Underwater R.O.V. Robot
Science Fair Project

Project Guidebook

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 underwater robots, 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.

- Three 12VDC motors (Radio Shack part #273-256)
- Three film canisters (black Kodak canisters work great)
- ½" PVC pipe (6 pieces: 1.5" long, 4 pieces 2.5" long, 4 pieces 3" long, 2 pieces 4" long, 2 pieces 4.5" long, and 2 pieces 12" long… total length is roughly 6 feet of pipe.)
- 2" diameter (two pieces 6" long each)
- Four 2" PVC end caps
- Four ½" PVC tees (slip-slip-slip)
- Ten 90 deg. Elbow (slip-slip)
- Coarse sand paper
- Three 1" pipe clamps (*image right*)
- Three propellers that fit onto the motor shaft
- Three DPDT switches with a center OFF position (Radio Shack Part #275-038)
- Wire: 12' two-line (four-wire) telephone line and 20-50' lamp cord
- Project box (you'll need a plastic box: tupperware, soap dishes, or official project boxes from Radio Shack)
- 6-10 zip ties
- Wire (or plastic) mesh screen, 12" x 8" piece
- Soldering iron with solder
- Pliers, screwdriver
- Drill with drill bits
- Silicone or toilet seal wax (and an old mug to liquefy it in)
- Vaseline
- Power supply (car battery or car charger – make sure it's 12V DC)
- 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

Create a Science Fair Project in Submersibles

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 submersibles.

Up until 200 years ago, people thought the oceans were bottomless. The *diving bell* was one of the first recorded attempts at undersea exploration, and was simply a five-foot inverted cup with viewing holes on a platform that lowered into the water, which allowed people to breathe the trapped air inside… until they ran out of air. Leonardo da Vinci draw several sketches of underwater submersibles, and in the 1700s, John Lethbridge invented a long wooden cylinder with glass ends as one of the first diving units to reach 60 feet. In 1930, two explorers used the bathysphere (a giant ball with windows) reached 1,428 feet below the surface, which was later followed by the bathyscape (deep diving vessel) that reached the deepest part of the Pacific Ocean, the Marianas Trench, at 35,800 feet in 1960. The ROVs first made their appearance in the late 1960s, when military and offshore drilling required deeper dives. In the late 1980s, scientists needed a way to explore the remains of the *Titanic*, and a lower-cost, lighter weight version design was developed. ROVs are designed to be remote extensions of the operator.

One of the biggest challenges with deep-diving underwater vessels is keeping the tremendous pressure from crumpling the frame. The project we're going to design is meant for swimming pools and smaller lakes. When designing your underwater vehicle, you'll need to pay close attention to the finer details such as waterproofing the electrical motors and maintaining proper balance so that your robot doesn't flip over or swim in circles.

Your first step: Doing Research. *Why* do you want to do this project? What originally got you interested underwater vehicles? Is it the idea of seeing what's out there? Or do you just like how cool the ROV *looks*?

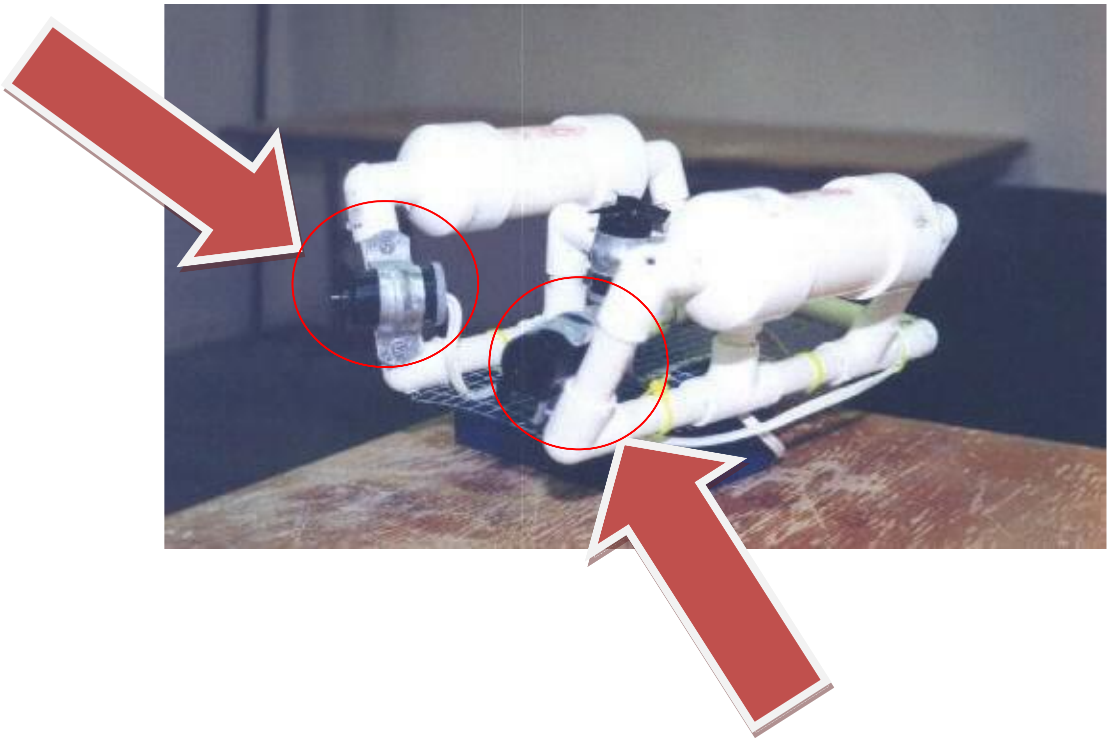
Take a walk to your local library, flip through magazines, and surf online for information you can find about submersibles and diving vessels. Learn what other people have already figured out before you start re-inventing the wheel!

