create a Science Fair Project in Solar Energy

Before we start diving into experimenting, researching, or even writing about the project, we first need to get a general overview of what the topic is all about. Here's a quick snippet about the science of solar energy.

There are three different ways to conduct heat energy: conduction, convection, and radiation. When you sit on a cold bench, you *conduct* heat to the bench through touch. Wind chill factor is a form of *convective* heat transfer, and requires a fluid (the wind, in this case) to move the energy (heat) around. *Radiant* heat explains how the sun can warm the earth through the vacuum of space. The sun doesn't need to touch (conductive) the earth or even share in the same fluid atmosphere to transfer the energy (convective) – it warms us up through radiation, or light.



Solar energy (power) refers to collecting this energy and storing it for another use, like driving a car. The sun blasts 174×10^{15} watts (which is 174,000,000,000,000,000 watts) of energy through radiation to the earth, but only 70% of that amount actually makes it to the surface. And since the surface of the earth is mostly water, both in ocean and cloud form, only a small fraction of the total amount makes it to land.

Solar cells (photovoltaics) collect light and transform it into electricity we can use using the photoelectric effect, first designed and tested in the late 1800s. When designing solar energy collectors, engineers pay attention to details. For example, does a solar cell need to point directly at the sun, or can it use only scattered (ambient) light? Engineers design space satellites armed with solar panel arrays which continually rotate to track the position of the sun. Solar panels on homes, however, are stationary and rely on the earth's rotation to guide their path.



Your first step: Doing Research. *Why* do you want to do this project? What originally got you interested in solar energy? Is it the idea of clean energy? Or is it the thought that you never have to replace batteries in your toys again? Or do you just like how cool the solar cell *looks*?

Take a walk to your local library, flip through magazines, and surf online for information you can find about solar energy. Learn what other people have already figured out before you start re-inventing the wheel!

Flip open your science journal and write down things you've find out. Your journal is just for you, so don't be shy about jotting ideas or interesting tidbits down. Also keep track of which books you found interesting. You'll need these titles later in case you need to refer back for something, and also for your bibliography, which needs to have at least three sources that are not from the internet.

Your next step: Play with the experiment. Hook up the solar cell to the motor, add a propeller, and shine a light on the cell (or bring it into sunshine). How fast can you make the propeller spin? Can you get the motor to spin in the reverse direction?

Formulate your Question or Hypothesis: You'll need to nail down ONE question or statement you want to test if it is true. Be careful with this experiment - you can easily have several variables running around and messing up your data if you're not mindful. Here are a few possible questions:

- Does it matter what angle the solar cell makes with the sun (or light)?
- What angle does the solar cell need to be at for the maximum power output?

Once you've got your question, you'll need to identify the *control* and the *variable*. For the question: "What is the angle needed for maximum speed?", your control would be the solar car/boat you've created, the solar cell size, the incoming sunlight (if you're using a lamp, keep the distance constant between the solar cell and bulb), and your variable is the angle the solar cell makes with the incoming sunlight.

Taking Data: Sticking with the question "What angles does the solar cell need to make with the incoming light for maximum motor speed?", here's how to record data. Grab a sheet of paper, and across the top, write down your background information, such as your name, date, time of day, weather (is it cloudy?), type and size of solar cell and motor, and anything else you'd need to know if you wanted to repeat this experiment *exactly* the same way on a different day. Include a photograph of your invention also, so you'll see where you placed which parts.

Get your paper ready to take data... and write across your paper these column headers, including the things in (): (Note – there's a sample data sheet following this section).

- Trial #
- Angle of Solar Cell (degrees) – this is your independent variable.
- Voltage Output (volts) – this is your dependent variable.
- Speed of Car (feet per second) - this is another dependent variable.

Be sure to run your experiment a few times before taking actual data, to be sure you've got everything running smoothly. If you're making the racecar, you'll need to find a flat surface that has enough space for the car to come up to speed before you start clocking it.

Using chalk, space the *start* and *finish* lines ten feet apart, or if you're testing a boat, make a ten foot long trough out of rain gutters sealed with silicone. Place your solar vehicle in a spot where it has enough space to reach constant velocity before it hits the start line. (Have someone snap a photo of you getting ready to test, to enter later onto your display board.) Set the angle to zero and start clocking the time when it passes the start line. Hit the stop button when the vehicle reaches the finish line and write down the time shown on the stopwatch. Before moving the protractor, clip the test leads onto the motor terminals and read the output voltage keeping the vehicle in the *same position* as it was during the race. Record the voltage.

Run your experiment again and again, increasing the angle amount by 10 degrees each time until your motor stopping turning.

