2023
MMSTC Sophomore Research Manual

This completed research project, an acceptable written paper, and an acceptable presentation are mandatory to meet the tenth grade IDS/chemistry requirements and a passing grade in these courses. The tenth grade research project will be based on exploring a concept of chemistry via extension of an already existing laboratory experiment or previous research.

General

Please use a vocabulary and sentence structure that expresses your scientific knowledge and writing skills. It is your responsibility to proof read and revise all work conducted by you and your partner. Remember this is a **group** project their work is a reflection of you. Please communicate with your group member on a regular basis, delegate tasks, and work effectively and efficiently.

The paper is to be written in past tense (third person), using uniform font size (12 Arial). Since the page will be left bound, remember to have a 1.5 inch left margin. Do not use contractions. Alphabetized names appear as headers with a hyphen between names. Use page numbering with the **Introduction being Page 1**. Each section of the paper will begin on its own page.

Basic Formatting Requirement

- Written in third person past tense. Do not use "you," "I," etc. Procedures written in second person (Still, do not use "you" or "your").
- Uniform font size 12 and legible font type (Times New Roman or Arial). Keep this consistent throughout your entire paper! Information on labels, charts, and graphs can vary between size 10 and 12. Consistency is key!
- 1.5 inch left margin. 1 inch margin everywhere else.
- Tables and figures are properly formatted, labeled, scaled, and anchored. Table and figure numbering must be sequential throughout entire research paper. Each must be anchored in text (paragraph form).
- Correct spelling and grammar always apply. No contractions.
- Research partners' names are alphabetized and appear as headers with a hyphen between names (Acre – Estapa). Complete information is on title page.
- Use page numbering starting with the "**Introduction**" section as page 1. Page numbers are to appear in the header after partners' names and one space.
- Start each section of the research paper on a new page. Each section title is in **BOLD** and centered**;** subsections are underlined.
- Projects are to be original research or, with approval, extensions of previous research. All corrected rubrics and drafts must be submitted with final paper.

Sections of the Paper

1. **Title Page** (centered) must include:

TITLE
Your Names in Alphabetical Order
Macomb Mathematics Science Technology Center
Class
Section #
Science Teacher / IDS Teacher / FST Teacher
Due Date

2. **Table of Contents**

This section should consist of a complete table of contents listing all the parts of the paper and appendices with correct page number. No page number or header. Include the title of your Appendices, EX: Appendix A Thermodynamic Data

3. **Introduction** (1– 2 pages)

This section sets the stage for your scientific argument. It places your work in a broad theoretical context and gives readers enough information to appreciate your objectives. A good Introduction 'hooks' its readers, interesting them in the project and its potential significance to the scientific community and/or the general population. The writer must have a firm grasp of the concepts, expected results and relevance of the research. You may find that the Introduction is easier to write *after* you have written other portions of your paper and have a clearer understanding of just what you are introducing.

- What was the purpose of this project?
- State the objectives of your project and how you intended to accomplish your objectives.
- **Briefly** describe your methods of experimentation and what you hoped they would prove/solve.
- How is your project/concept of value to the scientific community?
- What are the practical applications of your research?

4. **Review of Literature** (2-3 pages)
(Need 5 cited sources, 3 must be books or journals, Wikipedia is not acceptable)

Resources can be found at:
http://mmstcchemistry.weebly.com/start-your-search-here.html

The purpose of this section of your paper is to discuss all the scientific information necessary to understand your topic. The Review of Literature includes an explanation of the progression of relevant research and related experiments in your field of study, and what methods were used by predecessors who have already studied this topic and the results of their work. Briefly mention how your approach varies from previous investigators. Your Review of Literature should help you formulate a good problem statement and give you a foundation from which to model your experimental testing. This is where you must educate the reader to the

SCIENCE involved. Consider your target audience and define or explain any terms, formulas (see Appendix A for format) and concepts that are critical to understanding this section. Your Review of Literature should help you formulate a good hypothesis, and give you a foundation from which to model your experimental testing.

- When scientific terms or words are used that are unfamiliar to most readers be sure to **explain the science behind these**
- What mathematical relationships/formulas will be used to conduct your research? What units will they be measured in? Describe these formula(s) with proper units. Use proper formatting (see Appendix A).
- Reference the work of other research and their experiments. What information of theirs will YOU use?
- How are the experiments noted above applicable to this research project and YOUR experimental design choices?

