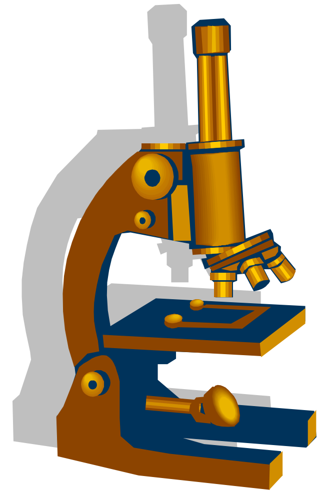
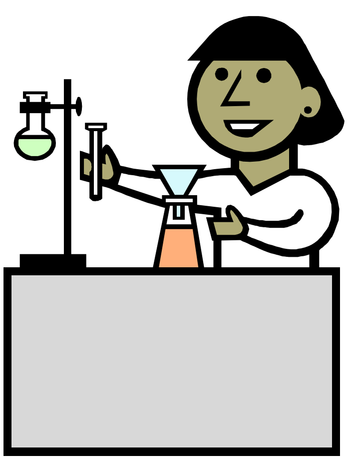


Science Fair Information

Glenelg High School



TIMELINE

For Science Research Project

Activity	Tentative Due Date	Grade
I. **Identify Topic:** Identify the specific problem to be investigated.	_______	______
II. **Introduction:** Research the subject of project (p. 11) and submit the Introduction (p. 12) with a Bibliography (also bottom of p. 12).	_______	______
III. **Questions for Professional:** Submit questions to be asked in professional interview (p. 13 – 14).	_______	______
IV. **Review ISEF Requirements:** Review the ISEF (International Science and Engineering Fair) restrictions and requirements on Forms 1A and 1 (in the ISEF Packet). (Note: SRC = IRB = outside authoritative body over science fair projects.) Also, find out what ISEF Forms are required by going to the ISEF Rules Wizard (web address on p. 6) and answering the questions on each page.	_______	______
V. **Professional Interview Report:** Interview an expert in the field of project and submit the typed Professional Contact (p. 14). Also, revise the Introduction based on the interview. Submit final draft of Introduction and edited rough draft.	_______	______
VI. **Experimental Design:** Submit the typed Experimental Design (p. 14).	_______	______
VII. **Submission of ISEF Forms:** Everyone submits forms 1, 1A, 1B, Research Plan Attachment. Some projects require more forms. All forms are in the ISEF packet. Complete and submit ALL required ISEF Forms.	_______	______
VIII. **Graph(s), Results, Error Analysis, and Conclusions:** After conducting the experiment submit the Data Table(s), Graph(s), Results, Error Analysis, and Conclusions (p. 15 – 22).	_______	______
VII. **Final Materials and Methods and G, R, E.A., C:** Submit Methods and Materials, Data Table(s), Graph(s), Results, Conclusions, and Error Analysis.	_______	______
VIII. **Abstract:** Submit Abstract (p. 23).	_______	______
IX. **Presentation:** Assemble ALL parts of the research paper and combine them into one large paper (p. 5). Complete the display board (p. 24). Give the five-minute oral presentation (p. 25) to the class as if they are judges.	_______	______
X. **Present at Science Fair:** Present project to judges at Science Fair.	Wednesday Jan. 27 Snow Date Feb. 3	______

Note: Your teacher will give you actual due dates.

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GLENELG SCIENCE FAIR RULES

EVERYTHING you submit to be graded (except for forms in the ISEF packet and the back of this packet) MUST be typed, DOUBLE SPACED, and 12 point Times New Roman font.

If any part of the project is submitted late it will be deducted 10% each day it is late. Even once it is not worth any points it must still be submitted to the teacher.

If you are taking two GT Science classes you will be graded for the science fair in only one of the classes. In the other class you will be excused from the requirement. This is so that you will not receive grades for both classes for doing one project.

You may work in pairs. Please be aware that we have seen many friendships damaged and even ended over science fairs because one partner did not do their part and therefore hurt the other partner's grade. If you want to work in pairs, choose your partner carefully! Also, if you do a project with a partner you must study two variables instead of just one.

Keep all teacher corrected papers with teacher comments. They will be required when you turn in the final drafts.

The Science Department is seldom able to provide materials or equipment for science projects. Please plan accordingly.

Any project involving ANY safety hazards you must be supervised by a QUALIFIED adult sponsor and you must follow ALL International Science and Engineering Fair (ISEF) rules. ISEF is the organization that regulates high school science fair projects. Violating these rules could bring harm to you and your family and would cause your project to be disqualified resulting in a zero on all science fair assignments. Safety hazards include, but are not limited to, hazardous chemicals or controlled substances, working with vertebrates, culturing bacteria, and using human or animal tissue.

As you are doing your project **take pictures!!!** These help the judges see what you have done and add a lot to your display board.

At the County Science Fair there is a category of Mentored projects. These projects are normally done by students in the Mentorship class. These students spend over 100 hours working on their projects with the direction of a professional and so the projects are normally at a very high level. The County Science Fair committee has decided that **ANY** project that includes **30 or more hours of a professional's time** will be counted as a Mentored project. Please note, if your parent is a professional in the field you are studying and they spend 30 or more hours working with you on your project, your project is also considered a mentored project and would be put in that category if you went to the County Science Fair.

ORDER OF THE FINAL PAPER

When you finish your science fair project you will have a final paper with all of the following parts. Each part is completed individually and at the end they are brought together into one final paper. Your final paper will be in the following order:

1. **TITLE PAGE:** Keep the title short. If accuracy requires more than a few words, consider using a very brief main title and a more definitive subtitle. Also on this page have your name, your teacher's name, the class, and the date.

2. **TABLE OF CONTENTS:** A list of all the parts of your paper and the page that they start on.

3. **ABSTRACT:** This is a summary of the entire paper. It summarizes your objectives, what you did, and your conclusions. The maximum is 250 words, but yours will probably be about 150 words.

4. **INTRODUCTION:** Describe your topic and give the necessary background so that an average person could understand your project. Identify why you wanted to study this subject.

5. **PROBLEM AND HYPOTHESIS:** This should be a clear statement of the problem and your working hypothesis, separate from the introduction. Your hypothesis is your guess of what your research findings will be.

6. **MATERIALS AND METHODS:** List in detail the materials, equipment, and methods (the procedure) you used. Use diagrams and drawings as needed. Provide enough information so that the reader could reproduce the study.

7. **DATA TABLE(S) AND GRAPH(S):** Display your data table(s) and graph(s). Metric units must be used. If you have more data than can easily be presented, put the essence of the project in this section, but the rest should go in an appendix.

8. **RESULTS (a.k.a. ANALYSIS):** Write your data table(s) in paragraph form. Some people like to read data tables and others want to read it in paragraph form. Your paper will have both options.

9. **CONCLUSIONS:** Use accepted analytical techniques. Compare your results and interpretations with those of other scientists in the same field where possible. Discuss the utility of your data. State if the hypothesis is supported or not supported by the data.

10. **ERROR ANALYSIS:** Identify the sources of error in your project.

11. **LOOKING FORWARD:** Discuss how you would improve your project if you were to do it again. Discuss applications of your project. Identify any new questions this project brought up.

12. **ACKNOWLEDGEMENTS:** Both prudence and the best traditions of science require that you acknowledge all help that you received, including your science teacher.

13. **BIBLIOGRAPHY:** Keep it brief, listing only those books and periodicals that you actually used to write the Introduction.

14. **APPENDIX:** Include critical information that is too lengthy for the main section of the paper, such as raw data, additional tables and graphs, copies of surveys or tests, and diagrams of specialized equipment.

SCIENCE FAIR PROJECTS
AT THE
HIGH SCHOOL LEVEL

We have very high expectations, and hope you are genuinely interested in some science or engineering topic that you will investigate during the course of the next few months.