Hot Tip: Be sure to get the voltage reading each time (either before or after you race) so you have two measurements of performance. Make sure the car is in the same position as it was when you raced so you don't alter the position of the solar cell!

Don't forget to take photos as you go along - see if you can get a picture of the vehicle actually crossing the finish line!

Analyze your data. Time to take a hard look at your numbers! You'll need to convert the time measurement to speed before you analyze your data. Simply divide the distance (10 feet) by the number of seconds you recorded to find an average speed in feet per second. Do this calculation for each trial you recorded).

Make yourself a grid (or use graph paper), and plot the *Angle of Solar Cell* (in degrees) versus the *Vehicle Speed* (in feet per second). In this case, the *Solar Cell Angle* goes on the horizontal axis (independent variable), and *Speed* (dependent variable) goes on the vertical axis. You can make a second graph showing the *Solar Cell Angle* (degrees) and *Output Voltage* (volts).



Using a computer, enter in your data into an Excel spreadsheet and plot a scatter graph. Label your axes and add a title. You can plot two sets of data on one graph to show the similarities between output voltage and vehicle speed. Just make sure to add a legend so you know which set of data is which!

For Advanced Students: Use your Ohm's Law equations from electronics to check your measurements against theoretical values. You can easily measure the current and resistance to determine the theoretical power (in watts) delivered to the motor.

Conclusion: So - what did you find out? What solar cell angle gives you the fastest vehicle speed? Is it what you originally guessed? Science is one of the only fields where people actually *throw a party* when stuff works out differently than they expected! Scientists are investigators, and they get *really* excited when they get to scratch their heads and learn something new.

Hot Tip on Being a Cool Scientist One of the biggest mistakes you can ever make is to fudge your data so it matches what you wanted to have happen. Don't *ever* be tempted to do this... science is based on observational fact. Think of it this way: the laws of the universe are still working, and it's your chance to learn something new!

Recommendations: This is where you need to come up with a few ideas for further experimentation. If someone else was to take your results and data, and wanted to do more with it, what would they do? Here are a few spins on the original experiment:

- Make a lighter-weight chassis (frame)
- Vary the size of the solar cells
- Vary the size of the wheels
- Alter the gear ratio (if testing the solar car)

Make the display board. Fire up the computer, stick paper in the printer, and print out the stuff you need for your science board. Here are the highlights:

- **Catchy Title:** This should encompass your basic question (or hypothesis).
- **Purpose and Introduction:** Why study this topic?
- **Results and Analysis** (You can use your actual data sheet if it's neat enough, otherwise print one out.)
- **Methods & Materials:** What did you use and how did you do it? (Print out photos of you and your experiment.)
- **Conclusion:** One sentence tells all. What did you find out?
- **Recommendations:** For further study.
- **References:** Who else has done work like this? (Charles Fritts, James Maxwell, Ernst Werner von Siemens, Russell Ohl, Calvin Fuller, Daryl Chapin...)

Outline your presentation. People are going to want to see you demonstrate your vehicle, and you'll need to be prepared to answer any questions they have. We'll detail more of this in the later section of this guidebook, but the main idea is to talk about the different sections of your display board in a friendly, knowledgeable way that gets your point across quickly and easily. Test drive your presentation on friends and relatives beforehand and you'll be smoothly polished for the big day.