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: Define what it is that you really want to do. In this project, we're going to walk you step by step trough creating a small underwater vehicle that swims in a pool, made out of hardware-store parts, and is easy to operate.

You'll need to build your ROV before you can test it. This process should have you about 20 hours, from shopping for materials to piloting your first dive. Start construction of your ROV frame and toss it in the pool – does it sink or float?

IMPORTANT NOTE: Do NOT glue together the PVC to the elbows that the thruster motors are going to mount to. You will need to rotate the thruster angle, so DO NOT GLUE THIS JUNCTION!



Now make your thruster motors and wire it up to the project control box. Do all the motors go forward and reverse? Add the motors to your frame and add the wire mesh screen and throw it into the pool – does it sink or float? Add weights and check your balance as shown in the video. Once you've created your ROV, play with it and experiment driving it around. When you're done, go on to the next step.

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

- "What is the ideal thruster angle for maximum maneuverability?"
- "Does thruster angle matter?"
- "How does thruster angle affect the forward speed?"

Once you've got your question, you'll need to identify the *control* and the *variable.* For the question: "What is the thruster angle needed for maximum maneuverability?", your variable is the angle the thruster makes centerline (an imaginary line drawn from the nose to tail, or where cords extend from).

Another question to consider is: How will you measure 'maneuverability'? Does it mean you can turn on a dime (spin about the center axis)? Go from rest to full speed within a certain time limit, and in which direction? What does maneuverability mean to you?

You might want to set up an underwater 'training' course for your ROV – using sandbags to weigh down hula hoops and other obstacles to test how well it can travel in, around, and under objects.

Taking Data: Sticking with the question *"What thruster angles are needed for maximum maneuverability?*", 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, water conditions weather (is it calm or choppy?), 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 so everyone can see exactly what your setup looks like.

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 Thruster Motor (degrees) – this is your independent variable.
- Time to Perform Maneuver – this is your dependent variable
- Speed of ROV (feet per second) - this is another dependent variable.

Decide which kind of maneuver you're going to test. Here are a few options: time to travel 10' horizontal forward motion, 90^o right turn, 90^o left turn, swim 10' backwards, complete U-turn, go from the ceiling to the floor of the water (or vice versa), etc. Make sure it's a maneuver that is easy to measure the results of. If you decide on "Time to retrieve car keys", you're introducing other variables into your experiment, such as the time it takes for the operator to pilot the craft into position. Find an experiment to test that is easily repeatable and easy to measure. Flipping a switch and timing a U-turn is a quick, effective test of one facet of maneuverability.

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 testing for sharp right turns and deep vertical dives, you'll need to test each experiment in calm water that has enough room for your ROV to move about.

If you're going to test total forward speed, you'll need a distinct start and finish line. Using chalk, space the *start* and *finish* lines ten feet apart on the deck near the water. Set the thruster angle to zero and start clocking the time when it passes the start line. (Make sure your ROV has enough time to hit cruising speed *before* it hits the start line, or you'll have trouble with the calculations later.) Hit the stop button when the vehicle reaches the finish line and write down the time shown on the stopwatch.

