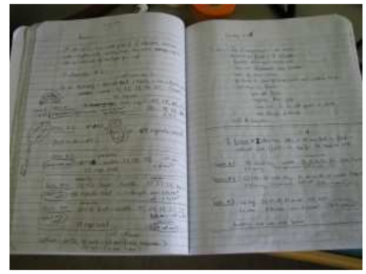
Seven Essential Steps to a Rock-Solid Science Journal



By Aurora Lipper, Supercharged Science

I'm going to share with you how we teach engineering students to keep their lab books at the University. This is the same techniques used by astronomers, automotive designers, nuclear engineers, and NASA scientists.

When you use this approach when working through the activities, projects, and experiments in the eScience program, you will have a rock-solid documentation that will pass any curriculum adviser, college-entrance examiner, or state required documentation. And it will be organized, easy to use, and rewarding to flip through years later.

Once your notebook is completed, you can easily match it with your state's requirements for science (see *Bonus Ideas* below), provide it as a writing sample with your college application (especially if it contains photos of you taking data, but you might want to send a copy and not the original), and show it (as you work through it) it to your homeschool organization curriculum adviser.

By documenting your work in this way, you are setting one of the corner foundations of being a real scientist. Your experiments aren't going to be useful if you can't tell other people about it. There's a standard format that most scientists follow, and that's what we're going to cover here. When you practice these seven essential steps, your child will be light-years ahead of the game when they hit college. Your kids will not just know the steps on an intellectual level, but it will become built into their system and be a guide as they work through their experiments for years to come.

Here's what you need to know:

Step 1: Title

The first thing you need is a title. Something that says what you did in ten words or less and describes the main idea. If you ever wanted to transform your experiment into a lab report, your title would have an entire page to itself.

In this case, your title area needs to have the title of the experiment, your name (and the names of any helpers that assisted you during your experiment), and the date you performed the experiment (or date range, if your experiment happened over more than a day).

For example:

Effects of Antenna Wire Length on Crystal Radio Reception
Aurora Lipper
November 23, 2010

Step 2: Introduction (Purpose)

In your science journal, save a half-page to write this later. You won't be able to write it beforehand, as it includes your hypothesis, background information, and summary of how the experiment went. Just leave a spot so you can jot it in later. Keep it simple, straightforward, and only one paragraph. The best thing to include in this section is why you did the experiment.

For example:

Which antenna length gives the best radio signal? After researching the electromagnetic spectrum, frequency, wavelength, quartz crystals, and radios, I realized I had all the basics for picking up AM radio stations using simple equipment from Radio Shack. But which antenna length would produce the clearest, strongest radio signal in my crystal radio? This radio detects in the AM band that have been traveling from stations (transmitters) thousands of miles away. One of the biggest challenges with detecting low-power radio waves is that there is no amplifier on the radio to boost the signal strength. When designing the experiment, I had to take into account the finer details, such as the width of the wire, whether to use magnet or plastic-insulated wire, the type of diode, and the tube diameter. In addition, I also needed to find an adequate grounding source (I used a metal water pipe) and have enough space to spread out my antenna, which ranged from 10’ to 100’.

Step 3: 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.)

For example:

- Toilet paper tube
- Magnet wire – Radio Shack part #278-1345
- Germanium diode (1N34A) – Radio Shack part #276-1123
- Telephone handset or get a crystal earphone from C. Crane at (800) 522-8863 (part #EKI)
- Alligator clip test leads – Radio Shack part #278-1157

- 100’ stranded insulated wire (for the antenna)
- 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

Step 4: Procedure

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.

For example:

First, I became familiar with the experiment and setup. After raiding Radio Shack for magnet wire, diodes and earphones, I created a simple crystal radio that could detect AM radio waves without the use of a battery. I ran ten trials varying the length of the antenna and estimated the signal strength using the following scale:

- 1 – No Signal: you can’t hear any signal at all
- 2 –Inaudible Sound: you can barely hear a signal, but can’t make out any words
- 3 – Weak Signal: you can hear a few words here and there, but nothing that makes sense
- 4 – Medium Signal: you can hear most words, but it still sounds scratchy
- 5 – Strong Signal: you can clearly hear words or songs

I made myself a data logger in my science journal. I placed the crystal radio in a spot clear from noise, obstructions, and interference from nearby transmitters and connected the ground wire to the metal pipe and strung the antenna along the ground. I then listened to on the earphone and connected up different antenna lengths to get a better feel for judging the scale for signal strength from 1 to 5. Once I finished the pre-tests, I ran ten trials, varying the antenna length in increments of 10’, recording the signal strength with each trial run.

Step 5: Results

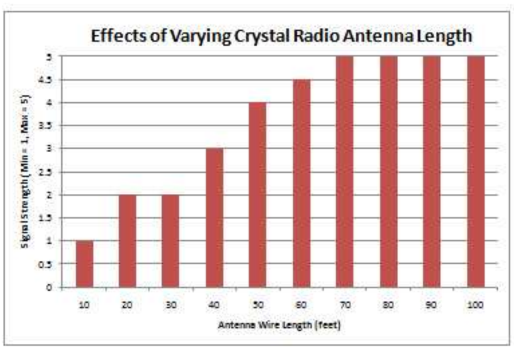
This is the data you logged during your experiment. You can leave a page or two to include a chart or graph – whichever suits your data the best, or both if that works for you. Use a scatter or bar graph, label the axes with units, and title the graph with something more descriptive than “Y vs. X or 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).