Solar Energy Data Log

Name *Aurora Lipper*

Size of Solar Cell *2" x 3" from Radio Shack Solar Kit*

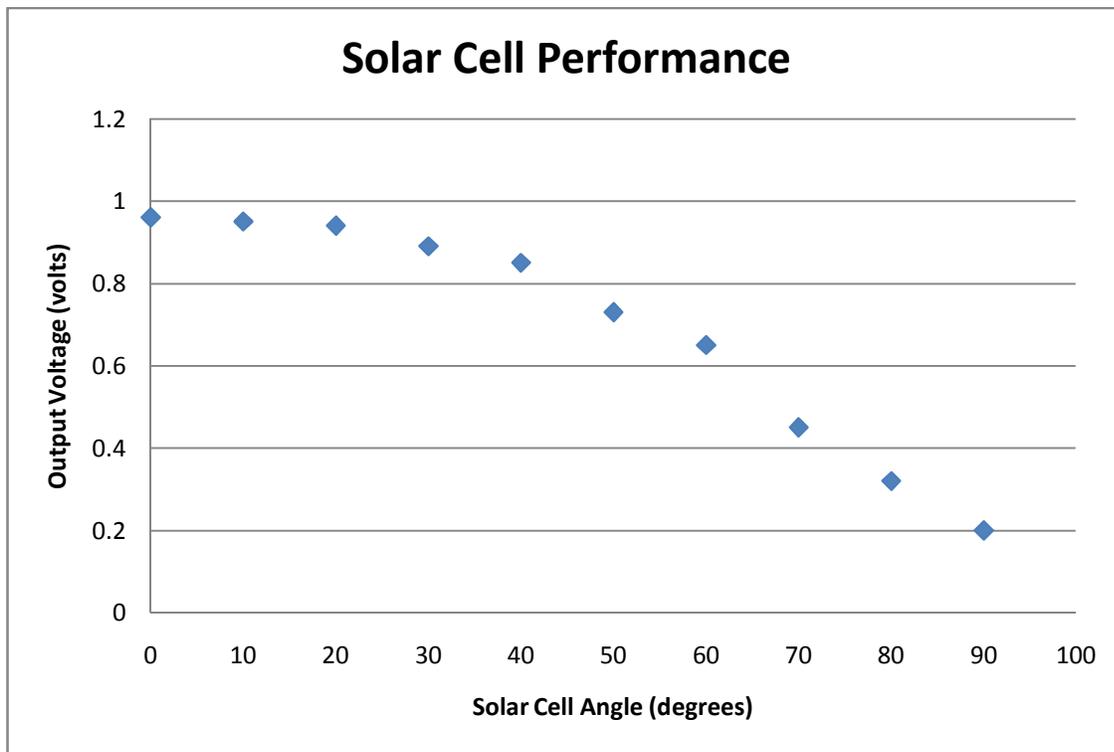
Date *12-Nov-09*

Vehicle Weight *5 oz.*

Time of Day *11:58am*

Weather Conditions *Calm, sunny, 72 deg. F*

Trial Number	Solar Cell Angle (degrees)	Time to Travel 10' (seconds)	Voltage Output (volts)	Speed (feet/second)
1	0	7.2	0.96	1.39
2	10	7.3	0.95	1.37
3	20	7.5	0.94	1.33
4	30	8.2	0.89	1.22
5	40	9.6	0.85	1.04
6	50	10.9	0.73	0.92
7	60	12.2	0.65	0.82
8	70	did not run	0.45	none
9	80	did not run	0.32	none
10	90	did not run	0.2	none



Note – The numbers shown here are NOT from a real experiment... be sure to get your own!

Sample Report

In this next section, we've written a sample report for you to look over and use as a guide. Be sure to insert your own words, data, and ideas in addition to charts, photos, and models!



Title of Project

(Your title can be catchy and clever, but make sure it is as descriptively accurate as possible. Center and make your title the LARGEST font on the page.)

by Aurora Lipper

123 Main Street,
Sacramento, CA 10101

Carmel Valley Grade School
6th grade

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Abstract

This is a *summary* of your entire project. Always write this section LAST, as you need to include a brief description of your background research, hypothesis, materials, experiment setup and procedure, results, and conclusions. Keep it short, concise, and less than 250 words.

Here's a sample from Aurora's report:

How fast can a solar cell really power a vehicle model? After researching photovoltaics, solar cells, and wiring up circuits, I realized I had all the basics for making a solar powered vehicle. But how fast could the solar cell really make a small vehicle travel?

I hypothesized that the solar cell's maximum power output happens when pointed directly at the sun. Using an inexpensive solar cell from Radio Shack, a block of foam, and a protractor with a pivoting arm, I created a solar race car that had a rotatable solar cell. I ran ten trials varying the angle the solar cell made with the sun (increasing in increments of 10 degrees with each trial) and measured both the voltage output using a digital multimeter and the time to travel ten feet using a stopwatch and a racetrack.

I found that my initial hypothesis was supported by the data, but not in the way I expected. **The racecar actually had an ideal power output/speed range when the solar cell was oriented from zero to 20 degrees.** (It actually performed about the same for three trials, instead of having an obvious "peak" performance setting as I originally had hypothesized.)

For further study, I recommend running an experiment to test the various sizes of solar cells, and also another experiment to test for the ideal motors to use with this experiment. This experiment was a lot of fun, and had unexpected results, and I learned something new!

Introduction/Research

This is where all your background research goes. When you initially wrote in your science journal, what did you find out? Write down a few paragraphs about interesting things you learned that eventually led up to your main hypothesis (or question).

Here is a sample from Aurora's report:

There are three different ways to conduct heat energy: conduction, convection, and radiation. When I sit on a cold bench, I *conduct* heat to the bench through touch. Wind chill factor is a form of *convective* heat transfer, and requires a fluid (the wind, in this case) to move the energy (heat) around. *Radiant* heat explains how the sun can warm the earth through the vacuum of space. The sun doesn't need to touch (conductive) the earth or even share in the same fluid atmosphere to transfer the energy (convective) – it warms us up through radiation, or light.