Run your experiment again and again, increasing the thruster angle amount by 10 degrees each time until you hit 90^o.

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! If you're testing the vehicle forward speed, 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 Thruster* (in degrees) versus the *Time for Maneuver* (in seconds). In this case, the *Thruster Angle* goes on the horizontal axis (independent variable), and *Time for Maneuver* (dependent variable) goes on the vertical axis. 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 chart more than one maneuver on the graph, but be sure to add a legend so you can tell your data lines apart!

If you're testing vehicle forward speed, you can graph a chart that shows *Thruster Angle* on the horizontal axis (independent variable), and *Vehicle Speed* (dependent variable) on the vertical axis.

Conclusion: So - what did you find out? What thruster angle gives you the fastest vehicle speed? Or the best maneuverability? 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 thruster motors
- Vary the size of the power supply
- Place the thruster motors in a different location
- Use six motors instead of three (one for each axis)

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? (Chris Nicolson, US Navy…)

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.

Sample Data Sheets

Underwater ROV Robot Data Log

Name
Number/Size of Thrusters

Date
Vehicle Weight

Time
Water Conditions

Trial Number	Thruster Angle (from centerline)	Time to Travel 10' (horizontal forward)	Time to Turn 90^o (left turn)
	(degrees)	(seconds)	(seconds)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Create this table yourself using Microsoft Excel. You can download your free copy at this link:

http://www.ability-usa.com/download.php

OR...download your free 60-day trail copy from Microsoft at this link:

http://office.microsoft.com/en-us/excel/default.aspx

ROV Data Log

Name

Date

Time

Water Conditions

Size/Number of Thursters

ROV Weight

Trial #	Propeller Design	Time to Travel 4m	Time to Dive 2m	Time to U-Turn
		(seconds)	(seconds)	(seconds)
1	2 blade boat			
2	3 blade boat			
3	4 blade boat			
4	2 blade airplane			
5	3 blade airplane			
6	4 blade airplane			

Feel free to design your own data sheet. What do YOU want to test?

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 maneuverable can hobby motors really make an underwater vehicle? After researching underwater submersibles, diving vessels, chassis designs, and wiring up circuits, I realized I had all the basics for making a Remotely Operated Vehicle (ROV). But how maneuverable could the hobby motors really make a small underwater vehicle?

I hypothesized that the thruster motors maximum maneuverability happens when the motors are tilted 45^{o} from the centerline of the vehicle. Using plumbing parts from the hardware store and electrical motors from Radio Shack, I created an underwater vehicle that could swim freely in all six directions (up, down, left right, forward, and back). I ran ten trials varying the angle the thrusters made with the vehicle centerline (increasing in increments of 10 degrees with each trial) and measured the time the ROV took to perform a series of maneuvers, using a stopwatch and a measuring tape.

I found that my initial hypothesis was supported by the data, but not in the way I expected. **The ROV actually had an ideal maneuverability range when the thrusters were oriented from 20 to 30 degrees.** (It actually performed about the same for two 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 power input to the thruster motors, 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:

Up until 200 years ago, people thought the oceans were bottomless. The *diving bell* was one of the first recorded attempts at undersea exploration, and was simply a five-foot inverted cup with viewing holes on a platform that lowered into the water, which allowed people to breathe the trapped air inside… until they ran out of air. Leonardo da Vinci draw several sketches of underwater submersibles, and in the 1700s, John Lethbridge invented a long wooden cylinder with glass ends as one of the first diving units to reach 60 feet.

In 1930, two explorers used the bathysphere (a giant ball with windows) reached 1,428 feet below the surface, which was later followed by the bathyscape (deep diving vessel) that reached the deepest part of the Pacific Ocean, the Marianas Trench, at 35,800 feet in 1960. The ROVs first made their appearance in the late 1960s, when military and offshore drilling required deeper dives. In the late 1980s, scientists needed a way to explore the remains of the *Titanic*, and a lower-cost, lighter weight version design was developed. ROVs are designed to be remote extensions of the operator.

One of the biggest challenges with deep-diving underwater vessels is keeping the tremendous pressure from crumpling the frame. Designers pay close attention to the finer details such as waterproofing the electrical motors and maintaining proper balance so that the ROV doesn't flip over or swim in circles…

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 underwater ROV robot will be the most maneuverable when the thrusters are mounted at 45^o from the vehicle centerline. Maneuverability includes fastest time to turn sharply, travel a distance, and dive. My best educated guess is that the motors need to be mounted at an angle halfway between the front-back and left-right directions of the vehicle.