The Science Fair is different at the high school level from what you may have experienced in middle school. You are now asked to investigate a phenomenon using a more sophisticated approach – we want you to start doing the research as an actual scientist might. This means trying to understand the underlying "why" for a question you are trying to answer rather than just finding out "if" the answer to a question is true.

For example, in middle school you may have asked "what temperature do plants grow fastest at?" You could still be interested in the same area of science, but now you need to take this to a higher level. This means trying to understand what *causes* the effect you observed, and you'll need to be more specific in your investigation. Appropriate questions for a high school project are "how does the temperature effect the growth of onion root tips?" or "how does the temperature effect the absorption of water?" In both cases you are looking at the chemistry of laundry detergent, and in both cases you are looking for measurable correlations between two variables.

These correlations are a key ingredient in doing "real science" because they give you *predictive power*. If you simply test two vacuum cleaners and find that one is better, you can say nothing about the next model that comes along. If, however, you do a careful study of brush size or horsepower versus cleaning ability, then you can *predict* which others will do well. This predictive power is a key element in an acceptable scientific hypothesis. The goal of science is to make sense of the world, and if a hypothesis can't tell me what I can expect to happen in the world, it isn't really scientific.

At the high school level you are finding the underlying reason the vacuum cleaners do a good job, and that is a scientific approach. Your suspicion of the underlying cause is also an essential ingredient of your hypothesis. A good hypothesis will offer justification for the "educated guess" – it will say "if X, then Y, *because of* Z" rather than just "if X, then Y."

We also expect you to employ mathematical methods for data analysis. This includes producing and interpreting computer-generated charts and graphs, and determining if your result is statistically valid for the experiment you have done. We also expect you to do a very detailed error analysis to describe possible systematic, measurement, or random errors that affect the results of your experiment. Both of these topics are discussed in this packet and may be addressed in class.

Examples:

Middle School Project	High School Project
At what temperature does a banana rot fastest?	How does the percentage of sugar in a banana change as a function of time (or temperature)?
What wing shape makes a glider fly farther?	How does the coefficient of lift vary with angle of attack (or the temperature) for a given airfoil?
Which laundry detergent works best?	How does enzyme concentration in a detergent affect the breakdown of protein stains (such as blood)?

Unoriginal topics will not receive a grade better than a “C.” Examples include:

- How do different substances affect the growth of plants?
- How do different colors of light affect the growth of plants?
- How is popcorn popping affected by brand, temperature, etc.?
- The effect of music on memory.
- The effect of temperature on plastic wrap.
- Which battery works best?

Note: You may work on an extension of a project begun in middle school. However, the additional work must be substantially beyond the 8th grade project to receive a grade higher than a “C,” and you must discuss it with your teacher at the outset.

WEB SITES WITH SCIENCE PROJECT IDEAS

Science Fair Idea Exchange scienceclub.org/scifair.html

In most cases you will need to use the “Medium” or the “Advanced” level from this site.

Science Fair Project Resource Guide www.ipl.org/youth/projectguide/

Science Fair Tips www.cyberbee.com/science/scitips.html

E-Databases of Student Research youth.net/nsrc/nsrc-info.html

ISEF RULES WIZARD

Use this site to determine what ISEF forms you MUST fill out and submit.

www.sciserv.org/isef/students/wizard/index.asp

SAMPLE TITLES FROM PREVIOUS YEARS

Chemistry
The Heating Power of Nuts
The Effect of Baking Soda on Tooth Density
Will Different Types of Flour Used in Baking Bread Prevent the Growth of Mold?
Rust Revenge
Does Temperature and Moisture Content Affect the Granualization of Honey?
What Makes You Boil?
Sunscreen vs. Sunblock

Computer Science
Effect of Distance and Type of Network on Internet Speeds
Picture perfect?
The Inaccuracies of Computer Programming: Just How Many Are There?
The Effect of Configuration on Network Efficiency

Engineering Technology
The Effect of Dimple and Bump Placement on a Wing and its Flight Distance of a Styrofoam Plane
Radio Frequencies

Environmental Science
The Effect of Time Elapsed Since Application of Fertilizer on Concentration of Phosphate in Direct Runoff
Making Ethanol the Alternative Fuel of the Future
The Effect of Temperature on Concrete
How is the Strength of Water-saturated Wood Affected by Varying the Species?

Earth Science
The Relationship between Clear Air Turbulence and Proximity of Tropopause
The Effectiveness of Different Coatings in Protecting Marble from Erosion due to Acid Precipitation
Meteorological Factors Affecting Radon Levels in a Residence
Flow Rates in a Stream
Water Heating By Means of Solar Energy

Math
The Effect of Algorithms on Time Taken to Learn Them
How Probable Are You?

Microbiology
What is the Effect of Garlic Against Everyday Bacteria?
The Effect of Multiple Freeze-thaw Cycles on the Growth of Bacteria on Bovine Bone
Microorganisms: Good or Bad for Plants
The Effect of Ascorbic Acid on Food Spoilage

Physics
Aerodynamics vs. Hydrodynamics
Polymeric Thermal Interfaces
The Effect of Water Temperature and Salinity from a Homemade Electrostatic Water Generator
Impact Craters
The Effect of Wire Type and Gauge on Resistance
The Susceptibility of the Brightness of Light Based on Wavelength
The Effect of Humidity on Electrical Voltage Output of a Van de Graf Generator
Lift vs. Camber
The Effect of Different Types of Golf Balls on Trajectory and Spin
Polarization of Light
The Effects of Wing Design on Paper Airplane Flight

Plant Biology
What Type of Herb Kills Bacteria Grown in the Mouth?
The Effect of Compost Composition on the Height Rate of Lima Bean Plants
What is the Effect of Number of Stamens on Days of Survival
How Worms Affect Plant Growth
The Effect of Duration of Fall on the Amount of Chlorophyll/Pigmentation a Leaf Contains
The Effect of Caffeine Introduction on Algal Growth
Nontoxic Weed Killers

WARNING: **The topics below involve human subjects, often involving variables that are difficult to measure or control, and requiring groups of as many as 20 or more subjects per group. This also increases the ISEF forms required proportionally.**

Animal Biology
Dynamics of Gymnastics
The Effect of Salinity on the Dark False Mussels Ability to Filter
Number of Fish vs. pH
Back Pack…Back Crack
The Muscles of Runners
The Effect of Finger Length vs. Grip on Reaction Time
Efficiency of the Dark False Mussel

Behavioral Biology
Does the Color and Scent of Fishing Lures Affect the Amount of Fish Caught
Effect of Population Density on Territoriality in Cinchlids
The Effect of Auditory Learning on Memory
Advertising's Effect on High School Girls' Buying Behaviors
Does Attempted Deception Affect Pupillary Size?
Atmospheric Influences on Emotions

IDENTIFYING A PROBLEM AREA OR QUESTION

Things to consider as you try to choose a problem area or question (a.k.a. a topic) for your science fair project:

- It should be an area that interests you
- You must be able to accurately measure both variables
- You must have access to the necessary equipment and materials
- You must consider the cost involved in the purchase of equipment and materials
- Data collection must be completed within two months

WRITING YOUR HYPOTHESIS

Your hypothesis is a statement of what you are testing by doing your experiment. It should make a measurable prediction regarding the outcome of your experiment.

Your hypothesis needs to explore the relationship of the dependent variable vs. the independent variable. For example, a good hypothesis is, "As the density of a material increases so does the insulating capacity."

Avoid choosing a random hypothesis! An example of a random hypothesis is, "Small shirts will get cleaner than large shirts washed the same way." Why would small shirts get cleaner? There is no reason to suspect that they would, and so this is a random hypothesis. You need to be able to justify why you think your hypothesis might be true. Your background research should lend support to your hypothesis.

TAKING RESEARCH NOTES

Research notes are an important part of an investigation, and will help you stay focused. They will also be collected and graded by some teachers before you are allowed to conduct your interview. The following procedures are recommended:

1. Write your name and the topic of your investigation at the top of the first page!

2. Keep notes in a 3-ring binder or in a bound research notebook. This allows you to refer easily to them when you have questions about your project or need to review steps you have already taken.