Solar energy (power) refers to collecting this energy and storing it for another use, like driving a car. The sun blasts 174×10^{15} watts (which is 174,000,000,000,000,000 watts) of energy through radiation to the earth, but only 70% of that amount actually makes it to the surface. And since the surface of the earth is mostly water, both in ocean and cloud form, only a small fraction of the total amount makes it to land.

Solar cells (photovoltaics) collect light and transform it into electricity we can use using the photoelectric effect, first designed and tested in the late 1800s. Today, engineers design space satellites armed with solar panel arrays which continually rotate to track the position of the sun. Solar panels on homes, however, are stationary and rely on the earth's rotation to guide their path.

Does it really matter what angle the solar cell makes with the incoming sunlight? If so, does it matter *much*? When the sun moves across the sky, I found that the solar cells on a house receive different amounts of sunlight. When researching solar cells, I realized I needed a way to vary the angle of the solar cell while still maintaining a firmly hold onto a moving vehicle...

Purpose

Why are you doing this science fair project at all? What got you interested in this topic? How can you use what you learn here in the future? Why is this important to you?

Come up with your own story and ideas about why you're interested in this topic. Write a few sentences to a few paragraphs in this section.

Hypothesis

This is where you write down your speculation about the project – what you think will happen when you run your experiment. Be sure to include *why* you came up with this educated guess. Be sure to write at least two full sentences.

Here's a sample from Aurora's report:

My hypothesis is that the vehicle will travel the fastest when the sunlight hits the solar cell directly. The electricity generated from the solar cell will drive a motor, which will make the solar vehicle move. My best educated guess is that the more sunlight the cell receives, the faster the vehicle will travel.

Materials

What did you use to do your project? Make sure you list *everything* you used, even equipment you measured with (rulers, stopwatch, etc.) If you need specific amounts of materials, make sure you list those, too! Check with your school to see which unit system you should use. (Metric or SI = millimeters, meters, kilograms. English or US = inches, feet, pounds.)

Here's a sample from Aurora's report:

Solar cell kit from Radio Shack (includes solar cell, solar motor, and wires)

Gears from an old toy

Thin length of balsa wood, measuring 6" x 2" x 1/8"

Straws

Wooden skewers

Film canister lids for wheels

Measuring tape

Chalk

Digital multimeter

Stopwatch

Camera to document project

My Science Journal to take notes

Procedures

This is the place to write a highly detailed description of what you did to perform your experiment. Write this as if you were telling someone else how to do your exact experiment and reproduce the same results you achieved. If you think you're overdoing the detail, you're probably just at the right level. Diagrams, photos, etc. are a great addition (NOT a substitution) to writing your description.

Here's a sample from Aurora's report:

First, I became familiar with the experiment and setup. I connected the solar cell to the solar motor and stuck them in sunlight... and the solar motor turned! Then I tried to measure the voltage and watched the numbers change while rotating the solar cell, and saw the range of voltage to expect. I then built my vehicle and added the solar cell on a protractor.

Once I was comfortable with the setup, I could now focus on my variable (solar cell angle) and how to measure my results (time, distance, voltage). I found a very flat sidewalk and marked off the start and finish lines ten feet apart. I made sure to perform this experiment in the morning when the winds were calm, and ran through all my trials at the same time of day (around noon) to minimize my variables.

I made myself a data logger in my science journal, and then brought my materials for this experiment outside. Using my digital multimeter, I first measured the voltage of the solar cell in the zero degree (horizontal) position, lifting the drive wheel just a hair above the ground, so I didn't change the angle too much *and* the car didn't zoom off while reading the voltage measurement. Afterwards, I placed the vehicle about 12 feet from the start line, to make sure it reached cruising speed before it hit the start line.

When the car passed the start line, I started my timer, stopping it as soon as it reached the finish line. I recorded the time measurement and voltage measurement in my data sheet. After the first trial, I chased after the vehicle and set the solar cell to the next angle (increased by 10 degrees). I continued this process, increasing the angle amount by ten degrees for each trial.

Results

This is the data you logged in your Science Journal. Include a chart or graph – whichever suits your data the best, or both if that works for you. Use a scatter or bar graph, label the axes with units, and title the graph with something more descriptive than “Y vs. X or Y as a function of X”. On the vertical (y-axis) goes your dependent variable (the one you recorded), and the horizontal (x-axis) holds the independent variable (the one you changed).

