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Advice to students for science fair projects

Ask a question and think about what you think the answer might be.

Don't ask a question that can be answered by **yes or no**. You won't learn much. Ask a question that makes you test ideas and **make measurements** of results.

Keep the experiment simple. Have a "control" in the experiment--that is, run the experiment without changing anything to get a **"normal" result**. Then you can compare changes against the normal.

You might want to change several things in your experiment and measure what happens. But you can **only change one thing** each time. Then you measure that result. The more things you want to change, the more trials you will have to do. This may mean a lot of trials, but they will help you to understand what is actually causing changes in the outcomes.

Write down all your measurements. If they don't look like what you expected, test again. If they still don't look like what you expected, try to figure out why that happened. You may learn something interesting and important by doing that.

Judges like to see your data. If you have a "notebook" where you kept track of measurements during the experiment, bring it along to the fair. Make tables where you present your measurements, or charts, or graphs that summarize the trials and results. If you have made multiple trials of the same variation (and you should), try to also show the **average results**. The average is likely to be a more representative result than any individual one.

Put **labels** on your charts and graphs so we can see what is being measured.

The judge will want to have a short **conversation** with you. You don't have to make a report. Be prepared to explain your project, to explain how you got the idea, and to show what your results are. Try to do some reading about the subject so you know more than just what the experiment shows.

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Science Project Tips for Parents

Why are Science Fair Projects Important?

1. Science Fair Projects provide opportunities for students to develop skills necessary to function productively as problem-solvers in a scientific and technological world.
2. The best way to learn about science is by "doing" science. "Doing" science and writing about what you observed and experienced enables students to construct their own understanding of the world around them.
3. It's FUN!

How Can Parents Best Help Their Children with Their Project?

1. Help them ask questions.
2. Provide them with hints.
3. Provide them with the materials necessary.
4. Encourage thinking through questions, alternatives, answers and data, **without giving them the answers**.
5. Help them to follow the teacher's guidelines or instructions.
6. Help them **gather background information**, through reading, to encourage good questions, appropriate conclusions and the ability to speak knowledgably about their project.
7. **Help select a project, based on your child's skills, age, knowledge and interests.**
8. Get started right away, so it doesn't become overwhelming.
9. Don't copy a project from a website. But you may use a website to give some ideas about a possible project. Some websites that can give interesting ideas are:
   www.sciencebuddies.org
   www.sciencemadesimple.com
   www.education.com/science-fair/middle-school/
   www.hometrainingtools.com/a/high-school-science-projects/
   www.cool-science-projects.com/Middle-School-Science-Projects.html
   www.navigatingbyjoy.com/science/
10. Remember that it is ok if their hypothesis, or prediction of what will happen, is not correct. The important thing is that they measure their results, and do <u>**multiple**</u> **trials**. Science experiments do not always turn out the way you think they will. Do not change your hypothesis.
11. Have **FUN** working with your child!

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Example Science Fair Projects

Science projects are an excellent way for students to learn about the scientific method and try something new, while having fun at the same time. Many students have trouble coming up with ideas, and the below tables present examples of past science projects to help students find their own creative topic. Two tables are presented - one labeled "Elementary and Middle School Projects" and the other "High School Projects". Students do not have to limit themselves to their own school grade, as the judges have seen many good "High School" projects prepared by middle schoolers and vice versa. Don't forget - these are just examples. We hope these examples will give students ideas for their own projects. A list of websites that provides many science projects and the instructions for carrying them out is shown on the last page.

Elementary and Middle School Projects

Descriptive Title	Summary of Procedure[1]
Measuring plant growth in different soil types	The student collected equal amounts of 3 kinds of soil (potting, garden dirt, and sand) and placed the soils in equal size pots. Then the student planted 5 bean seeds in each pot and gave each pot equal amounts of water every other day for 3 weeks. At the end of 3 weeks the student measured the height of each plant and graphed the averages. NOTE: this project could also be done by varying the amounts of fertilizer given to each group of plants.
Measuring cat behavior with different cat toys	The student made 4 different cat toys: shoe lace on a dowel; small sock filled with catnip dangling from a dowel; cat treat tied to shoe lace on a dowel; and catnip-filled sock with a bell pinned to it dangling from a dowel. The student tested each toy for 5 minutes for 3 days and recorded the cat's behavior. The student recorded how many times the cat exhibited each of 7 behaviors: watching, following, pouncing, kicking, batting, biting, and rolling/tumbling. The student then summarized the results.
Measuring the bounce of a basketball with different air pressures	A regulation basketball has 8 pounds per square inch of air pressure, and the students wanted to see the effect of different air pressures on the bounce of a basketball. They inflated a regulation basketball to 6 PSI of pressure and dropped it from a height of 10 feet. They measured the bounce height and repeated this 10 times at the 6 PSI pressure, recording the results. Then they repeated the experiment at 7, 8, 9, and 10 PSI and graphed the results.
How the angle of the sun affects a solar oven	The student built a solar oven using a tinfoil-lined cardboard box. He placed a thermometer in the middle of the box and recorded the temperature each hour on 4 sunny days. He averaged the hourly temps and graphed the averages by hour showing how the sun's position affected the solar oven temperature.

[1] This is just a summary of the science project. Important elements, like variables, controls, equipment used, complete procedure, and results are not shown.