Crystal Radio Data Sheet

Name	*Aurora Lipper*	Antenna wire gauge	*24g*
Date	*Nov. 28, 2009*	Tube wire gauge	*28g magnet*
Time	*12:45pm*	Diode type	*germanium*

Trial #	**Antenna Length** (feet)	**Signal Strength** (Min = 1, Max =5)
1	10	1
2	20	2
3	30	2
4	40	3
5	50	4
6	60	4.5
7	70	5
8	80	5
9	90	5
10	100	5

NOTE: The numbers above are NOT real!



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- 5 – Strong Signal: you can clearly hear words or songs

Step 6: 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!

For example:

I found that my initial hypothesis (the longer the antenna, the stronger the signal in the crystal radio) was supported by the data, but not in the way I had expected. My best guess was that an antenna of 100' would produce a clear enough signal to hear distinct words and songs. I found that **an antenna length of 60' and above all gave clear, strong signal results.**

For further study, I recommend running an experiment to test the various gauges of wire, tube diameter, and types of grounding sources. This experiment was a lot of fun!

Step 7: References

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.

For example: *(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.

Whew! So to recap...

Step 1: Title: *Effects of Antenna Wire Length on Crystal Radio Reception*, by Aurora Lipper, November 23, 2010. This goes at the top of the page.

Step 2: Introduction (Question/Hypothesis/Intro): *What effect does antenna length have on an AM band crystal radio?* After researching the electromagnetic spectrum, frequency, quartz crystals, wavelength, radio circuitry, sonic vibrations, and how the human ear detects sound, I realized I had all the basics for building a small radio. But which antenna length would produce the best signal? I hypothesized that the longest antenna would give strongest and clearest radio signals. This takes a half page (one paragraph maximum), and is written last.

Step 3: Materials: List everything you used in your experiment here. Leave a page for this in case you have to add to it later.

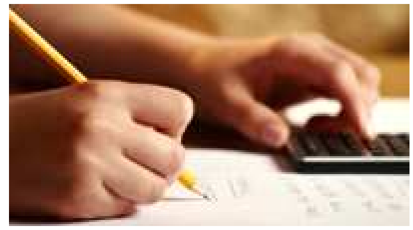
Step 4: Procedure/Experiment: After a quick trip to Radio Shack, I built a crystal radio to test. I ran ten trials varying the type of radio and estimated the signal strength using a sound scale from 1 to 5. Leave two pages for this, one for drawing your experiment out (or snap a photo and insert it here), and the second for writing out what you did and how you set it up.

Step 5: Results: Record your data and analyze any numbers. You can add a discussion about what went on during your experiment. Leave a page or two (depending on how many trials you're running) in table form. Test only one thing at a time (the antenna length, in our example), and record what you found.

Step 6: Conclusion/Recommendations: I found that my initial hypothesis (the longer the antenna, the stronger the signal in the crystal radio) was supported by the data, but not in the way I had expected. *I found that an antenna length of 60' and above all gave clear, strong signal results.* For further study, I recommend running an experiment to test the various gauges of wire, tube diameter, different types of grounding sources, and types of diodes (such as germanium, zener, and silicon) as each diode cuts the signal strength by a different amount. Leave a page for this section, as you might have to rewrite your conclusion a few times before you get it the way you want it.

Step 7: References: Leave a page for this section, and fill it in as you do your research in the beginning.

Bonus Ideas!



There are a lot of steps to keeping a rock-solid science journal, but once you get into the rhythm, it'll come naturally and you'll actually start to think ahead as you work through your experiment, because you know what you'll need to record to make it worthwhile. One of the things I do is write the seven steps on the inside cover of my journal as a quick reference sheet, so I know how many pages to mark off ahead of time as I write up a new experiment.

If I'm starting a fresh notebook, then I'll usually skip the first 5-10 pages before starting to write, and stop writing 5-10 pages before the end. Then I'll go back and add a table of contents in those first skipped pages and an index and/or glossary in the last skipped pages for a more complete book. I'll also number the pages as I go along so this part is a lot easier!

Often, I don't take data right in my book, because I make a lot of mistakes and have to rerun the experiment or redo the way I set it up. I'll usually take data on a clean sheet of paper that's got a table marked off, and when I finally get a good run I want to use, I'll tape it into the results page of my notebook.

When I first do a new experiment, I don't record anything at all. In fact, I'll just play with the experiment to get really familiar with how it works, why it works, and what I have to tweak to get it to work just right. The recording process comes *after* I've rolled around and played with the main ideas. With this approach, I'm able to formulate a better question because now I have experience with the experiment and I find that I am not as worried about making mistakes as I was in the beginning.

Often with an entirely new subject area, I'll have two journals - one is much more informal, and usually titled *"My Great Ideas"*, and the other follows the steps above and is titled *"My Science Journal"*. The *"My Great Ideas"* is a place for me to write down all the crazy ideas I have before I am ready to record anything, along with any books or media I found that might be useful in doing the experiment, and *Ah-HA!* moments and all questions that pop up. That way, I've got a spot to brainstorm and come up with experiment ideas before committing it to my more formal write-up book. The great ideas book is usually just for my eyes only, so I don't worry about spelling, neatness, or anything that slows down my creativity.