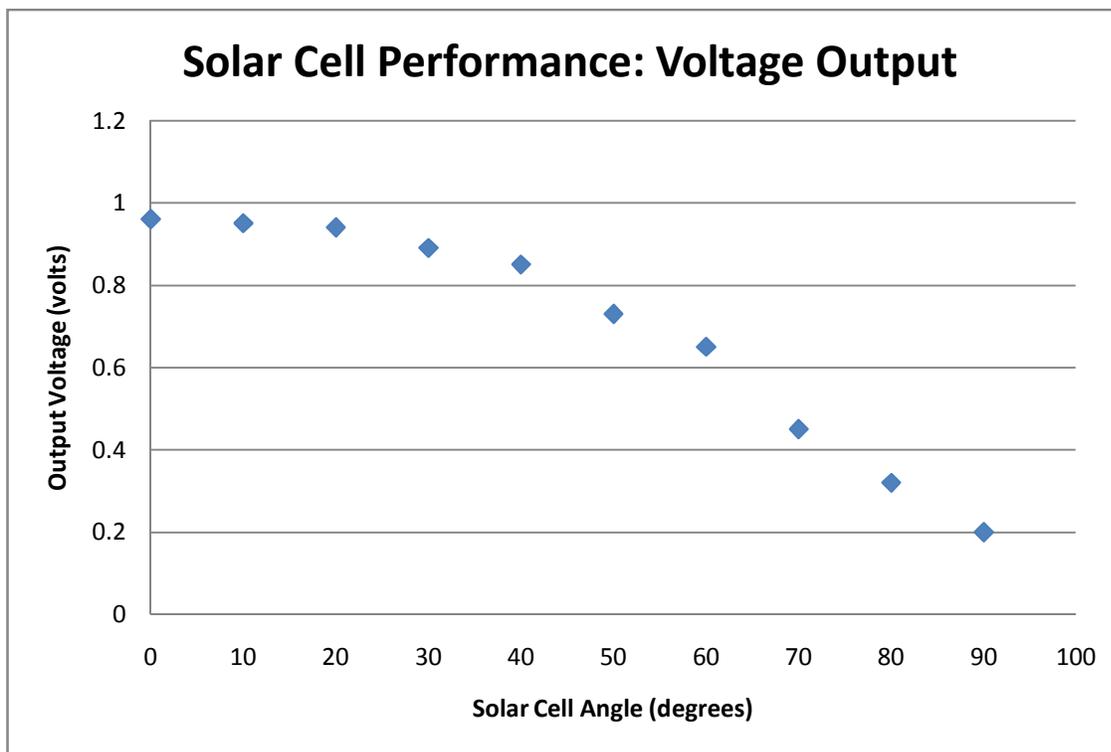
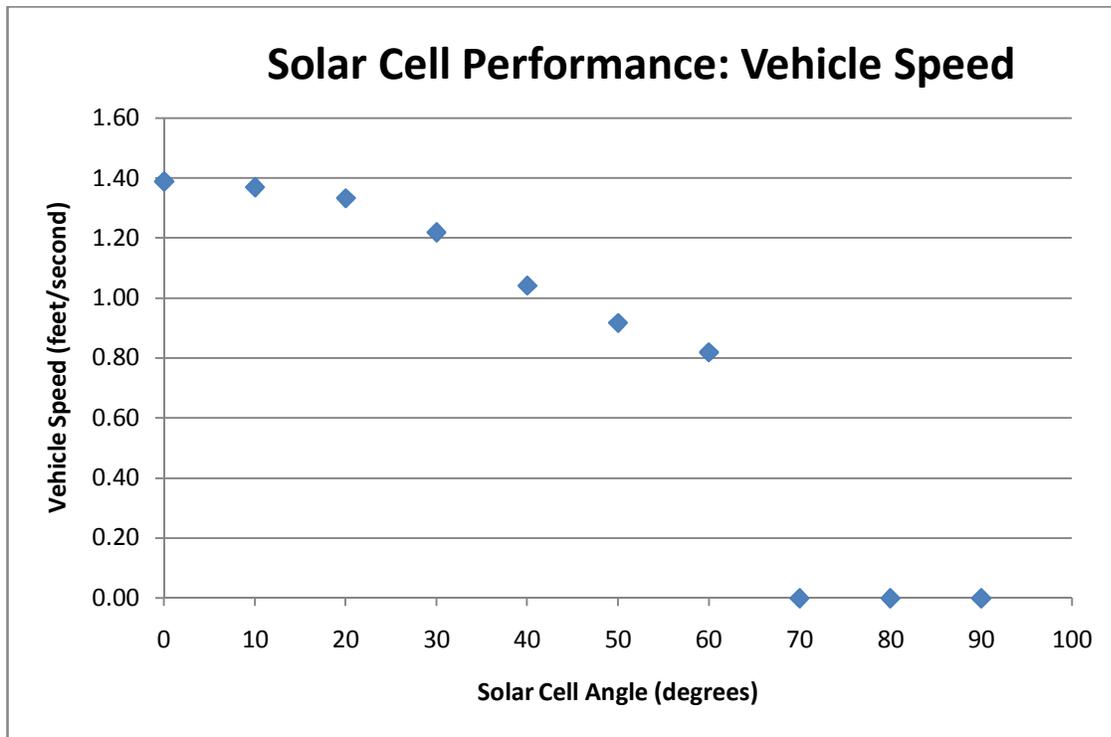
Here is a sample from Aurora’s report:

Solar Energy Data Log

Name *Aurora Lipper* **Size of Solar Cell** *2" x 3" from Radio Shack Solar Kit*
Date *12-Nov-09* **Vehicle Weight** *5 oz.*
Time of Day *11:58am* **Weather Conditions** *Calm, sunny, 72 deg. F*

Trial Number	Solar Cell Angle	Time to Travel 10'	Voltage Output	Speed
	(degrees)	(seconds)	(volts)	(feet/second)
1	0	7.2	0.96	1.39
2	10	7.3	0.95	1.37
3	20	7.5	0.94	1.33
4	30	8.2	0.89	1.22
5	40	9.6	0.85	1.04
6	50	10.9	0.73	0.92
7	60	12.2	0.65	0.82
8	70	did not run	0.45	none
9	80	did not run	0.32	none
10	90	did not run	0.2	none

The data is shown in the following graphs:



Conclusion

Conclusions are the place to state what you found. Compare your results with your initial hypothesis or question – do your results support or not support your hypothesis? Avoid using the words “right”, “wrong”, and “prove” here. Instead, focus on what problems you ran into as well as why (or why not) your data supported (not supported) your initial hypothesis. Are there any places you may have made mistakes or not done a careful job? How could you improve this for next time? Don’t be shy – let everyone know what you learned!

Here’s a sample from Aurora’s report:

I found that my initial hypothesis was supported by the data, but not in the way I expected. **The racecar actually had an ideal power output/speed range when the solar cell was oriented from zero to 20 degrees.** (It actually performed about the same for three trials, instead of having an obvious “peak” performance setting as I originally had hypothesized.)

I did not have absolute control over the outside weather conditions, which may have affected my vehicle’s performance a bit. And the sidewalk was a little bumpy here and there, which may have affected the overall speed of the vehicle. Next time, I’d recommend doing this indoors on a smooth, flat length of floor (like a gymnasium).

For further study, I recommend running an experiment to test the various sizes of solar cells, and also another experiment to test for the ideal motors to use with this experiment. This experiment was a lot of fun, and had unexpected results, and I learned something new!

Bibliography

Every source of information you collected and used for your project gets listed here. Most of the time, people like to see at least five sources of information listed, with a maximum of two being from the internet. If you're short on sources, don't forget to look through magazines, books, encyclopedias, journals, newsletters... and you can also list personal interviews.

Here's an example from Aurora's report on Rocketry:

(The first four are book references, and the last one is a journal reference.)

Fox, McDonald, Pritchard. Introduction to Fluid Mechanics, Wiley, 2005.

Hickam, Homer. Rocket Boys, Dell Publishing, 1998.

Gurstelle, William. Backyard Ballistics, Chicago Review Press, 2001.

Turner, Martin. Rocket and Spacecraft Propulsion. Springer Praxis Books, 2001.

Eisfeld, Rainer. "The Life of Wernher von Braun." Journal of Military History Vol 70 No. 4. October 2006: 1177-1178.

Acknowledgements

This is your big chance to thank anyone and everyone who have helped you with your science fair project. Don't forget about parents, siblings, teachers, helpers, assistants, friends...

Formatting notes for your report: Keep it straight and simple: 12 point font in Times new Roman, margins set at 1" on each side, single or 1.5 spaced, label all pages with a number and total number of pages (see bottom of page for sample), and put standard information in the header or footer on every page in case the report gets mixed up in the shuffle (but if you bind your report, you won't need to worry about this). Create the table of contents at the end of the report, so you can insert the correct page numbers when you're finished.

Add a photo of your experiment in action to the title page for a dynamic front page!

Exhibit Display Board

Your display board holds the key to communicating your science project quickly and efficiently with others. You'll need to find a tri-fold cardboard or foam-core board with three panels or "wings" on both sides. The board, when outstretched, measures three feet high and four feet long.

Your display board contains *all* the different parts of your report (research, abstract, hypothesis, experiment, results, conclusion, etc.), so it's important to write the report *first*. Once you've completed your report, you'll take the best parts of each section and print it out in a format that's easy to read and understand. You'll need to present your information in a way that people can stroll by and not only get hooked into learning more, but can easily figure out what you're trying to explain. Organize the information the way museums do, or even magazines or newspapers.