Elementary and Middle School Projects

Descriptive Title	Summary of Procedure[1]
Do sports drinks provide more electrolytes than orange juice?	The student made a conductance sensor out of a drinking straw and some copper wire following the instructions on sciencebuddies.com. Then she connected one end of the sensor to a 9 volt battery and the other end to a multimeter. Then she connected the other end of the battery to the multimeter. She placed the conductance sensor in a container filled one-by-one with the same quantity of different liquids: water, Gatorade, Powerade, orange juice, and milk. For each liquid, she recorded the multimeter reading of the electrolyte conductance and graphed the results.
How heat affects light-emitting diodes	Using a digital light meter ($12.00 and up on Amazon), an LED flashlight, and a cardboard box the student measured the light intensity of the LED bulbs as they heated up over time and graphed the results. NOTE: students should be sure they understand what an LED bulb is and how it works.
How to make a homemade barometer	Following the instructions found on www.stormthecastle.com, the student used a glass jar, balloon, rubber band, and drinking straw to make a homemade barometer. He taped a piece of graph paper to the wall next to the barometer and calibrated his homemade device with what he found on www.weather.com. The student then measured the reading from his barometer with the weather site and recorded and graphed the 2 air pressures for 2 weeks. NOTE TO STUDENTS: Be sure you are able to state what the barometer measures and why the barometric reading is important to weather forecasting.
Making potato batteries	Using some potatoes, galvanized nails, copper wire, alligator clips, and a multimeter, the student built 5 potato batteries (using potatoes of different size) and measured the voltage output of each with a multimeter. Then the student graphed the voltage output against the weight of the potatoes to understand how potato size affects electrical output. NOTE TO STUDENTS: Be sure to be able to explain why the potato can create electricity.
Separating water into its basic components	Following the instructions on www.navigatingbyjoy.com (also found on other websites), the student built an electrolysis apparatus to separate water into its oxygen and hydrogen molecules. Then the student tested the hydrogen tube by igniting the hydrogen, and observing the (very small) explosion, and tested the oxygen by flaming a hot wooden match ember. NOTE: This experiment should be made with adult supervision.
Does adding salt to water make it boil faster or slower, and why?	The student recorded the length of time it took to boil 2 cups of distilled water in a pan on the stove. Then the student discarded that hot water, cooled the pan, and poured in another 2 cups of distilled water, but this time added 1 tablespoon of salt, and recorded the time to boil. The student repeated this with 3 and with 4 tablespoons of salt, and then prepared a graph showing the time to boil for each amount of salt. NOTE TO STUDENT: Be sure to be able to explain why you might have observed a difference in time.

Elementary and Middle School Projects	
Descriptive Title	**Summary of Procedure[1]**
How does temperature affect yeast's ability to produce carbon dioxide?	The student heated a water bottle filled with 1 cup of water in a large pot of water on the stove. Using a candy thermometer, the student waited until the water in the bottle was 80˚F, and then added 2 Tbsp of sugar and 1 packet of yeast and quickly attached a balloon to the top of the water bottle. The student measured and recorded the circumference of the balloon every 30 minutes for 2 hours. The student repeated this at 90˚F, 100˚F, 110˚, 120˚F, and again at room temperature (70˚F), i.e., without putting the water bottle in the hot water pan. The student then graphed the results.

High School Projects

Descriptive Title	Summary of Procedure[2]
Can emotional intimacy be accelerated between strangers?	Students hypothesized that by providing complimentary information to two strangers about the other that the two would become more intimate (or at least friendly) upon meeting each other. The students pick 12 pairs of strangers and in 6 of the pairs provided complimentary information to the pairs. After each pair met for 30 minutes, they were asked to complete a standardized form that assessed their impression of their partner. The results showed whether giving information about a stranger before a meeting would lead to a more successful meeting.
The effect of light pollution on stargazing	Three students counted stars at three different locations on the same night looking at the same place in the sky. The locations were: downtown Plaza, the Santa Fe Municipal Recreation Sports Complex on Caja del Rio Road (outside of city lights, but at city elevation), and at the Ski Santa Fe parking lot (10,350 ft. elevation). They each used a toilet paper tube, placed the North Star in the upper left portion of their view (to assure they were all looking at the same area), and counted the stars inside the TP ring (they counted twice). Then they each put the constellation Gemini in the upper left corner of their TP ring and again counted stars. Their results showed how light pollution from Santa Fe city lights affected their ability to see stars.
Which bridge construction design is strongest	The student used popsicle sticks to build 4 bridges of the same length, each using a different design: suspension, arch, truss, and beam. One by one he then placed increasingly heavier weights in the middle of each bridge and recorded when the bridge broke.
Measuring the speed of light using a microwave, egg white, and a ruler.	The student measured the speed of electromagnetic waves in the microwave portion of the spectrum by measuring the spacing between hot spots in a microwave oven. First the student poured several egg whites onto a microwave-safe plate. After cooking the egg whites for 30 seconds, the student measures the distance between "hot spots". This distance is one-half of the microwave's wavelength. Now the student calculated the speed of the microwaves by using the wave length and the unit's frequency (taken from the oven's label).
A robotic car that can traverse a windy road and obey traffic signals	With a purchased kit, students built a robotic car, which with its camera, could recognize and traverse a winding road, could recognize the color of a stop light and proceed through a green light, but stop at a red light.

[2] This is just a summary of the student's project. Important elements, like variables, controls, equipment used, complete procedure, and results are not shown.