For example:
The First Law of Thermodynamics states that energy is not created or destroyed. The chemical reaction between zinc and hydrochloric acid produced heat. Then you would go on to explain enthalpy, exothermic reactions, calorimetry, system and surroundings, perhaps a diagram showing enthalpy for the reaction. You MUST explain HOW this happens, and WHY it happens.

5. **Problem Statement**

This part will consist of three labeled subsections:

Problem: A short, concise description of the problem.
*Example of a **poor** problem statement:*
If density is determined the unknown metal will be identified.

Hypothesis: It is a statement which is to be tested. Written in quantifiable (number) terms. Be specific.

Data: You are to identify the independent and dependent variables, units of measure for ***each*** variable, and the intended statistical analysis. You should account for all variables you will need to measure to calculate your data with units. Write this section in complete sentences.

6. **Experimental Design**

This section contains a detailed description of the materials used and the procedures employed. Consult the laboratory format we have used this year. This section MUST include the three, separately labeled subsections:

Materials: List in either one or two columns with quantities. Chemicals are labeled with full name and chemical formula and molarity if applicable. Include size and measurements where applicable (100 mL beaker). Include model number and precision of all measuring devices (0.1 g).

Procedures: A detailed, numbered step-by-step approach used in the experimental investigation. Common procedures for all lab work -- such as putting on goggles and a lab coat or how to mass a scale -- are not necessary. Calibration of equipment and randomization of trials *should* be included. Format Note: Single space each entry, double space between numbered steps. **You must also have a video clip for your presentation.**

Diagrams: Detailed **labeled** useful photograph of experiment set up(s). You will be marked down for useless photos (i.e. a roll of tape sitting on a lab bench, scale, beaker). Tables and observations are not diagrams. Blank data tables should not be included in your paper.

* Procedures, calibrations and diagrams that expand on your experimental design or used within it (pre/post lab work) appear in an appendix.

7. **Data and Observations**

This is where you will directly report the raw data, the manipulated data, and any observation for each trial.

Data: Data tables (in MLA format) should show all variables needed to calculate your final answer. Conversions need not be shown. In data tables, report the number of significant figures that each measuring device gave you. If data tables run more than one page, repeat column headings on second page. Objective commentary only.

Observations: Place observations in a table format as close as feasible to the data that they describe. Include **observations** for each trial. Observations may include information regarding the setup, equipment, and problems encountered for **each** trial of each experiment etc. Include any photos of these observations where applicable (i.e. the metal bent in half on trial 4, pre/post treatment photos). Any photos documenting observations you have made should appear in this section only. Do not include photos of experimental set up. Objective commentary only no analysis is allowed.

8. **Data Analysis and Interpretation**

Use this section to calculate and report any statistical analysis you have performed with your data. Start with a paragraph describing your method of collections and what type of analysis was performed; why it is appropriate and how you know it is valid. This is where graphs, modeling, curve fittings, and/or statistical tests appear. Include the test statistic and p-value along with the results of the test in this section, if appropriate. See specific requirements/explanations in Appendix B of this manual [page 8].

9**.** **Conclusion** (1-3 pages)

This section is one of the most important sections of your paper and tends to be the one that receives the least attention. It is used to summarize the general conclusions drawn from your experiment. Experimental strengths, scientific

relationships, patterns, and arguments that you have been building up in your paper, all come together in this section.

- This section is used to draw final conclusions with respect to your experiment.
- Recap your problem statement and hypothesis and if it was accepted or rejected and why.
- Did your data support your hypothesis? Why or why not (use science to support this and explain the how).
- Briefly state your conclusion with an appropriate statistic or percent error. Specifically, tell the reader what your findings mean, supported with scientific and/or experimental evidence.
- Explain **WHY** the results occurred. Explain these results scientifically. Tell whether your results agree or disagree with current research you referenced in your review of literature and explain **WHY**.
- Was your experiment well designed? Explain.
- What problems or errors did you encounter in making your measurements?
- Suggest ways to make your experiment better and ways to minimize error. "**Human error" is not an acceptable suggestion**.
- What additional experiments could/should be done in the future to support your work? What equipment and data would be needed?

10. **Acknowledgments**

Express your appreciation to people who assisted you with your paper or research project. This page is optional.

11. **Appendix**

Appendices allow you to include detailed information in your paper that would be distracting in the main body of the paper. Examples of items you might have in an appendix include mathematical formulas, additions to your experimental setup, a detailed description of an apparatus used in the research, etc.