3. Write four or more questions you have about your project at the top of the notes page to help guide your book research.

4. Take freehand notes <u>WHILE YOU ARE READING</u> BOOKS, MAGAZINES, or REVIEWING WEB SITES! Note the name of the source and the date you were accessing it, for your own reference. See examples below.

5. If you think you might use this reference in your Introduction, then write down all of the information that is needed in a bibliography. For a book this would be the title of the book, author's name, place of publication, publisher, and year of publication.

6. Jot down new questions or ideas as they occur to you, also noting the date. This often happens to scientists while reading about a topic of interest. See examples below.

(Yours would be freehand.)

Scientific American Oct. 2001, p.28 – 30	• Moons of Saturn cause some rings to be braided • Rings are made of ice and dust ~ size of golf balls to suitcases • Seen by Galilao in 1610. Cassini → separation between rings

Q 9-5-05 → Why doesn't Jupiter have braided rings?

I 9-5-05 → If we put up artificial satellites in Earth orbit, could we support braided rings to be used by space station to move around?

nasa.gov/satellites 9-6-05	• There is work on formation flying satellites to minimize fuel use. • Such formations could be used for a very large space telescope.

INTRODUCTION

The purpose of the introduction is to acquaint the reader with important background information about your topic so that he/she can understand your project. It should be a minimum of three well constructed paragraphs which follow an "inverted pyramid" in terms of the information you convey: broad/general to specific.

- Paragraph #1 should present a broad overview of the general topic you are investigating. If the topic is the effect of candle dye on how fast a candle burns, then a general discussion of the history of candle making, components of candles, and variations of the generic candle should be presented.
- Paragraph #2 should be more specific to that aspect of your topic that you are interested in. For instance, if I were interested in the effect of wax dyes on the rate of burn on a candle, this paragraph would detail dyes, associated chemistry if available, information on why a candle burns, and any other relevant information you may find that directly relates to your investigation.
- Paragraph #3 should be specific to your exact topic, and should end with a statement of the problem you are investigating. For example, "This project will investigate the relationship of candle dye to rate of burn."

The introduction should only contain facts. No opinions are offered from you. This is a review of the literature for the purpose of enlightening the reader. It is written in passive voice. Remove all "I," "me," statements from your writing. Example: "Candles were first made by…." "Research on wicks reveals that…." etc. Avoid all use of unnecessary adjectives. Stick to the facts, and relate them clearly and logically. Good technical writing does not include superfluous words.

Finally, your paper should be supported by a bibliography in APA (not MLA) format. APA is the science format. MLA is the English Format. You will need a minimum of four references, one being your interview with the professional, which you have not conducted yet. You may have no more than one from a general reference such as an encyclopedia. You may use on-line references, books, periodicals, etc. for the rest.

You must submit a Bibliography with your Introduction, although it will not be complete because it will not have your interview with a professional. To make a Bibliography you can use Noodle Tools (see below) or the MLA guidelines in your planner or get help from the Media Center.

Please read the example science paper that has been given to you as a model in the back of this packet. Ultimately this is what your paper will look like, and if you save your sections on disc as you write them and edit corrections as they are given, then assembling the final paper will be very easy. The final paper which accompanies your project will be about 3-4 pages in length.

Good luck, and see your teacher if you need help.

Using Noodle Tools to write your Bibliography

To use Noodle Tools, go to www. NoodleTools.com, click on the "NoodleBib 5" link and sign in using the school user name and password. Then click on "NoodleBib." If you already have a personal folder, login. If you don't already have a folder, click on "Create your Folder" and then enter the information to create the folder. Then once the folder is created, open the personal folder. Then click on "Start New List." Then for Step 1 choose "APA Advanced," leave Step 2 Class Name blank, and choose a name for your list like "Science Fair Bib." Click on "Start Adding Citations" and click on the "Select a citation type" drop down menu and click "Go." Then answer the questions about the citation and click on "Generate Citation." This will take you back to the "Select a citation type" page and enter another citation. Continue until you have entered them all. Then click on "Open in Word," which is on the toolbar on the left side of the screen. Then click on "Save as an .rtf" and tell the computer where to save it. When you are done make sure you log out of Noodle Tools. The next time you log in to Noodle Tools you will have this Bibliography in a list that you can edit when necessary.

PROFESSIONAL INTERVIEWS

Part of the experience we want you to get with your science fair project is to have contact with a working scientist or engineer. You will find that these people are very willing to talk to you and are generally happy that you have an interest in their field of expertise.

Goal: The goal of your interview is to help you learn more about science/engineering, learn how to make your project better, and clarify any questions you have that your research of the literature did not answer. (It's also to get you out of your shell to talk to some professionals – and maybe to make contact with someone who could be a mentor to you in the future!)

Who: The person interviewed should be a professional in the field you are studying. Since we want you to learn some science, we prefer that they have a *degree in some field of science or engineering*. For example, the local grocer may know about keeping bananas from rotting, but may not have an understanding of the science behind the methods used. Your teacher may grant an exception to this rule in some cases, as we do realize the value of practical experience.

How: The best interviews are generally done *in person*, so you can point out research you have already done and refer to graphs or drawings if need be. If this is not possible, phone interviews are satisfactory – they still allow you to interact with the professional in a meaningful and productive manner. E-mail interviews are not generally acceptable, as they insulate you from actual "back and forth" discussion with a professional, and often are very one-sided. See your teacher if you would like an exception from this rule, but don't count on it!

Where do I find this person?!

You will be amazed at the resources you have available to you, once you start looking. This is another learning experience! Ask about your family's friends and perhaps their co-workers' friends. Ask your friends about *their* parents. Check around your neighborhood. Western Howard County is replete with science and engineering specialists. If the project is health-related, you might ask the school nurse or your own doctor. There are also online resources available, and for botanical projects the county agricultural extension office is very helpful. If you're still having trouble, ask your teacher or counselor for a reference.

PROFESSIONAL INTERVIEW REPORT

You will submit the information listed below typed, double spaced and in 12 point Times New Roman font.

Title of Project:
Content Area of Project:

Professional Contact's Name:
  Company / Institution:
  Professional Title and Degree(s):
  Phone #: **E-mail address:**

Method of Contact: (Personal interview, phone interview, or e-mail (attach copy).)
Date of Interview:

Summary of information and discussion: (List the questions (at least 3) you asked and their response.)

EXPERIMENTAL DESIGN

You will submit the information listed information typed, double spaced and in 12 point Times New Roman font.

Statement of Problem:
Hypothesis:
Independent Variable:
Dependent Variable:
Constants:
Materials: (List what you will need and how many or how much)
Procedure (or Methods): (Number each step and write in complete sentences):
Data: (Show what your data table(s) will look like. Show what your graph(s) will look like including labeled axis.)

GRAPHING DATA AND ERROR BARS

Below are directions for graphing sample data from a project investigating the effect of octane on the temperature of car exhaust gases.

1. Open Excel.
2. Type the independent variable title in cell A1 (Octane). The value for each goes in A2, A3, A4 etc. (87, 89, 93).
3. Type the title "Trial #" in cell B1, C1, D1, etc. (Trial 1, Trial 2, Trial 3 etc.) The value of the dependent variable will go in the cells in columns B, C, D, etc. (see example).

Octane	Trial 1	Trial 2	Trial 3	Trial 4	Trail 5
87	109	112	108	110	109
89	115	116	115	116	116
93	120	117	113	121	119

<u>To calculate the average values for each octane:</u>

4. Type "Average" into an empty column (e.g. G1).
5. In the cell below "Average" type =average(
6. Then highlight the data in the same row (B2 through F2).
7. Then hit Enter.
8. The average for the row should appear in G2.
9. Repeat for all rows of data. (You can do this by copying the formula in G2 to G3 and G4 etc..)
10. Then highlight the cells that have your averages in them.
11. Click on Format.
12. Click on Cells…
13. Click on Number.
14. Decide how many decimal places you want your averages to show and put this number in next to "Decimal Places." (If you are taking or have taken Chemistry use the appropriate number of sig. figs.) For the above data 1 decimal place would be appropriate, so 118 will be written as 118.0 In most cases 1 or 2 decimal places is appropriate.
15. Click OK. Do this formatting for any of the numbers the spreadsheet calculates.