High School Projects	
Descriptive Title	**Summary of Procedure[2]**
Using a laser to measure the speed of light in gelatin	Following the instructions on www.sciencebuddies.org, the student used an inexpensive laser pointer to measure the speed of light by applying Snell's Law of Refraction and a little high school math. Then the student varied the amount of sugar in the gelatin to see if the index of refraction (and therefore the speed of light) changed. NOTE: Lasers should never be pointed at a person's (or animal's) eyes.
Does singing along with music affect reaction time?	The student acquired 12 subjects and explained that their reaction time was going to be measured by dropping a ruler between their thumb and forefinger and recording the centimeter number on the ruler, which corresponds to the length of their reaction time. The subjects were broken into 4 groups of 3 and each subject practiced performing in each of the 3 roles of dropper, grabber, and recorder. After practicing for 15 minutes, each subject took turns grabbing the ruler ten times as it was dropped, and their results were recorded. Then the experiment was repeated, but droppers had to listen to and sing along with (out loud) their favorite music played at a rather loud, but not excessively loud, level. The volume level was consistent for each dropper. Their results were again recorded, averaged, and compared to their results without music.
How will changing my style of clothes and appearance affect the way people react to me when asked a question?	This student dressed in a "fancy/good" outfit, then went downtown to the Santa Fe Plaza and asked 10 people at random for the time. She recorded their responses on a scale of 1 to 5 (where 1 was they ignored her and 5 was they politely told her the time). Then she changed into a "dirty/bad" outfit and again asked 10 people at random for the time and recorded the results. Her results showed a highly significant difference in people's response strictly based on her appearance.

Good websites to search for ideas:

- www.sciencebuddies.org
- www.sciencemadesimple.com
- www.education.com/science-fair/middle-school/
- www.hometrainingtools.com/a/high-school-science-projects/
- www.cool-science-projects.com/Middle-School-Science-Projects.html
- www.navigatingbyjoy.com/science/

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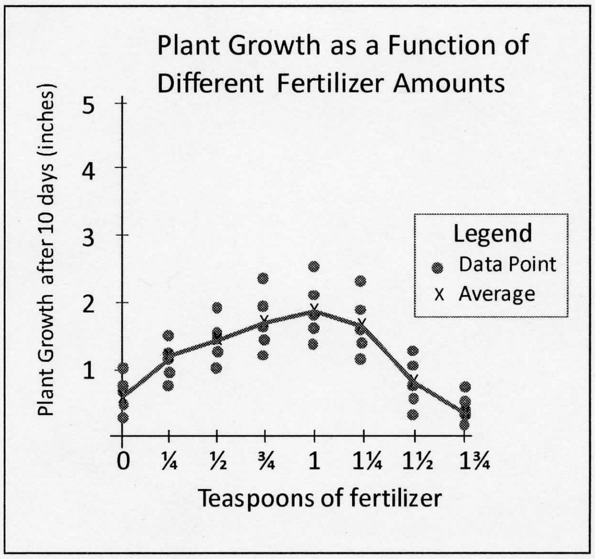
Characteristics of a Good Science Project

- Choose a project that you are interested in and that you are curious about.
- Good sources of inspiration are:
  http://hubpages.com/education/k12interactivescienceprojects
  http://www.sciencebuddies.org
  http://www.cool-science-projects.com
  http://www.stevespanglerscience.com/lab/experiments/
  http://reekoscience.com/category/science-experiments
  http://ag.ncat.edu/extension/programs/dte/science.pdf
  http://www.ipl.org/div/projectguide/
- Be able to state where the science is in the project (important!)
- Be able to define your variables. The independent variable is the input variable you change during your experiment to observe its effects on the dependent variable (output variable). A control variable (sometimes called 'controls') is a variable that you hold constant throughout the experiment. For example, let's say you wanted to measure plant growth using different amounts of plant fertilizer. In the example shown on the right, the independent variable is the amount of fertilizer (that's what you're changing); the dependent variable is plant growth (height) that you measure; and controls are the seeds (from the same packet), the soil (from the same bag), water (same amount given to each plant), and sun (same amount of sunlight).



- Projects should have a presentation board with at least the following sections: Title, Question, Research, Hypothesis, Independent & Dependent variables, Procedure, Data results, Graphical results, and Conclusion.
- A project should have the following characteristics:
  1. An experiment should have only one independent variable and it should be clearly identified.
  2. Dependent and control variables should be clearly identified.
  3. Trials should be repeated multiple times and data collected for each trial.
  4. Results should be able to be measured by counting or by using a measurement tool (scale, watch, ruler, voltmeter, tape measure, thermometer, etc.). Results that are merely observed (for example, "It looks like there is more mold on the apple than on the pear.") are not truly measured.
  5. Results from each trial should be recorded and provided on the board.
  6. Data should be summarized by totaling or averaging the results.
  7. Either detail or summary results should be graphed.
  8. Students should relate the conclusion back to the hypothesis ("My hypothesis was proved to be correct, because . . ."), and be able to state the role "science" plays in the conclusion.

WWW.SFAFS.ORG

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Questions judges may ask at a science fair

Where did you get the idea for your project?

What did you read about the topic of your project?

What were you trying to find out by doing your project?

What help did you get in doing the project?

Can you show me your project notebook?

What things went "wrong" or frustrated you? What did you learn from that experience?

How could you have improved your project, or how could it be a better project if you did it again next year?

What did you learn about science from this project?

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Measuring tools to use in your science fair project

Good experiments require measurements. Descriptions with words--like hot or cold, short or long, heavy or light, fast or slow--are not very useful. Descriptions with numbers are much better.