How to Write for your Display Board Clarity and neatness are your top tips to keep in mind. The only reason for having a board is to communicate your work with the rest of the world. Here are the simple steps you need to know:

Using your computer, create text for your board from your different report sections. You'll need to write text for the title, a purpose statement, an abstract, your hypothesis, the procedure, data and results with charts, graphs, analysis, and your conclusions. And the best part is - it's all in your report! All you need to do is copy the words and paste into a fresh document so you can play with the formatting.

The title of your project stands out at the very top, and can even have its own 'shingle' propped up above the display board. The title should be in Times New Roman or Arial, at least 60 pt font... something strong, bold, and easy to read from across the room. The title has to accurately describe your experiment *and* grab people's attention. Here are some ideas to get you started:

- Solar Car: Determining the Ideal Cell Angle for the Fastest Speed
- Solar Speed Racers: Studying the Effect of Photovoltaic Angle to Incoming Photons
- Battery-Free Cars: Just How Big of a Solar Cell Do You Really Need?
- How to Turn your Suntan into Speed: Investigating the Effects of Solar Cell Size

On the left panel at the top, place your abstract in 16-18 pt font. Underneath, post your purpose, followed by your hypothesis in 24 point font. Your list of materials or background research can go at the bottom section of the left panel. If you're cramped for space, put the purpose in the center of the board under the title.

In the central portion of the board, post your title in large lettering (24-60 pt. font). (You can alternatively make the title on a separate board and attach to the top of the display board... which is *great* if you really want to stand out!) Under the title, write a one-sentence description of what your project is really about in smaller font size (24-48 pt. font) Under the title, you'll need to include highlights from your background research (if you haven't put it on the left panel already) as well as your experimental setup and procedures. Use photos to help describe your process.

The right panel holds your results with prominent graphs and/or charts, and clear and concise conclusions. You can add tips for further study (recommendations) and acknowledgements beneath the conclusions in addition to your name, school, and even a photo of yourself doing your project.

Use white copy paper (*not* glossy, or you'll have a glare problem) and 18 point Times New Roman, Arial, or Verdana font. Although this seems obvious, spell-check and grammar-check each sentence, as sometimes the computer does make mistakes! Cardstock (instead of white copy paper) won't wrinkle in areas of high humidity.

Cut out each description neatly and frame with different colored paper (place a slightly larger piece of paper behind the white paper and glue in place. Trim border after the glue has dried. Use small amounts of white glue or hot glue in the corners of each sheet, or tape together with double-sided sticky tape. Before you glue the framed text descriptions to your board, arrange them in different patterns to find the best one that works for your work. Make sure to test out the position of the titles, photos, and text together before gluing into place!

In addition to words, be sure to post as many photos as is pleasing to the eye and also helps get your point across to an audience. The best photos are of *you* taking real data, doing real science. Keep the pictures clean, neat, and with a matte finish. Photos look great when bordered with different colored paper (stick a slightly larger piece of paper behind the photo for a framing effect). If you want to add a caption, print the caption on a sheet of white paper, cut it out, and place it near the top or bottom edge of the photo, so your audience clearly can tell which photo the caption belongs to. Don't add text directly to your photo (like in Photoshop), as photos are rich in color, and text requires a solid color background for proper reading.

Check over your board as you work and see if your display makes a clear statement of your hypothesis or question, the background (research) behind your experiment, the experimental method itself, and a clear and compelling statement of your results (conclusion). Select the text you write with care, making sure to add in charts, graphics, and photos where you need to in order to get your point across as efficiently as possible. Test drive your board on unsuspecting friends and relatives to see if they can tell you what your project is about by just reading over your display board.

How to Stand Out in a Crowd Ever try to decide on a new brand of cereal? Which box do you choose? All the boxes are competing for your attention... and out of about a hundred, you pick *one*. This is how your board is going to look to the rest of the audience – as just one of the crowd. So, how do you stand out and get noticed?

First, make sure you have a BIG title – something that can be clearly seen from across the room. Use color to add flair without being too gaudy. Pick two colors to be your “color scheme”, adding a third for highlights. For example, a black/red/gold theme would look like: a black cardboard display board with text boxes framed with red, and a title bar with a black background with red lettering highlighted with gold (using two sets of “sticky” letters offset from each other). Or a blue/yellow scheme might look like: royal blue foam core display board with textboxes framed with strong yellow. Add color photographs and color charts for depth. Don’t forget that the white in your textboxes is going to add to your color scheme, too, so you’ll need to balance the color out with a few darker shades as you go along.