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:

- Three 12VDC motors (Radio Shack part #273-256)
- Three film canisters
- ½" PVC pipe (6')
- 2" diameter (two pieces 6" long each)
- Four 2" PVC end caps
- Four ½" PVC tees (slip-slip-slip)
- Ten 90 deg. Elbow (slip-slip)
- Coarse sand paper
- Three 1" pipe clamps
- Three propellers that fit onto the motor shaft
- Three DPDT switches (with a center OFF position)
- Wire: 12' two-line (four-wire) telephone line and 20-50' lamp cord
- Project box (you'll need a plastic box: tupperware, soap dishes, or official project boxes from Radio Shack)
- Zip ties
- Wire (or plastic) mesh screen
- Soldering iron with solder
- Pliers, screwdriver
- Drill with drill bits
- Silicone
- Vaseline
- Power supply (12VDC car charger)
- Camera to document project
- Computer and printer
- Stopwatch
- 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 constructed the underwater ROV and built it entirely from hardware store parts. After minor troubleshooting, I was able to pilot the ROV in our pool and get a feel for the controls and what to expect for maneuverability and time frames.

Once I was comfortable with the setup, I could now focus on my variable (thruster angle) and how to measure my results (time, distance) to test the different maneuvers. I marked off the start and finish lines ten feet apart on the pool deck. I made sure to perform this experiment when no one else was in the pool (for calmest water conditions), and ran through all my trials at the same time of day (around ten) to minimize my variables. I used a car charger instead of a car battery, so identical amounts of power were delivered during each trial.

I made myself a data logger in my science journal, and then brought my materials for this experiment outside. I set the angle of the thruster to the zero degree position (pointing straight out the back), and placed it in the pool, about 12 feet from the start line, to make sure the ROV reached cruising speed before it hit the start line.

When the ROV passed the start line, I started my timer, stopping it as soon as it reached the finish line. I recorded the time measurement in my data sheet. I then waited for the water to calm down (about two minutes), and then started my timer at the same time I flipped the switches to make a left turn, stopping after the ROV made a complete 90^o turn. (I needed to modify which switches I engaged, as using only one thruster was not enough to cause it to rotate.) After the first trial, I set the thrusters 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.

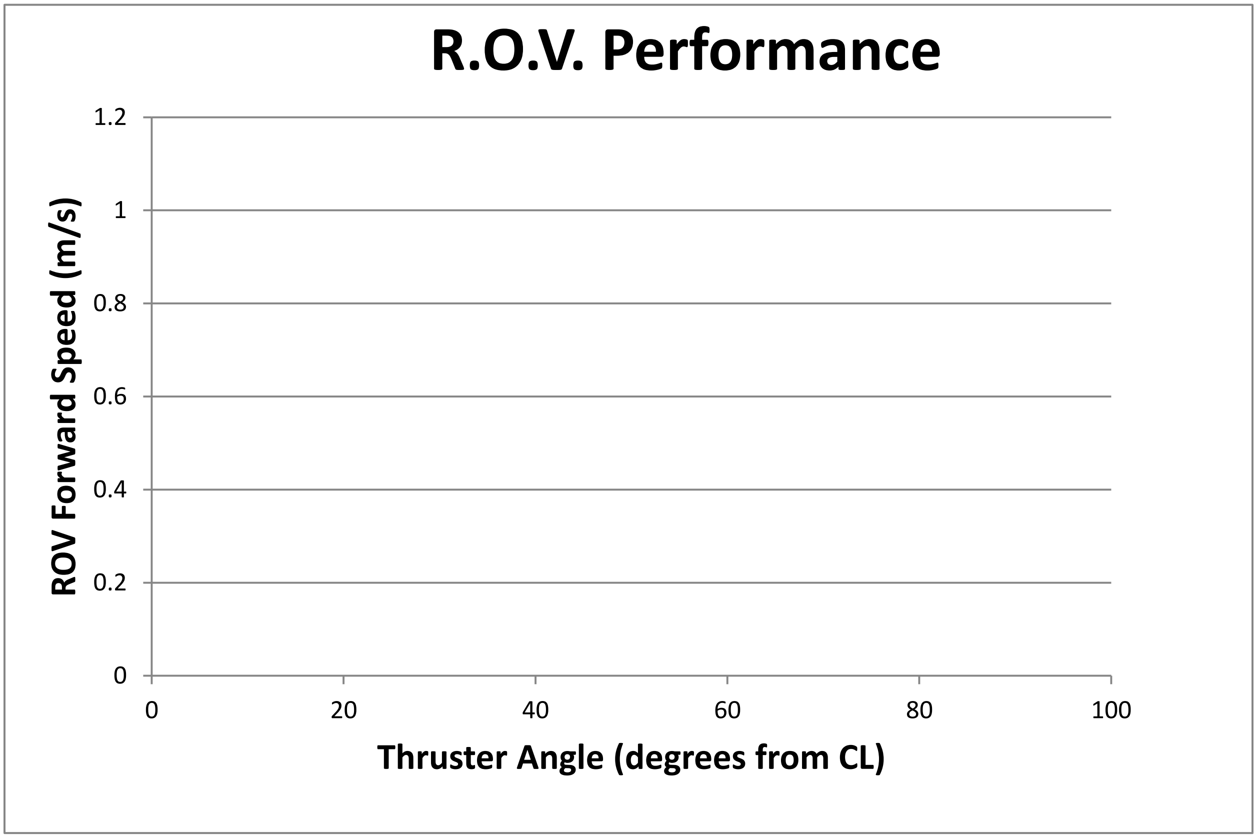
Here is a sample from Aurora's report. This data sheet shows an experiment designed to test how thruster angle affected forward speed. The experiment measured how long it took the ROV to travel a specific distance (4 meters), while changing the angle of the thrusters 10 degrees with each trial.