You have many simple things in your home that can be used to make measurements. Here's a list of some of them:

- Measuring cup
- Clock
- Room thermometer
- Ruler or measuring tape
- Scale

And don't forget one of the simplest and best of all ways to measure: Counting!

Many people have or can use a smartphone. You can use one as a stopwatch, to photograph your experiment, to take videos (even speeded up or slowed down motion), and to measure many other things. Free "apps" can be downloaded from the "store" on the phone.

But what if your experiment asks people to describe something without numbers, like:

- How they feel after some event
- How much energy they have after doing something or hearing something or seeing something
- How well they can concentrate in different parts of the experiment

These are more difficult experiments, and your results will not be as easy to demonstrate (and you will need large numbers of trials). You may have better results if you ask people to "rate" their answers on a scale of one to ten, and give them examples of what a score of one or a score of ten could be described as. These results will still not be as good as those that can be measured directly, but they may make it easier for you to compare and present results in your display.

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How many measurements do you have to make?

When planning a science project, one of the most important decisions to make is how many measurements or trials you're going to make (sample size). In general, the answer is **always more than one**. In fact, **the more measurements you make the better the project will be**. Below are several typical examples for you to use as guidance when deciding the proper sample size for your type of project:

Distance: If you're measuring the "bounce" of the same ball at different pressures, ten or more measurements for each pressure tested would seem reasonable.

Time: If you're measuring the time it takes for different balls to travel down a ramp, you should make ten or more measurements for each ball.

Effect of music on arithmetic ability: Experiments with people need even more measurements. Use at least twenty subjects having similar characteristics such as age or grade level. If you choose to measure the differences caused by age, gender, etc., be sure to have a similar (and large) number representing each subset of participants.

Temperature: If you're trying to find out the effect of salt on the boiling point of water, use at least five separate measurements for each salt concentration.

Plant growth: While measuring the effect of fertilizer on plant growth, set up at least two containers for each concentration of fertilizer. Each of the containers should be planted with five to ten seeds, and as time passes, every plant in every container should be measured. Don't fall into the trap of just measuring the tallest (or shortest) plant in each container.

Many more examples could be given, but you get the idea. **The more the better**. Don't throw away data. For the most part it is best to use all the data you collect. Manipulation of data by the use of average values is covered in another section.

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What is an engineering project?

Some students like to build things for their science fair projects. But just building something is not enough. An engineering project tries to build something to solve a problem. It could be how to get across a river, or how to purify water, or how to use solar energy to move a car.

But engineering is not just finding "how" to get something done. Engineering can also be about finding better ways to get something done. So an engineer may try to get a result using the smallest number of parts, or using the least amount of energy, or costing the least, or lasting the longest. Remember, building things to solve real problems costs money, and an engineer will want to solve the problem in an affordable way.

In an engineering project for a science fair, you will probably try different designs, or models, and test them. The judges will want to know about all the things you tried and how you decided to try something different--even when designs didn't work well.

A good engineering project can also have something to measure. You can show how well different engineering models perform, or for different conditions that you tested. There are many ways to solve engineering problems. You want to find the best one you can.

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How to graph your results

You will have collected data during your project, things you measured. Judges like to see your collection of data in your lab book or notes, but on your display board you have to summarize the data so it can be understood clearly. You do with charts and graphs.

It is very important that charts and graphs have good labels on them. You may know what the lines or bars mean, but unless they are labeled, someone else, like a judge, will not know. Your project will receive a lower score if the charts and graphs are not easy to understand, no matter how much work you did to produce them.

For line and bar graphs, you will have a vertical (up and down) direction (called an axis) and a horizontal (left and right) direction. Each should be labeled.

If you have more than one line on a graph, each should be labeled in some way (you can use different colors or word labels). If you have many bars on a graph, each should be labeled in some way.

You can't show all your data, and you don't have to. Learn what an "average" is. You should have run several trials during your experiment, because you don't want to rely on only one measurement. If you have three or five or ten measurements of the same experiment, find the average result. Do that for each set of trials (different sets of trials mean you changed one thing and ran the experiment again), then make a number chart or a graph of the average results.

If you can't show all your data on your display board, you should bring your lab book or notes to the science fair. Many judges will be interested in seeing the "raw" data.

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Getting averages from your results

You should do your experiments more than one time. When you do that, even though you think nothing has changed, you may still find that your measurements are not identical. This is for two reasons:

1. It's hard to measure something precisely with your measuring tools. Results may fall between marks on a ruler or measuring cup. If you're using a timer, you may click it slightly differently each time. Things like that are expected, and they won't hurt the experiment. Just try your best to make measurements the same way each time.
2. There will also be slight variations in how the experiment is run, things you may not even be aware of. You might give something a little push when you're releasing it. There might be some little wind in the room when you're "sailing" an airplane. Rolling objects encounter friction that may slow them down; an uneven surface may produce more friction for some trials than for others. Things like that.

Even if you have controlled the conditions as much as you can, your results will be close to each other, but different enough to make it hard to know which is the "best" measurement. That's why we have averages.

Averages are easy to calculate.

1. Add up all the results to get a single number.
2. Count how many numbers you added up (that's the number of trials you ran)
3. Divide the total results by the number of trials.
4. The result is the average value, the result that falls closest to the middle of all the trials. That will be the best number to represent that set of trials.