<u>To Graph the Data</u>

16. Go to Chart Wizard.
17. Then choose (XY) Scatter.
18. Select the graph on the right with two curves and dots on each line (this should be in the middle of the left hand column.)
19. Click Next.
20. Then choose the Series tab in the Source Data window.
21. Choose values by clicking the red arrow box on the right (this should send you to spreadsheet).
22. Go to the X value cells (cells A2 to A4). It should appear in a small Source Data window.
23. Click the red arrow button in the small window. This should put you back to the large Source Data window.
24. Choose the Y value box by clicking the red arrow box on the right.
25. Choose the Y value cells (<u>the average value</u>, G2 to G4).
26. Click the red arrow key in the small window. This should send you back to the large Source Data window.
27. This should graph all the data points. Then click Next.
28. Choose the Legend Tab.
29. Uncheck the Show Legend box.
30. Choose the Titles Tab.

31. Fill in the Title, and X and Y axes titles.

32. Choose Next.
33. Choose Finish.

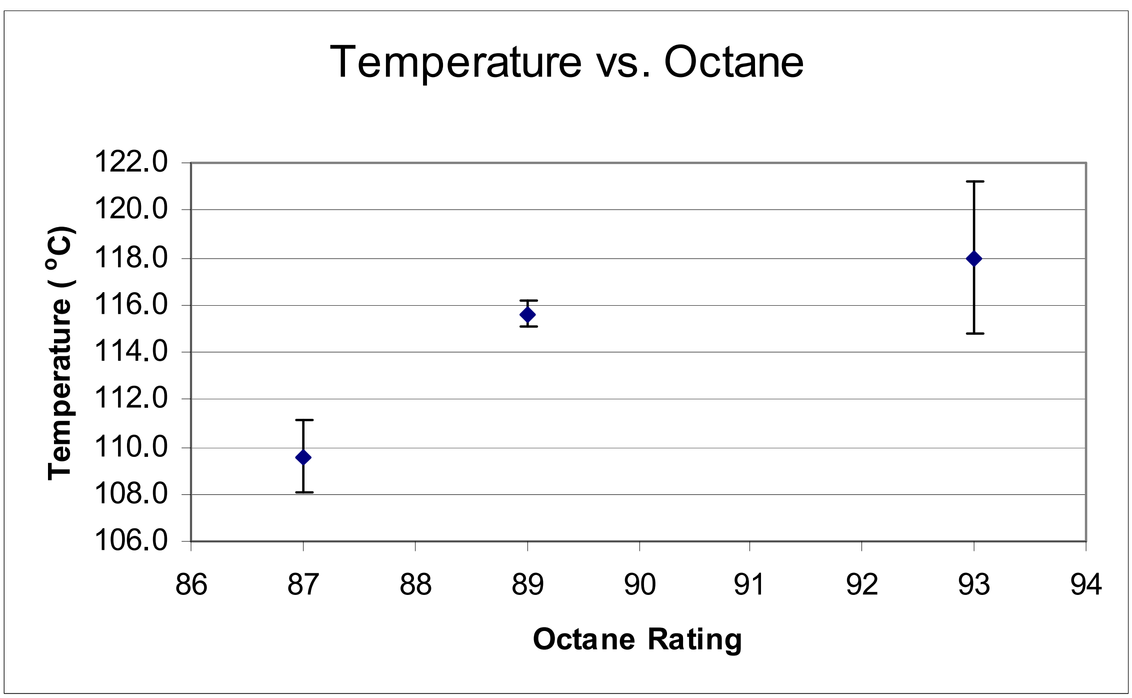
To calculate Standard Deviation

34. On the spreadsheet add a title of Standard Deviation to the next column (cell H1).
35. In the cell below (cell H2) type =stdev(
36. Highlight the data in that row (NOT the average) and hit Enter.
37. Generate a standard deviation on the spreadsheet for each row of data.
38. Format this data as we did in Steps 10 – 15. Keep the same number of decimal places that you did for the Average calculation.
39. Notice that for the sample data the standard deviation is small for 89 octane and large for 93 octane, this is because the 89 octane data is close together (115 - 116) and the data for the 93 octane is far apart (113-121).

To graph Error Bars

40. When all the Standard Deviations are calculated, click on the graph.
41. Click on the first data point
42. Select Format from the toolbar above.
43. Choose Selected Data series
44. Choose Y error bars tab
45. Choose Custom Error bars +
46. Click the red arrow box
47. Select the standard deviation cells (cell H2 to H4). The address should appear in the small window.
48. Click the red arrow box in the small window.
49. Choose Custom Error bars –
50. Click the red arrow box.
51. Select the same standard deviation value (cell H2 to H4). Click the red arrow box. The error bars should appear on the graph.

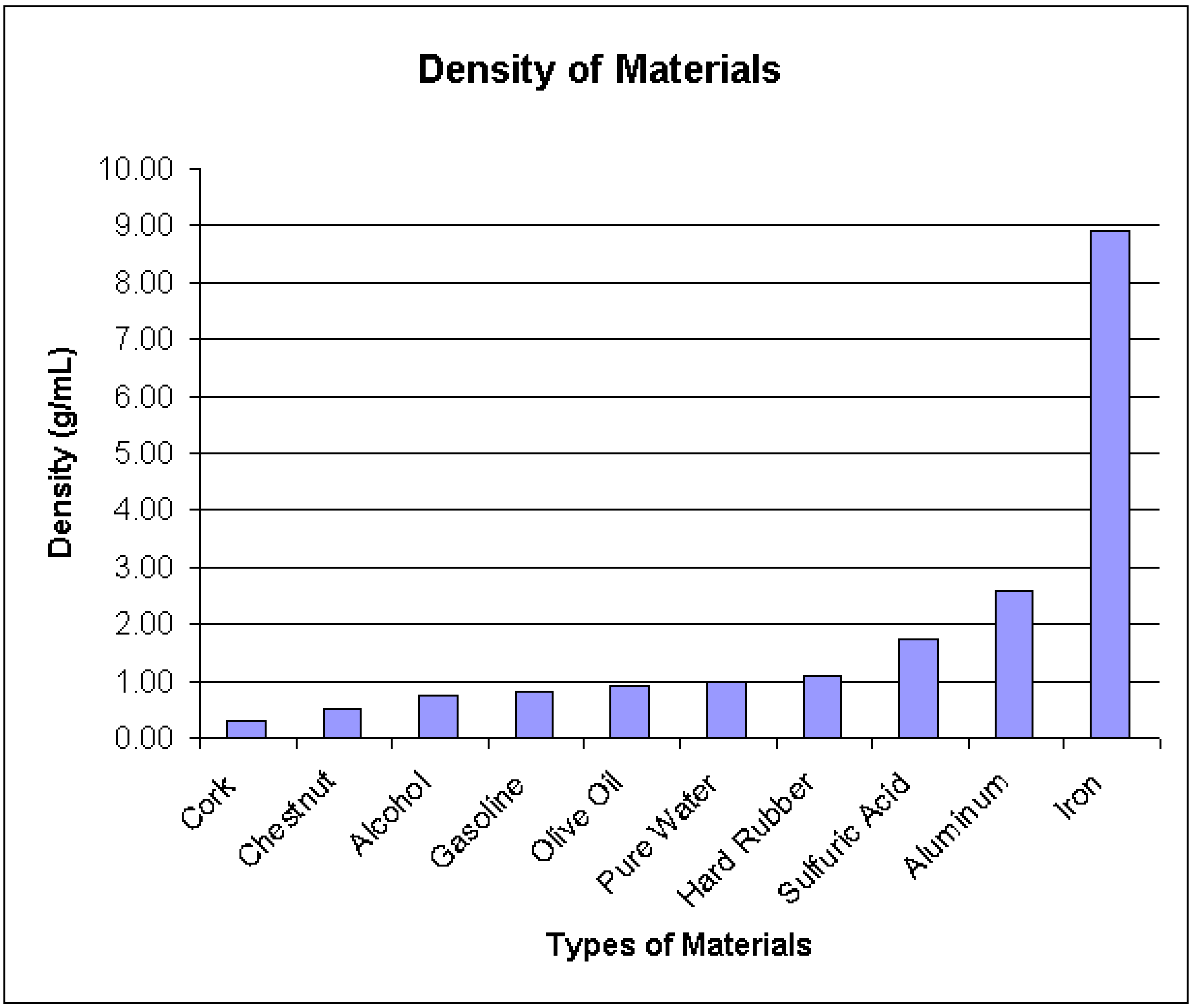
52. Repeat until each point has + and – error bars.