Format: Page has a header and a title and is a numbered page. Each new appendix will start a new page and should be identified in the table of contents by letter (A,B,C) and title (Sample Calculations). EX: Appendix A Sample Calculations

Hilliard-May 45

Appendix A: Sample Calculations

12. **Works Cited** (Need 5 cited sources, 3 are books or journals)

It is necessary to list all the references used in this investigation. Only sources used in the investigation should be included in your Works Cited page. You will be marked down for having sources that are not referenced in the body of your paper. A good reference originates from a reliable source such as a peer reviewed journal or industry specialist. Your paper is only as good as your resources.

Citations should be presented in correct MLA style and support any parenthetical citation used throughout the paper. The work cited will appear as all uniformly double spaced, and the page has a header and is numbered.

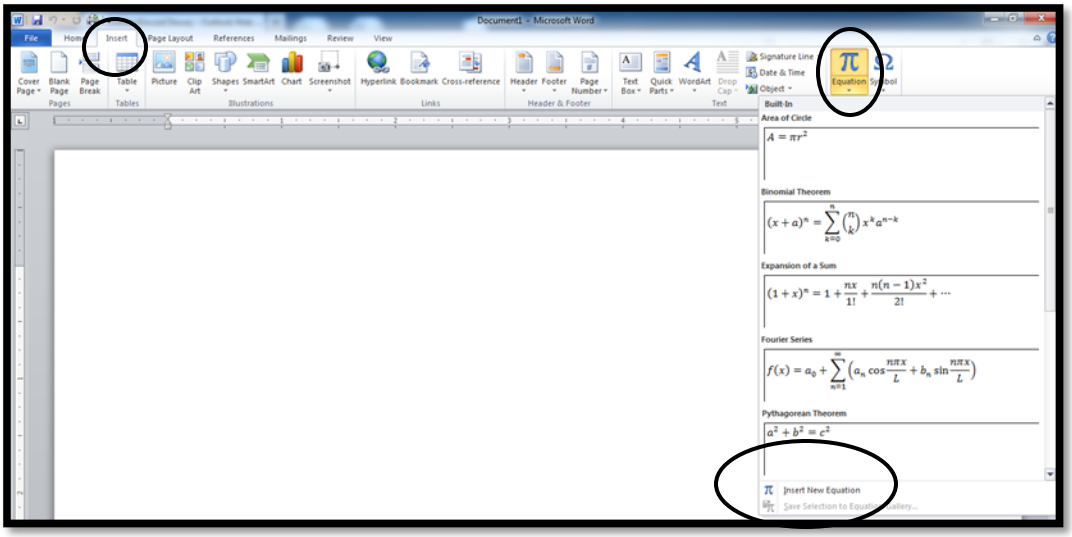
Example of intext citation*:

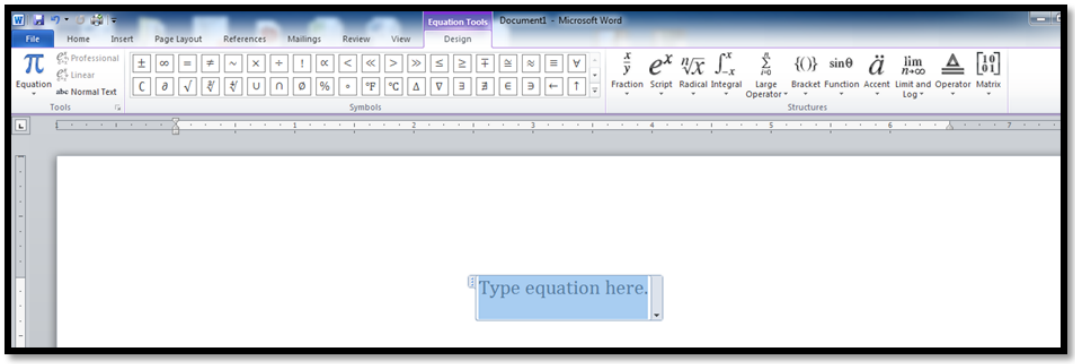
Karry Mullis is the father of PCR (Hilliard).

*The purpose of an internal citation is to help the reader easily & quickly find the entry in the Works Cited page. What you cite should be the first thing a reader will see when reading your Works Cited.

Appendix A: Formatting Formulas and Equations

Use Equation feature when typing formulas. (*Insert* tab → click on *Equation* → *Insert new equation* [at bottom of pull down menu]) See screenshots below. **When formatting scientific notation use 10^{-6} NOT 10^-6.**





How to reference and format a formula/equation in your paper:

Example:

Plank gave the name quantum to the smallest energy that can be emitted or absorbed. He proposed that energy, E, of a signal quantum number equals a constant, h, times its frequency, v.

$$E = h \times v$$

Others built on his contributions by…….(Continue paragraph here)

How to reference and format sample calculations

Note: The original formula is centered, but not the actual sample calculation **and** that the units are identified throughout the work. Sample Calculations are formatted using Equation Editor.