When you compare results of different sets of trials, compare the averages. That will be the best way to interpret your results.

Example of an average:
Distance a ball rolls from the top of a ramp.

Trial 1:	5.8 meters (or feet or inches)
Trial 2:	6.1 meters(or feet or inches)
Trial 3:	6.0 meters(or feet or inches)
Trial 4:	6.3 meters(or feet or inches)
Trial 5:	5.9 meters(or feet or inches)

Add up the results:	30.1 meters(or feet or inches)
Divide by the number of trials:	5
Average time:	6.02 meters(or feet or inches)

The average may be slightly different from any of the actual measurements, but it is going to be the result that means the most.

See, easy!

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Growing plants for your science fair project

If you grow plants from seeds:

1. Know what the seed is! Is it a bean, a flower, a grass? Don't just tell the judge that "my teacher gave the seeds to me." Try to learn a little about that plant, things like how long it should take the seed to sprout, how fast it grows, what kinds of soil and water and light it needs to grow.
2. Not all seeds will sprout, so you should put more than one seed in each pot. Let them all grow and measure them all. It's necessary to have measurements from two pots and seeds for each condition you are testing. With seed-growing experiments, you really need at least two and hopefully more of each thing you're trying, because some will not produce any results.
3. What are you going to measure?

   How long until it sprouts?
   How tall it will grow in a certain number of days?
   How many leaves it produces?
   How large the leaves are?

   All of those are useful measurements of plant growth. You have to choose which you will use and then find a way to measure the plant growth.

For all plant experiments, once you decide what single thing you are comparing (such as growing in light or dark, with or without more water, different kinds of soil, with or without added plant food, in a quiet or noisy place, in heat or cold), then you have to make certain everything except the one thing you're comparing is exactly the same. That way you can be sure that the changes you measure were caused by that single difference.

Make sure you let the experiment run long enough to get results. You can't do a plant experiment at the last minute. It may take weeks for the seeds to sprout and grow. If you are doing an experiment where you are trying to do things to improve plants' growth, remember that seeds contain enough plant "food" for the seedling to grow for a while with no outside food needed. So give them enough time to use up that "seed food" and start to use food from the soil or any liquid they may be growing in (if you are trying an experiment using aquaculture--growing in water with no soil).

Avoid plant experiments with obvious or uninteresting results. Watering plants with harsh chemicals, like motor oil, gasoline, or bleach) will only result in a bunch of dead plants. Instead, think about ways to compare how different things help plants grow.

STEM Project Scoring Guidelines

Project Title:____

____

Student(s):____

____

Teacher:______________________ **Judge:**______________________

Grade Level:_______ **Category:** ______________________ **School:**__________________

Judging Criteria for Scientific Investigations	Judging Criteria for Engineering Design Projects	Score
1. Asking Questions • Clear, concise, measureable/testable question • Researched subject	**1. Defining Problems** • Clear description of a need/problem to be solved • Researched subject • Criteria and constraints (limitations) explained	/5
2. Developing & Using Models to Plan and Carry Out Investigations • Procedure designed to measure change in one variable • **Multiple** trials conducted to collect data in measurable units • Clearly defined variables	**2.Developing & Using Models to Plan and Carry Out Design Solutions** • Ideas for best possible solution written and illustrated • Steps in the design of best possible solution explained • Multiple trials to test model conducted, data collected in measurable units • Model redesigned, repeating steps above, if needed	/5
3. Analyzing and Interpreting Data, Using Mathematics • Data collection organized in tables and graphs • Average or sum of data results • Data used to support conclusion	**3. Analyzing and Interpreting Data, Using Mathematics** • Data collection organized in tables and graphs • Average or sum of data results • Data used to support conclusion	/5
4. Using Evidence to Explain and Communicate Results • Clear explanation in conclusion, with supportive data	**4. Using Evidence to Explain and Communicate Solutions** * Clear explanation in conclusion, with supportive data	/5
5. Innovation • Original, creative approach to the question, design, method or modeling of the project		/5
6. Presentation – Display Board • Clear, descriptive project title (Does it tell what the project is investigating?) • Steps used in your scientific process (question, research, hypothesis, experiment, data collection/analysis, conclusion) <u>or</u> engineering design process (problem, research, criteria, constraints, test solution, redesign, test solution, explanation of results) displayed • Captions for photos (if used), clear and descriptive • Display of graphs and tables (title, measurement units, labeled axes/columns) organized		/5
7. Presentation – Interview • Clear and thoughtful response to questions • Basic science related to the project understood • Age-appropriate independence in conducting and explaining the project • Quality ideas/questions for further exploration stated **Note:** TEAM PROJECTS – contributions and understanding of project must be shown by ALL team members		/5 /35 **Total**

Notes on the Overall Project (extra space on back)