Sample Data Table

Material	Density (g/mL)
Cork	0.30
Chestnut	0.50
Alcohol	0.75
Gasoline	0.80
Olive Oil	0.93
Pure Water	1.00
Hard Rubber	1.10
Sulfuric Acid	1.75
Aluminum	2.60
Iron	8.90

Sample Bar Graph
(Excel calls this a Column Graph)

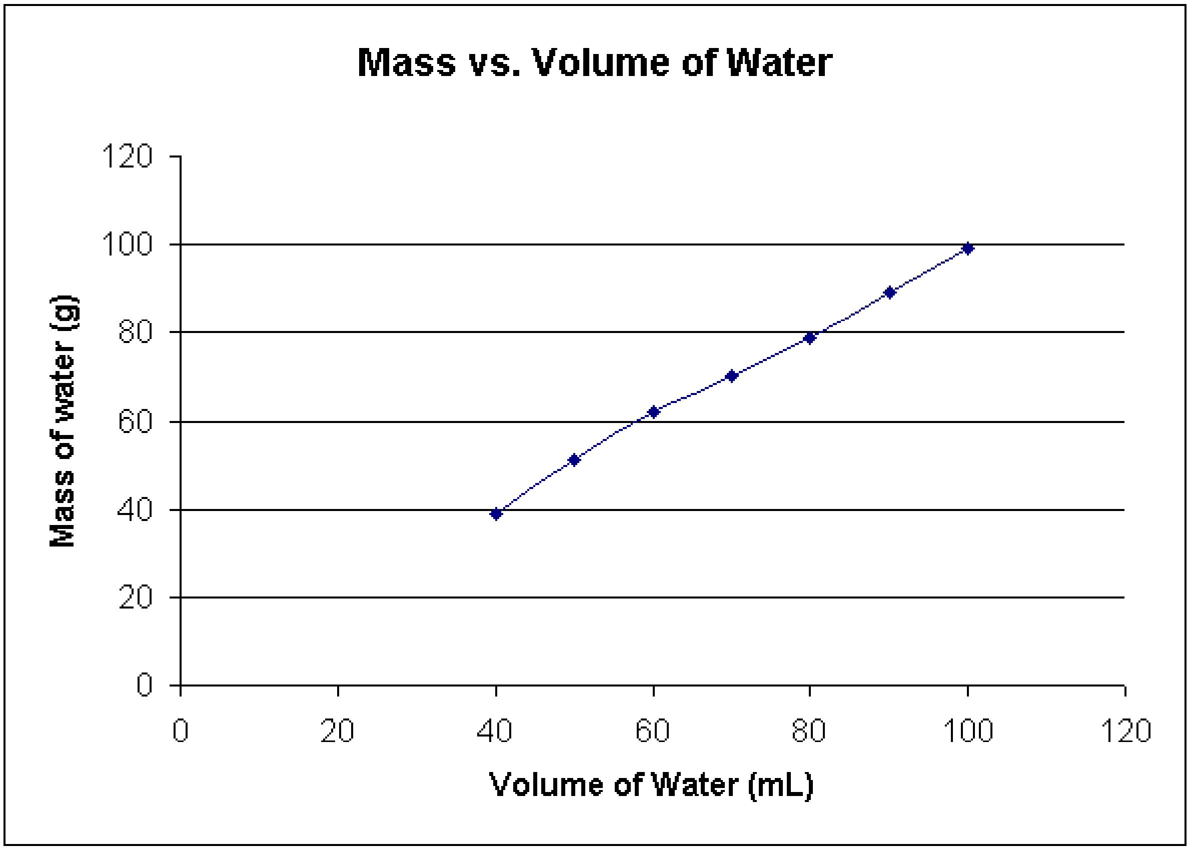


Sample Data Table

Volume (mL)	Mass (g)
40	39
50	51
60	62
70	70
80	79
90	89
100	99

Sample Single Line Graph

(Excel calls this a Scatter Plot)

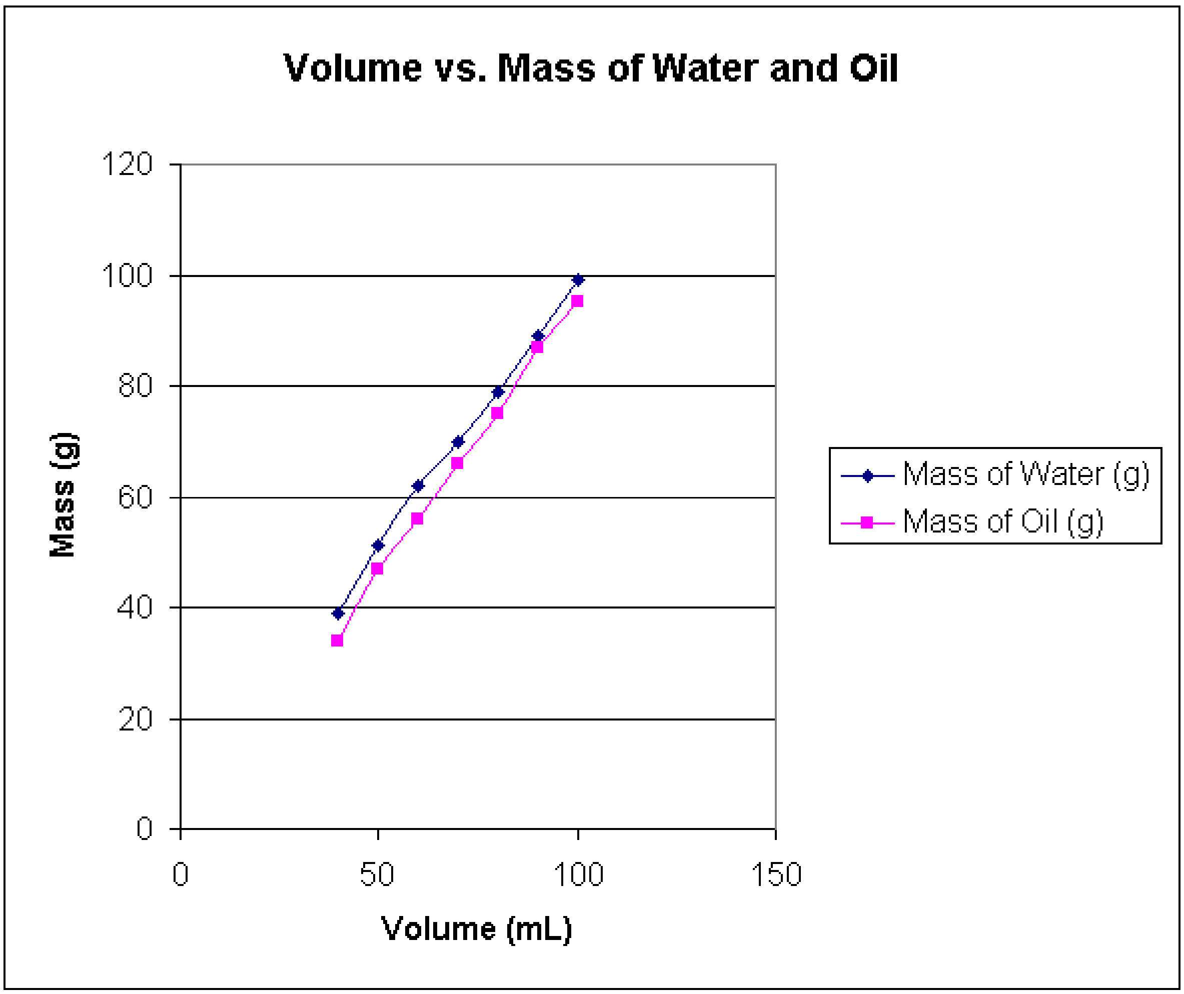


Sample Data Table

Volume (mL)	Mass of Water (g)	Mass of Oil (g)
40	39	34
50	51	47
60	62	56
70	70	66
80	79	75
90	89	87
100	99	95