It’s important to note that while stars, glitter, and sparkles may attract the eye, they may also detract from displaying that you are about ‘real science’. Keep a professional look to your display as you play with colors and shades. If you add something to your board, make sure it’s there to help the viewer get a better feel for your work.

For a solar cell exhibit, you can add sparks of electricity up the edges of your display board and around the top of your board in gold or blue. Add your model vehicle (preferably a larger model) at the top of your board as an attention-getter. Have a solar vehicle jacked up (so it doesn’t zoom away) and angled toward a desk lamp so people can see your experiment in action. Hook up a digital multimeter so onlookers can see the effects their shadow has when they cover up the solar cell.

If you’re stuck for ideas, here are a few that you might be able to use for your display board. Be sure to check with your local science fair regulations, to be sure these ideas are allowed on your board:

- Your name and photo of yourself taking data on the display board
- Captions that include the source for every picture or image
- Acknowledgements of people who helped you in the lower right panel
- Your scientific journal or engineer’s notebook
- The experimental equipment used to take data and do real science
- Photo album of your progress (captions with each photo)

Oral Presentation

You're now the expert of the Solar Energy Science Experiment... you've researched the topic, thought up a question, formulated a hypothesis, done the experiment, worked through challenges, taken data, finalized your results into conclusions, written the report, and build a display board worthy of a museum exhibit. Now all you need is to prep for the questions people are going to ask. There are two main types of presentations: one for the casual observer, and one for the judges.

The Informal Talk In the first case, you'll need quick and easy answers for the people who stroll by and ask, "What's this about?" The answers to these questions are short and straight-forward – they don't want a highly detailed explanation, just something to appease their curiosity. Remember that people learn new ideas quickly when you can relate it to something they already know or have experience with. And if you can do it elegantly through a story, it will come off as polished and professional.

The Formal Presentation The second talk is the one you'll need to spend time on. This is the place where you need to talk about everything in your report without putting the judges to sleep. Remember, they're hearing from tons of kids all day long. The more interesting you are, the more memorable you'll be.



Tips & Tricks for Presentations: Be sure to include professionalism, clarity, neatness, and 'real-ness' in your presentation of the project. You want to show the judges how you did 'real' science – you had a question you wanted answered, you found out all you could about the topic, you planned a project around a basic question, you observed what happened and figured out a conclusion.

Referring back to your written report, write down the highlights from each section onto an index card. (You should have one card for each section.) What's the most important idea you want the judges to realize in each section? Here's an example:

Research Card: How fast can a solar cell really power a vehicle model? After researching photovoltaics, solar cells, and wiring up circuits, I realized I had all the basics for making a solar powered vehicle. But how fast could the solar cell really make a small vehicle travel?

Question/Hypothesis Card: But how fast could it really go? What was the power output of a solar cell? I hypothesized that the solar cell's maximum power output happens when pointed directly at the sun.

Procedure/Experiment Card: Using an inexpensive solar cell from Radio Shack, a block of foam, and a protractor with a pivoting arm, I created a solar race car that had a rotatable solar cell. I ran ten trials varying the angle the solar cell made with the sun (increasing in increments of 10 degrees with each trial) and measured both the voltage output using a digital multimeter and the time to travel ten feet using a stopwatch and a racetrack.

Results/Conclusion Card: I found that my initial hypothesis was supported by the data, but not in the way I expected. **The racecar actually had an ideal power output/speed range when the solar cell was oriented from zero to 20 degrees.** (It actually performed about the same for three trials, instead of having an obvious “peak” performance setting as I originally had hypothesized.)

Recommendations Card: For further study, I recommend running an experiment to test the various sizes of solar cells, and also another experiment to test for the ideal motors to use with this experiment. This experiment was a lot of fun, and had unexpected results, and I learned something new!

Acknowledgements Card: I want to express my thanks to mom for slathering on sunscreen every time I went to retest my experiment, for my teacher who encourages me to go further than I really think I can go, for my sister for helping chase down the vehicle when it escaped, and for dad for his help building the vehicle model that actually went straighter.

Putting it all together... Did you notice how the content of the cards were already in your report, in the abstract section? The written report is such a vital piece to your science fair project, and by writing it first, it makes the rest of the work a lot easier. You can do the tougher pieces (like the oral presentation) later because you took care of the report upstream.

As you practice your oral presentation, try to get your notes down to only one index card. Shuffling through papers onstage detracts from your clean, professional look. While you don't need to memorize exactly what you're going to say, you certainly can speak with confidence because you've done every step of this project yourself.



You're done! Congratulations!! Be sure to take lots of photos, and send us one! We'd love to see what you've done and how you've done it. If you have any suggestions, comments, or feedback, let us know! We're a small company staffed entirely human beings, and we're happy to help you strive higher!