Strengths

Area for Improvement

STEM Project Scoring Guidelines

Project Title: Making electricity from lemons

Student(s): Dean Gerber

Teacher: Ms. Kauffman **Judge:** Bruce Abell

Grade Level: 5 **Category:** — **School:** El Dorado

Judging Criteria for Scientific Investigations	Judging Criteria for Engineering Design Projects	Score
1. Asking Questions • Clear, concise, measureable/testable question • Researched subject	1. Defining Problems • Clear description of a need/problem to be solved • Researched subject • Criteria and constraints (limitations) explained	3 /5
2. Developing & Using Models to Plan and Carry Out Investigations • Procedure designed to measure change in one variable • <u>Multiple</u> trials conducted to collect data in measurable units • Clearly defined variables	2.Developing & Using Models to Plan and Carry Out Design Solutions • Ideas for best possible solution written and illustrated • Steps in the design of best possible solution explained • Multiple trials to test model conducted, data collected in measurable units • Model redesigned, repeating steps above, if needed	3 /5
3. Analyzing and Interpreting Data, Using Mathematics • Data collection organized in tables and graphs • Average or sum of data results • Data used to support conclusion	3. Analyzing and Interpreting Data, Using Mathematics • Data collection organized in tables and graphs • Average or sum of data results • Data used to support conclusion	3 /5
4. Using Evidence to Explain and Communicate Results • Clear explanation in conclusion, with supportive data	4. Using Evidence to Explain and Communicate Solutions * Clear explanation in conclusion, with supportive data	3 /5
5. Innovation • Original, creative approach to the question, design, method or modeling of the project		4 /5
6. Presentation – Display Board • Clear, descriptive project title (Does it tell what the project is investigating?) • Steps used in your scientific process (question, research, hypothesis, experiment, data collection/analysis, conclusion) <u>or</u> engineering design process (problem, research, criteria, constraints, test solution, redesign, test solution, explanation of results) displayed • Captions for photos (if used), clear and descriptive • Display of graphs and tables (title, measurement units, labeled axes/columns) organized		5 /5
7. Presentation – Interview • Clear and thoughtful response to questions • Basic science related to the project understood • Age-appropriate independence in conducting and explaining the project • Quality ideas/questions for further exploration stated		5 /5
		26/35 Total

Note: TEAM PROJECTS – contributions and understanding of project must be shown by ALL team members

Notes on the Overall Project (extra space on back)

Strengths Good control of variables. Made measurement of voltage.
Did reading about electricity and batteries.
Graphed results.
Kept a notebook and wrote down procedure and results.

Area for Improvement Would be better with several trials and results averaged.
Graph was not well labelled.
Did not have ideas about how to improve
or expand the experimont.

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SCIENCE

Link to a short video about how to turn a so-so idea into a real project

We have prepared a short video that can help students see how science demonstration, which makes no measurements, can be modified to become an interesting science fair project.

It starts with an attempt to demonstrate that you might be able to light a bulb using a lemon as a battery. It then shows how such a demonstration can be improved to actually measure if and how well a lemon can produce electricity, to show how to vary the experiment by combining more than one lemon, and to think about why a lemon can become a "battery."

The video is about 12 minutes. It can be viewed at

https://www.sfafs.org/science-fairs.html

Comparing Strengths of Different Electromagnets

Reading

I read there are magnets that can be turned on and off. They are called electromagnets, and they can be little or big. Some can pick up thousands of pounds of metal. They are made by running electricity through wires, which creates a magnetic field around the wire. Putting metal next to the wire will make the metal into a magnet for as long as electricity is running.

There are many uses of electromagnets in everyday life, such as locks on car doors, electric motors, ear buds for listening to music, even high-speed trains that rise up off the tracks and travel on air. These magnets are everywhere.

Electromagnetism was discovered in the nineteenth century and studied by a scientist named Michael Faraday in England.

Research:
Electromagnetism article in Wikipedia.org
"Electric current and magnetic fields" Video by Derek Owens on YouTube

Variables

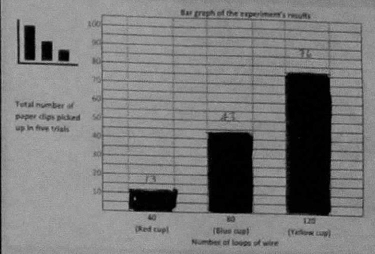
Independent Variable – The one thing I will change is the <u>number of layers</u> of wire loops. Each layer will have 40 loops.

Dependent Variable – I will <u>measure the number of paper clips</u> picked up by the magnet each time.

Things that don't change – (1) the power supply is constant; (2) the bolt lengths are identical; (3) wire loops are all made with the same kind of wire; (4) the paper clips are identical and in a large pile in a container; (5) the same person does all the trials.

Procedure

1. Have a bowl with many more paper clips than you expect to need.
2. Connect the power supply to the switch device. Have the knife switch straight up so the circuit is "open." Attach the 1-layer bolt to the switch device.
3. Arrange five numbered, colored cups in front of the switch device.
4. Pick up the wire-wrapped bolt with the flat head down. Close the switch to allow electricity to flow through the wires.
5. Touch the flat head of the bolt to the pile of paper clips. Pick up the bolt and attached clips and move it carefully to the first cup.
6. Open the switch. The clips will fall into the cup. Repeat the process four more times so that all five cups have clips in them from each of the five trials.
7. Repeat the process with the two-layer, then the three-layer magnets.
8. Count the number of clips in each cup and enter the number on the data sheet.
9. Do not leave a bolt connected to power for any longer than necessary; it will heat up and become dangerous.



Examples of electromagnets in use


Ear buds for music


Lifting tons of scrap metal


Old-fashioned alarm bell


Very fast high speed Maglev Train

Materials

1. Power supply
2. Three metal bolts wrapped with 40, 80, or 120 loops of wire in one, two, or three layers
3. A container of 200 paper clips
4. Apparatus with an on/off switch to provide electricity to the magnets
5. Cups to collect the paper clips before counting
6. Data sheet for recording my results

Performing the Experiment

Conclusion

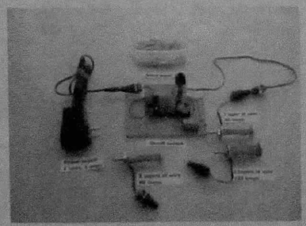
My hypothesis was correct. The bolts with more layers of looped wire picked up more paper clips, so the magnets were stronger. Results of individual trials were very consistent, so I think that the measurements were accurate.