Sample Double Line Graph

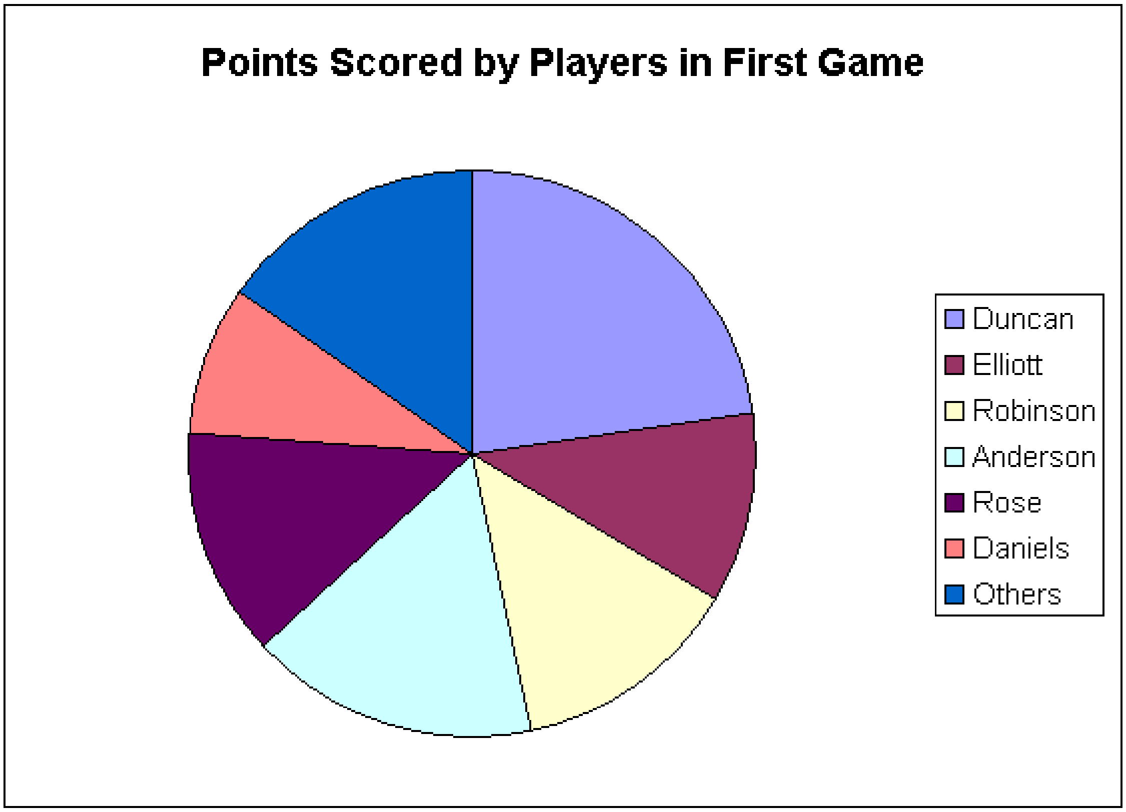
(Excel calls this a Scatter Plot)



Sample Data Table

Player	Points Scored
Duncan	21
Elliott	10
Robinson	12
Anderson	15
Rose	12
Daniels	8
Others	14

Sample Pie Graph



RESULTS, ERROR ANALYSIS, AND CONCLUSIONS

There is typically confusion among students (at all levels, including upper division college students...) about what is meant by the title words for this section. Here it is:

RESULTS: This is the section where you will graph your data and discuss trends in the data that differ from random distributions. Statistical analysis of the significance (i.e. reliability) of your result is also done in this section. If there is a lot of data, it is generally put in an appendix and the "results" section of the paper gives a summary and refers the interested reader to the appendix where all of the data is given. (The raw data is almost always present somewhere in the paper, so skeptical scientists can see how the experiment was actually done and interpret results themselves to see if you've made an error in interpretation.) Be sure to clearly label data tables so a person can tell what you were doing.

ERROR ANALYSIS: This is NOT "where you went wrong." If you make mistakes in a scientific experiment, you do not go forth and report them to the world! You go back to the lab and fix them. So it is at Glenelg. **Do not report mistakes, fix them!**

What you DO need to report, however, is an analysis for the types of *errors* found in all science work. These are not mistakes, but rather are sources of inconsistency among different experiments that can result from a variety of sources. They generally come in three flavors: systematic, measurement, and random (or statistical). The hard ones to characterize are the systematic errors.

Systematic errors are sources of inconsistency in your experiment that result from the way it was designed or implemented. These are the ones you have to sit and think of, and are most often the ones that result in scientific findings being retracted or invalidated. No experiment can control all possible variables, but we generally list these in our reports so that (1) we can assess how much they might affect the validity of our result, and (2) other scientists will know we considered them even if they are not explicitly controlled for. This promotes thinking of new ways around such problems in future experiments.

In the case of a person measuring the growth of 40 plants in four groups receiving different amounts of water, the following systematic errors might occur:

- Some plants are always in the shade of others, and therefore grow more slowly but not because they have less water;
- some plants have harder soil and the water may evaporate before it gets absorbed even though the experimenter poured the same amount of water in each;
- air currents around the plants evaporate more water from one area than another;
- some plants receive more artificial light than others;
- plant food or organic material may have settled to the bottom of the watering container and always be more concentrated on some plants than on others
- the measuring cup used for watering may be calibrated incorrectly;
- the soils may have differing chemical makeup and consistencies;
- water may stick to the sides of the measuring cup, giving a greater percentage error to the plants receiving less water than to those receiving the most.

Many times you will discover systematic errors you had not thought of as you do your experiment. This is part of the learning process in real science labs, and the important thing is to note these errors in your lab notebook and put them in your report. Of course, if you can fix them and still complete the experiment that would be best, but you still want to note that they affected the first part differently from after your correction.

Measurement errors result from the limitation in precision of your measuring instruments. General scientific practice is to go to the precision of the markings on the measuring device, then estimate one decimal place further. ALL experiments will have measurement errors – your job is to report them correctly based on the tools you use. In the plant example there are measurement errors (uncertainties) associated with the water, the plant height or leaf size, depth seeds were planted, and amount of soil per pot.

Random (or statistical) errors result from many processes in nature being inherently random. Using the plant example from above, some seeds may be healthier than others; some may respond better to lower water levels through some genetic variation; some may sprout naturally taller plants; some may respond differently to the soil; etc. These errors cannot be eliminated, but are typically reduced by using a large sample size. The more random error an experiment is subject to, the more data is generally necessary. Some GHS science teachers have major experience in this area!

CONCLUSIONS: These are what you can say about the world as a result of your experiment. A common conclusion is that the experiment "suggests a correlation between [the variables], but is statistically inconclusive." This is OK, and usually points to the need to do additional experiments or to re-run the experiment with a much larger data set. Here you will state whether your hypothesis was supported or not supported.