ROV Data Log

Name	Aurora	Water Conditions	78 deg F, calm
Date	12-Nov-09	Size/Number of Thursters	3 12VDC, Radio Part
Time	12:00pm	ROV Weight	4.4 pounds

Trial #	**Thruster Angle**	**Time to Travel 4m**	**ROV Speed**
	(degrees from CL)	(seconds)	(meters/second)
1	0	6.2	0.65
2	10	6.8	0.59
3	20	7.5	0.53
4	30	7.9	0.51
5	40	8.1	0.49
6	50	8.9	0.45
7	60	9.2	0.43
8	70	10.9	0.37
9	80	12.9	0.31
10	90	Did not move	0.00

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).



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 not supported by the data, and not in the way I expected. **The ROV actually had an ideal maneuverability range when the thruster motors were oriented from 20-30 degrees.** (It actually performed about the same for two 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 (as the wind picked up near the end of the trial, making small waves on the surface of the water). And I didn't have an easy way to tell when the vehicle turned the full 90^o. Next time, I'd recommend testing a U-turn maneuver instead, as it takes longer and is easier to gauge by eye.

For further study, I recommend running an experiment to test the various sizes of ROV frames, 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 change 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:

- ROV: Determining the Ideal Thruster Angle for Maximum Manueverability
- Underwater Speed: Studying the Effect of Thruster Angle to Vehicle Speed
- Underwater Robots: Just How Big of a Motor Do You Really Need?
- How to Turn your Plumbing Pipes into Scientific Instruments: Investigating the Effects of Frame Size on ROVs

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 ROV 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 a smaller version of your model vehicle at the top of your board as an attention-getter. Have the ROV jacked up (so the props don’t hit) and connected to a 9V battery (instead of a car battery) so people can see your experiment in action (without losing a finger). Let people play with the control box and make the thrusters turn on and off.

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 ROV 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 maneuverable can hobby motors really make an underwater vehicle? After researching underwater submersibles, diving vessels, chassis designs, and wiring up circuits, I realized I had all the basics for making a Remotely Operated Vehicle (ROV). But how maneuverable could the hobby motors really make a small underwater vehicle?

Question/Hypothesis Card: I hypothesized that the thruster motors maximum maneuverability happens when the motors are tilted 45^{o} from the centerline of the vehicle.

Procedure/Experiment Card: Using plumbing parts from the hardware store and electrical motors from Radio Shack, I created an underwater vehicle that could swim freely in all six directions (up, down, left right, forward, and back). I ran ten trials varying the angle the thrusters made with the vehicle centerline (increasing in increments of 10 degrees with each trial) and measured the time the ROV took to perform a series of maneuvers, using a stopwatch and a measuring tape.

Results/Conclusion Card: I found that my initial hypothesis was not supported by the data, and not in the way I expected. **The ROV actually had an ideal maneuverability range when the thruster motors were oriented from 20-30 degrees.**

Recommendations Card: For further study, I recommend running an experiment to test the various power input to the thruster motors, 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 wearing goggles and diving in after the ROV when it needed help, and for dad for his help shopping for longer wires and bigger motors.

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!