Example:

To analyze our data we needed to use the following equation where energy, E, of a single quantum number equals a constant, h, times its frequency, v.

$$E = h \times v$$

Shown in Figure 1 below is a sample calculation using the equation for the energy of a photon.

$$E = h \times v$$
$$= (6.623 \times 10^{-34}\ J - s)(5.09 \times 10^{14}\ s^{-1})$$
$$= 3.37 \times 10^{-19}\ J$$

Figure 1. Energy Equation

Sample calculation of the energy of a photon using the first trial of the gathered data.

**Note in your paper this should not be boxed*

Appendix B: Data Analysis and Interpretation

There are three options: **(1) DOE** OR **(2) Descriptive** OR **(3) Descriptive <u>and</u> Another Statistical Treatment.**

(1) <u>DOE</u>:

(Use DOE packet in I:\MMSTC\Assignments\DOE Information as a MODEL--do NOT cut & paste!)

Factors	(+) Values	Standards	(-) Values

Level	DOE 1	DOE 2	Average
+ + +			
+ + -			
Etc.			

1. Clearly identify and label the high, low and standard values.

2. Include a table of all samples at each level (+++, -+-, etc.) for each DOE as agreed to on your contract, as well as the **average at each level**.
   The analysis is done on the **average at each level**.

3. Include a graph, table and comment for each of the single factors.

4. Include a graph, table and comment for each of the 2-factor interactions factors.

5. DO NOT include a summary page of all the effects.

6. Include a plot of standard points to look for trends and a comment about the plot.

7. Include a dot plot of all effects on a number line and comment on the effects found significant.

8. Include the parsimonious prediction equation.

9. Save conclusions for the Conclusion section of the paper [Section 9].

(2) Descriptive

1. Include plot(s) of the data (histogram, box plots, line graphs, etc.).

2. Comment on any trends, patterns, etc. present.

3. IF you have less than 30 trials, discuss the normality of your data. Use box plots, normal probability plots, and/or other information to determine.

4. State mean & standard deviation of each set, **if** appropriate.

5. Find a mathematical model, **if** appropriate.

6. Remember to interpret the results but save the science behind the conclusions for the Conclusion section of the paper [section 9].

(3) Descriptive and Another Statistical Treatment:

1. Include plot(s) of the data (histogram, box plots, line graphs, etc.).

2. Comment on any trends, patterns, etc. present.

3. State mean & standard deviation of each set, if appropriate.

4. Find a model, **if** appropriate.

5. Specific requirements for individual tests*:

One-sample *t* test

6. If less than 30 data points, plot the data and show that there are no outliers or skewness. (If there are, the *t* test does not apply. Do descriptive analysis only.)
7. Clearly state the standard and the sample.
8. State the null and alternative hypotheses. Use mathematical notation and identifying subscripts. Also explain in a sentence or two using the context of the experiment.
9. Identify the *t*-value. Show the graph and **explain** the *p*-value in relation to your problem (*t* test screen and graph).

Two-sample *t* test

6. If less than 30 data points, plot the data and show that there are no outliers or skewness. (If there are, the t-test does not apply. Do descriptive analysis only.)
7. State the null and alternative hypotheses. Use mathematical notation and identifying subscripts. Also explain in a sentence or two using the context of the experiment.
8. Identify the *t* value. Show the graph from the calculator and **explain** the *p*-value in relation to your problem (*t* test screen and graph).

*****Formulas for all statistical tests should be shown and detailed in an **appendix**. Also a sample calculation should be given. For example, if you a performing a *t* test you would show the equation for it and also define each variable in the anchor. Every calculation should begin with an introductory sentence. No paragraph should begin with a figure.

Example:

As shown in Figure 5 below, the *t* value of the experimental data compared to a known standard was determined using the following calculation.

$$t = \frac{\overline{x} - \mu}{\frac{s}{\sqrt{n}}}$$

$$t = \frac{17units - 20units}{\frac{3}{\sqrt{30}}}$$

$$t = 5.5$$

Figure 5. *t* test Formula and Sample Equation

This equation calculates the value *t* which represents the number of standard deviations above or below the mean that average data lie in a *t* distribution. The mean of the sample is represented by x□ [included units], μ shows the standard value that x□ is being compared to [include units], n represents the sample size and s is the sample standard deviation.

*Note in your paper this should not be boxed