Don't get yourself in trouble by saying you "proved" something. This you cannot do in science. The best we scientists can do is support a hypothesis or a theory with more and more evidence. Saying you've proved anything is a sure way to get a scientist to dismiss your work without even looking closely!

In scientific papers the conclusions also typically include the importance of the work to the field, whether it agrees or disagrees with previous work, and any notable applications of the results. Error analysis is also done in the "Conclusions" section of a scientific paper.

WRITING AN ABSTRACT

The abstract is a *very* concise summary of your entire project, and should in no circumstance exceed 250 words (most of your abstracts will be 150 words or less). It must include your hypothesis, a brief explanation of your experimental procedure, a brief overview of your results, your conclusion, and applications where appropriate. It should be printed in size 12 font, and it will be left on top of your paper on the table for the judges to read. It may be the only item they actually read while reviewing your project, so do a good job of "selling" your project by writing clearly and persuasively about your research. In fact, working scientists seldom read more than the abstracts of research they are not directly involved in, and they use this information to keep informed about the ongoing work in their discipline.

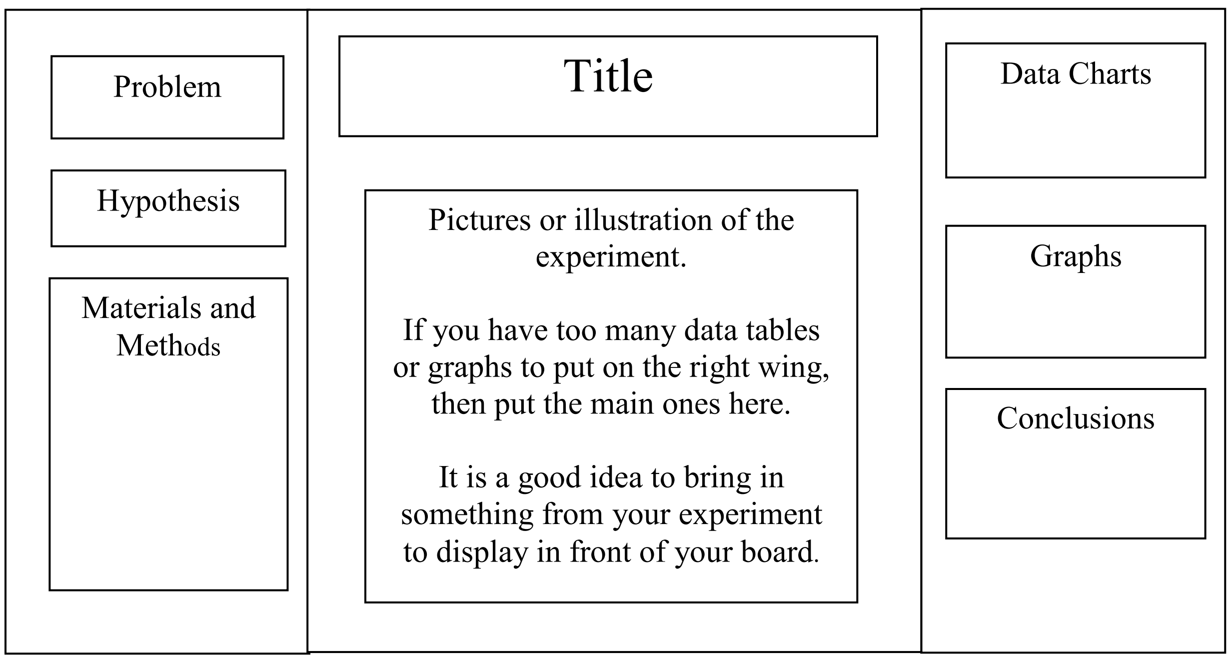
Abstracts should be written in past tense, passive voice, and you should not include graphs or tables. One way to organize your writing would be to have the first sentence or two introduce the problem investigated and your working hypothesis, with a possible rationale for doing the project. Following this would be a very brief review of the procedure you followed in the investigation. This is a summary and is not even close to the level of detail used in your procedure section – it should not exceed two or three sentences. Next you should summarize the numerical results of the investigation, interpret the data and draw conclusions. Finally, you would include any applications, extensions, or special significance of the research worth mentioning.

One of the most common problems with student abstracts is the lack of numerical data in the abstract. To summarize numerical results, give only the "bottom line" values that educated readers would be interested in – for example, "the candles kept at 10ºC burned 38±5 seconds longer than those at 20ºC." Too much data detracts from the readability of the abstract, while none at all causes one to question the scientific validity of the project. The conclusion should also be very brief and highly relevant – don't add extra "fluff" to make it sound good. Look at the abstract in the sample final paper located in the appendix of this booklet for further clarification. Edit your abstract at least 10 times, trying to cut out words and make it more concise and clear each time.

CONSTRUCTING THE DISPLAY BOARD

The science project display board is a visual summary of the entire investigation carried out by the student. You are required to have a free standing, three sided display no larger then 122 centimeters (48 inches) wide, 274 centimeters (108 inches) high, and 76 centimeters (30 inches) deep. The display is normally purchased from an office supply store and made out of corrugated cardboard. However, you could make your display board out of plywood or fiberboard hinged together. The display must be sturdy and not easily overturned. A typical arrangement of an investigation on the three-sided display is shown below.

Arrangement of Science Project on Three-Sided Display



Your name, your teacher's name, and your school
MUST be on the **back** of the display board.

- Not an art project! Maximum of 3 colors.
- Gender neutral – it should not look like it was made by a particular gender. For example, avoid the color pink.
- Minimum font size of 20. Should be able to read from 2' away.
- The title should be larger font and in center section only.
- A list of Materials and Methods should be on your board.
- A summary of your conclusion will be on your board. You want to minimize the amount of reading the judge needs to do.
- Photos are very useful to show what you did!
- Make sure Data Tables and Graphs are readable and quickly communicate your conclusion.

On the day of the science fair you must lay your final paper in front of your display board.

PRESENTING THE SCIENCE FAIR PROJECT

Both in front of your science class and at the science fair you will present your project. The visual display is used to help you organize your thoughts so that the project can be explained in a sequential and knowledgeable manner. You should discuss the science fair project from personal experience. Make sure you use your science terms correctly.

It would be helpful to present to a family member or a friend first and let them ask you to explain the project and also asks specific questions about how and why this particular investigation was performed.

On the day of the science fair make sure you dress nicely and look the judge in the eyes as much as possible. Answer any questions simply and concisely. Don't chew gum! Do NOT read from your display board.

Your Presentation

Introduction

1. Introduce yourself.
2. Tell how you became interested in the topic.
3. State your problem.
4. Review enough background information so that an average adult is could understand your experiment.
5. State your hypotheses.

Materials and Methods

1. Describe what you did (materials and methods).
2. Explain how the data were collected.

Results

1. Describe the results.

Conclusion

1. Summarize the major findings, including support for your hypothesis.
2. Explain how your finding apply to the real world.
3. Suggest improvements, topics for further study, and potential topics, applications.

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PREPARING FOR THE NEXT SCIENCE FAIR PROJECT

The science fair is over and the student's science project has been stored in the garage. Hopefully, this packet eliminated some of the frustration and the science fair project was a learning experience. Do not make the mistake of forgetting about the science fair until next year. Now is the time to evaluate the experience. Write down any ideas you might have to make completion of the science fair project easier for you next year.

SCIENCE FAIR JUDGING CRITERIA

Evaluation of projects and presentation includes the following:

1) adherence to the scientific problem-solving process;
2) accurate and detailed methodology and data collection;
3) appropriate and proper use of tools and equipment;
4) use of accepted research techniques.

- Overall, judges look for well thought-out research. They look at how significant the project is in its field and the thoroughness of the research. For example, were four experiments started and only three finished?
- Judges applaud students who speak freely and confidently about their research. They are not interested in memorized speeches – judges simply want to TALK with students about their research to see if they have a good grasp of the project from start to finish. Besides asking the obvious questions, judges often ask questions outside the normal scope to test students' insight into their research. For example, judges might ask, "What didn't you do?" and "What would be your next step?"