Question and Hypothesis

<u>**Question**</u>: If you make electromagnets out of loops of wire wound around a steel bolt, how does the strength of the magnet depend on the number of loops of wire?

<u>**Hypothesis**</u>: I think the strength of the magnet will be greater if there are more loops of wire around the bolt.

The experimental set-up



Data Sheet for Magnetism Experiment

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	Trial #	1 Layer of wire (40 loops) Red Cup	2 Layers of wire (80 loops) Blue Cup	3 Layers of wire (120 loops) Yellow Cup
How many paper clips were picked up	1	2	9	15
	2	3	8	15
	3	2	9	16
	4	3	9	15
	5	3	8	15
		Add ⬇	Add ⬇	Add ⬇
	Totals:	13	43	76

If I did the experiment again. . .

I would use bolts with more <u>layers</u>, at least four or five. I want to know if the strength of the magnet increases by the same amount with each added layer, or if it increases by less or more each time.

I would also try to measure strength of magnets where there was only <u>one</u> layer of wire loops, but there are more loops over a longer distance on the bolts (so the bolts would be longer than the ones used here). They could have 40, 80, and 120 loops, but only in one layer.

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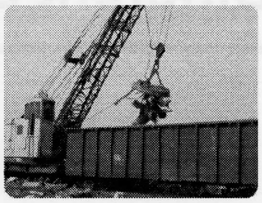
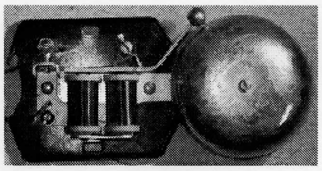


Lifting tons of scrap metal



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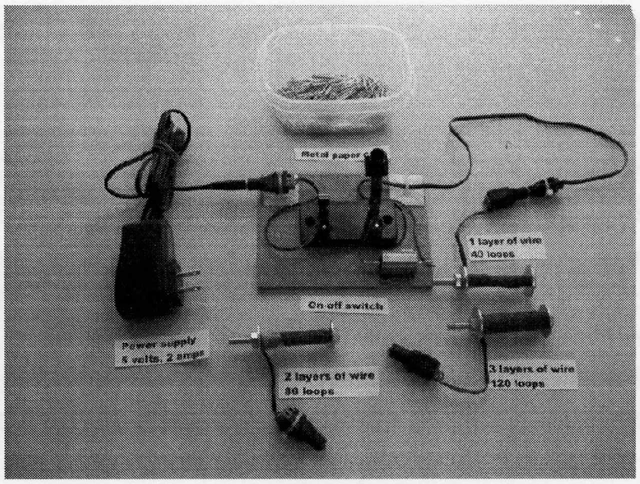

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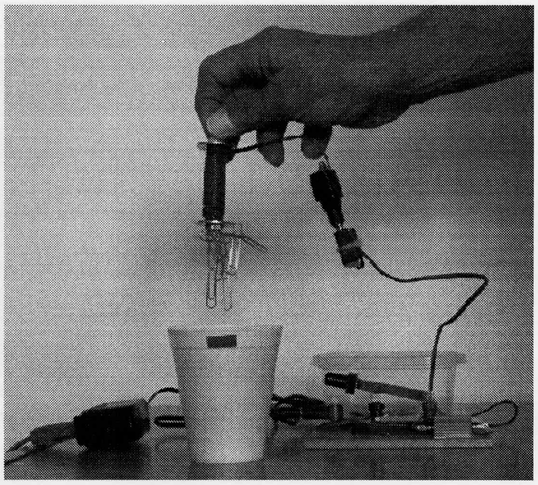

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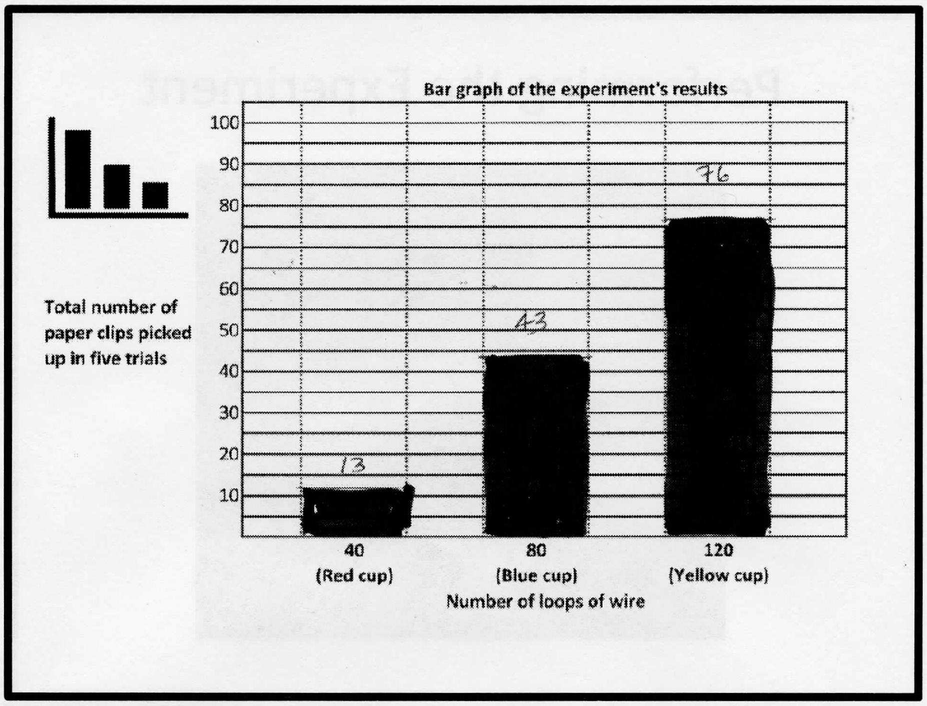