JUDGING CRITERIA

	Individual	**Team**
Scientific Thought & Engineering Goals	30	25
Creative Ability	30	25
Thoroughness	10	10
Skill	10	10
Clarity	10	10
Visual Display	10	10
Teamwork	-	10

AWARDS

- All students who enter will receive a certificate of participation.
- A Grand Trophy, from Shimadzu Scientific Instruments, Inc., and $50.00 will be awarded to the MST Fair winner's high school, in both the mentored and non-mentored categories.
- A trophy and $50.00 will be awarded to the grand prize winner in both the mentored and non-mentored categories.
- Trophies for the high school winners will be awarded in the following categories:

  - *Biological Science (Animal Biology, Behavioral & Social Science, Microbiology, and Plant Biology)*
  - *Chemistry*
  - *Earth & Space Sciences*
  - *Engineering (Computer Science and Technology_*
  - *Environmental Science*
  - *Mathematics*
  - *Mentored Projects*
  - *Physics*

- Other awards will be presented by scientific societies and professional organizations.

SAMPLE SCIENCE FAIR GRADING RUBRICS

Grading Rubric A

(This rubric is used by all judges at the Glenelg and the Howard County Science Fairs.)

EXHIBITS ARE JUDGED ON THE FOLLOWING BASIS:

Scientific Methodology (30 points)
Is the problem stated clearly? Is the procedural plan for the solution stated? Are variables clearly defined? Are the constants adequately controlled? Is the data clearly displayed and adequate to support conclusions? Are sources of error explained? **Total= ___________**
Comments:

Creativity and Originality of Scientific Process (30 points)
Does the project show creative ability and originality in
- the question asked? - the approach to solving the problem?
- the analysis of the data? - the interpretation of the data?
- the use of equipment? - the construction or design of new equipment? **Total= ___________**

Comments:

Thoroughness (10 points)
Does the project carry out its purpose to completion? Were adequate trials run to gather data?
Comments: **Total= ___________**

Skill – In Lab, Math, Observation, Design (10 points)
Does the student or team have the skills required to do all the work necessary to obtain the data which support the project? Laboratory skills? Computation skills? Observational skills? Design skills? Computer skills? Where was the project done? What assistance was received from parents or other adults? **Total= ___________**
Comments:

Clarity/Oral Expression (10 points)
How clearly is the student or team able to discuss the project and answer your questions? Are they able to explain its purpose, procedure and conclusions in a clear and concise manner?
Comments: **Total= ___________**

Visual Display (10 points)
Does the title accurately present the research? Is the display logically presented and easy to read? Are the visuals labeled with descriptive titles? Is the display eye-catching with interesting headings, charts, and graphs? **Total= ___________**
Comments:

ADDITIONAL COMMENTS: **FINAL TOTAL= ____________**
(List positive comments and suggestions for improvement on the reverse of this form)

Grading Rubric B

0 1 2 3 4	Creativity of Project
0 1 2 3 4	Display board attracts attention, but doesn't detract from science.
0 1 2 3 4	Display board is organized and experiment is easy to understand.
0 1 2 3 4	Data tables, graphs, and verbal presentation is clear and easy to read.
0 1 2 3 4	Sources of error are discussed and future improvements are recommended.
0 1 2 3 4	Graphs are complete and of appropriate type of data.
0 1 2 3 4	Conclusion is clearly stated and supported by data.
0 1 2 3 4	Oral presentation is concise, organized, and exhibits knowledge of the experiment.

- -

Grading Rubric C

Project Attribute	Points earned	Comments
Display (25 pts)		
All elements present (title, etc.)	0 1 2 3 4 5	
Attracts attention, doesn't detract from the science	0 1 2 3 4 5	
Organized and easy to understand	0 1 2 3 4 5	
Data clear, complete, easy to read, appropriate graphs used	0 1 2 3 4 5	
Conclusion clearly stated, supported by data	0 1 2 3 4 5	
Presentation (25 pts)		
Concise, organized, timed appropriately	0 1 2 3 4 5	
All aspects of experiment are discussed	0 1 2 3 4 5	
Sources of error discussed, future improvements recommended	0 1 2 3 4 5	
Applications and extensions discussed	0 1 2 3 4 5	
Question & answer session handled well	0 1 2 3 4 5	
Project Integrity (35 pts)		
Originality of idea/creativity in methodology	0 1 2 3 4 5	
Sample size adequate for valid results	0 1 2 3 4 5	
Variables adequately controlled where possible	0 1 2 3 4 5	
Research completed in timely manner	0 1 2 3 4 5	
Data collected relates to variable tested	0 1 2 3 4 5	
Statistical analysis completed with error bars	0 1 2 3 4 5	
Presentation to Judges at fair (10 pts)	0 10	
Paper and Abstract present, completed and corrected (25 pts)	0 5 10 15 20 25	
Total Points:	(120 possible)	

APPENDIX

EXAMPLE FINAL PAPER
and
GLENELG FORMS

SAMPLE PAPER – PAGE 1

(See paper copy which will be given out the 1st day of school.)

SAMPLE PAPER – PAGE 2

(See paper copy which will be given out the 1st day of school.)

SAMPLE PAPER – PAGE 3

(See paper copy which will be given out the 1st day of school.)

SAMPLE PAPER – PAGE 4

(See paper copy which will be given out the 1st day of school.)

SAMPLE PAPER – PAGE 5

(See paper copy which will be given out the 1st day of school.)

SAMPLE PAPER – PAGE 6

(See paper copy which will be given out the 1st day of school.)

SAMPLE PAPER – PAGE 7

(See paper copy which will be given out the 1st day of school.)

SAMPLE PAPER – PAGE 8

(See paper copy which will be given out the 1st day of school.)

PROJECT APPLICATION FORM

This form must be filled out and used as a cover sheet for your ISEF forms.
Please staple this and all ISEF forms together.
One set of forms is required per group.

INDIVIDUAL PROJECT:

Name _______________________________ Teacher _______________ Period _____ Grade _____

TEAM PROJECT:

Name _______________________________ Teacher _______________ Period _____ Grade _____

Name _______________________________ Teacher _______________ Period _____ Grade _____

ALL PROJECTS:

TITLE:____

____

CATEGORY: (Check one.)

- ☐ Earth and Space Science
- ☐ Animal Biology
- ☐ Behavioral Science
- ☐ Microbiology
- ☐ Plant biology
- ☐ Chemistry
- ☐ Physics
- ☐ Environmental Science
- ☐ Computer Science
- ☐ Engineering Technology
- ☐ Mathematics

Is this a mentored project? (A mentored project consumes 30 or more hours of a professional's time (even if the professional is a family member). ☐ Yes ☐ No

Is this a continuation from a previous year? ☐ Yes ☐ No If yes, date started _____ mm/yyyy

Special needs for display: ☐None ☐ Electrical ☐Space

IF ANY OF THE INFORMATION YOU SUPPLY ON THIS FORM CHANGES BEFORE THE FAIR YOU MUST SUBMIT A <u>COMPLTED</u> NEW FORM WITH THE WORD "<u>REVISED</u>" AT THE TOP AND THE INFORMATION THAT YOU CHANGED <u>HILIGHTED!</u>

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Name ____________________________

Science Fair Brainstorming Worksheet

Two General Areas of Science Interest:

1. ________________________

2. ________________________

Two Specific Problems for each Area of Interest:

1A. ________________________

____

____

1B. ________________________

____

____

2A. ________________________

____

____

2B. ________________________

____

____

Brainstorming Questions –

Circle the problem of greatest interest above and answer the following questions on that topic.

1. What materials are readily available to me for conducting experiments on this topic?

____

____

____

2. How does the topic act or respond? OR What type(s) of behavior can it exhibit?

____

____

____

3. What types of materials could be used to cause this topic to react or show change?

____

____

____

4. How can I measure this response or change?

____

____

____