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2017 Classroom Presentation Material

Ask an interesting question	Only change one thing at a time
Do some reading about it	Do multiple trials for each change
Test your question with an experiment	Label tables, graphs and photos
Measure and write down your results	Spend time on data, not glitter

Electromagnet Experiment Physics Primer for Judges/Demo Team

Electricity and magnetism are completely interconnected. In the mid-1800's James Clerk Maxwell wrote a set of equations that describe these relations. The key concepts from that theory that are relevant to our experiment are:

- Any electrical current flowing through a conductor will produce a magnetic field around this conductor. The shape/direction of this magnetic field depends on the shape of the wire carrying the electrical current and the direction of the current. The strength of the field is proportional to the current - more current, stronger field
- Magnetic fields "add up" - that is the field produced by one electrical current can add (or subtract) from the field produced by another electrical current.
- The strength of the magnetic field can be magnified by putting a material like iron or steel in the field. These are called ferromagnetic materials.

Our demo experiment will use the electrical current in a coil of wire that is wrapped around a steel bolt to create an electromagnet much like a typical bar magnet. We will demonstrate that adding more layers of wire increases the "strength" of the magnet in terms of how many paper clips it can pick up.

Even a single loop of wire carrying a current will produce a magnetic field with a North and South pole. By putting a number of loops in a row we create something (called a solenoid) whose magnetic field looks like that of a typical bar magnet. Even without the steel bolt, a solenoid carrying an electrical current would act like a bar magnet, it just wouldn't be very strong. By wrapping it around the steel bolt we magnify the field by a factor of a couple hundred.

What happens in our electromagnet experiment?

- Battery/Power Supply sends a current through the wire.
- Current flowing through a wire makes a magnetic field around it.
- We make loops of the wire so the magnetic field is shaped like that of a bar magnet.
- We have a steel bolt inside the wire loops to magnify the strength of the field.
- The attractive force of this magnet depends on the strength and shape of the magnetic field.
- The more layers of wire around the steel bolt, the stronger the magnet will be.
- We have three experimental electromagnets: one with 40 loops in one layer , one with two layers, for a total of 80 loops, and one with three layers, totaling 120 loops.
- We predict that the more layers/loops of wire, the stronger the magnet will be.
- We want to find out if that is correct by measuring how strong the magnet is with the different number of loops. We do that by seeing how many paperclips each will pick up.

Other concepts that may come up in discussion

What is a permanent magnet?

Many atoms are themselves little magnets with a North and South pole. In most materials these atomic magnets are randomly aligned so that their individual fields cancel each other out. In some materials it is possible to apply an external magnetic field to align those atomic magnets in the same direction. Some of those atoms may remain "frozen" in direction once the external field is removed, thereby creating a permanent magnet.

A possible misconception

It is not the strength of a magnetic field of itself that determines how many paper clips can be picked up. It is really how much the field is *changing with distance* (field gradient), which determines that. In our experiment, the magnetic field is strongest at the tip of the iron, and gets weaker as you move away. In a perfectly uniform magnetic field (i.e. *inside* a long solenoid, a hollow tube wrapped with wire) a piece of iron or steel would experience no net force, since the strength of the field is the same everywhere inside. However, ferromagnetic materials do want to move from areas of lower field strength to higher field strength (closer to the magnet) resulting in mutual attraction. For a given magnet shape/dimension, the field gradient is proportional to the actual field strength. Since in our experiment the shape/dimension of the magnet doesn't change, the number of paperclips we can pick up is a fair measure of the field strength.

Another possible misconception.

- For reasons beyond the scope of this discussion, the strength of the magnet is not strongly dependent on the total number of turns of wire but rather on the number of layers of wire. Putting 80 turns in a single layer (a longer magnet) would not be as strong as one with 80 turns in two layers of 40 turns each. In the same way, laying bar magnets end-to-end does not increase the magnetic field at the tips.

Concepts that may come up in questions regarding motors and generators

- Any changing magnetic field (either in magnitude, direction, or both) will produce an electric field (i.e. a voltage). If you put a loop of wire in that changing field a current will be produced in the wire. That's the basis of a generator.

- A current flowing in a wire located in an external magnetic field will result in a force between the wire and the external field. One way to think of this is that the current in the wire is creating its own magnetic field, which tries to anti-align (N to S) with the external field. That's the basis of a motor.

The Earth's magnetic field - random facts

The Earth's magnetic field is produced by electric currents running in the Earth's outer core, which consists of molten iron. It changes over time in both strength and direction. The North magnetic pole has moved more that 600 miles in the last 100 years. In fact the North and South poles have swapped places many times in Earth's history at intervals averaging several hundred thousand years.