

Introduction

"A massive steel ball and a feather were dropped from the same height at exactly the same time. Which of the two will hit the ground first?"

The Greek philosopher Aristotle theorized that a heavier body falls faster than a lighter one of the same shape in a dense medium like water. This led him to speculate that the rate of fall is proportional to the weight and inversely proportional to the density of the medium. Because his ideas appeared to make sense, they became popular and well accepted for many years.

According to legend, Galileo dropped balls of various densities from the Leaning Tower of Pisa in Tuscany, Italy and found that lighter and heavier ones fell at almost the same speed. In fact, he did quantitative experiments with balls rolling down an inclined plane and concluded that all bodies fall at the same rate neglecting friction.

While consistent with human experience, Aristotle's principles were not based on experiments that are controlled. With the help of Galileo, the scientific method and advancement in technology, their contribution to our knowledge of motion become remarkable. As a student of physics, you will encounter many situations that call for critical analysis and evaluation of everyday experiences and other phenomena. From simple motion problems to the behavior of subatomic particles, the principles, theories and laws of physics are rather overwhelming. We may know little about motion without scientists like Galileo who made careful observations and experimentation to bring principles to test.

As you embark in this investigative project once more, it is our desire that this guide will help you search answers to problems and make more meaning to this undertaking. This was written to give direction and purpose as you prepare yourself to many challenging tasks. We hope that you will use this opportunity to make this experience of science a work of human creativity and ingenuity. God has created this world with such beauty and precision one can ever imagine. May you realize that as you begin to discover little things about our world, you begin to discover the details of His creation - His masterpiece!

The Authors

The Physics Investigative Project

An investigative project is a planned undertaking in a particular field of science (biology, chemistry, physics and mathematics) or technology involving creative, critical thought and action. It is an activity that aims to develop one's ability to identify and determine possible solutions to problems in the community or possible explanations to a particular phenomenon.

Doing an investigative project is a complex process. It requires a careful and systematic evaluation of relevant information gathered in order to solve problems. Hence, the ability to manage time and follow-up on the project's intermediary stages is crucial to this undertaking.

As an overview, below is an outline of the different types of investigative projects.

- a. **Experimental Type.** This is a method of research wherein a variable is controlled so that experimental factor is separated for measurement of its change. It is a systematic approach which uses manipulation and testing to understand causal processes.

Examples:

- *The Effect of the Presence of Inorganic Depurative and Charcoal on the Cleanliness of Water (Geli et.al. 2011)*
- *The Effectiveness of Sodium Hypochlorite in Antibacterial Cleaners on the Percent Count of Bacteria Post Application (Doloroso, et.al. 2011)*

- b. **Observation Type.** This is a systematic and direct means of gathering data by watching and recording various situations and conditions in conducting the study. It is a correlational or non-experimental type of investigative project.

Examples:

- *Effects on Children of Occupational Exposures to Lead (Morton et.al. 1982)*
- *The Effect of the Presence of Earthworms on the Growth of Solanum lycopersicum (Macabulos, et.al. 2011)*

- c. **Survey Type.** This is a study that attempts to interpret, analyze and report the present condition of a thing or place. It is a type of quantitative investigative project that can be employed in a variety of disciplines.

Examples:

- *Perception of Fourth Year Regular High School Students on the Effect of Wi-Fi Technology on their Studies*
- *Prolonged Use of Visual Display Terminals and Its Perceived Effects on the Eye Vision (Lui, et.al. AHS 2011)*

INVESTIGATIVE PROJECT MAKING

CHOOSING A TOPIC

Choosing a topic to work on is a rather difficult task. The topic that you will choose will be the cornerstone of all your work for the entire school year. Therefore, it is important to identify the area of science that will work best for your group. Below are important considerations as you choose a topic.

- a. your own interests and abilities
- b. your scope or level of knowledge
- c. time required to complete the project-it should be reasonable
- d. availability of materials and other resources
- e. relevance of the topic to socio-economic growth or developmental needs of the country
- f. expenses involved must be commensurate to the benefits of the expected results
- g. safety measures-these must be observed (human subjects, use of hazardous substances)

To help you find an investigative project idea that can hold your interest, it is recommended that the following sources of information be utilized:

Survey of Community Problems

- Interaction/interview with community officials, residents
- Interview an ecologist about ecological problems

Library Research

- Books, periodicals, magazines and newspapers can provide problems for study as well as information on a particular subject of interest.

Use of Available Research Studies

- List of recommendations of a study can provide new research problems.
- Experimental factors that were not well studied due to lack of controls or variables.
- Experimental procedure that needs some modification

Other Sources

- Private corporations, government agencies, social and professional organizations.
- AV materials (maps, films, slides and recordings)
- Internet

As you start making a shortlist of topics for proposal to your teacher, take note of the following examples of good and poor investigative project topics with the corresponding explanation why they are considered as such.

Examples of Good Topics

- **Effect of arch curvature on load carrying strength**
This topic involves quantitative analysis and has scientific validity. It involves the use of scientific principles in relating one variable with another.
- **Identifying alternative insulation materials**
The project involves experimenting on different materials and observing the behavior of the dependent variable.

Examples of Poor Topics

- **Effect of colored light, music or talking on plants**
This topic is difficult to measure or quantify thus, it becomes very subjective and unreliable. Your group can be more creative and critical at the same time.
- **Construction of an electric generator**
The design and construction of an electric generator is an example of a simple demonstration and not experimentation.

- **any of the following topics described below**
 - creates unacceptable risks to human (physical or psychological) or animal subjects
 - requires dangerous, hard to find, expensive or illegal materials
 - requires measurement that will be extremely difficult to make or repeat given your equipment.

TOPIC PROPOSAL

Direction: Considering the guidelines in choosing your topic for investigative project, submit three (3) topic proposals following the format described below.

1. In two sentences, give the background of your chosen topic and its significance.
2. In three sentences, describe the problem that you want to investigate together with your proposed solution.
3. In two sentences, describe the resources needed and the methods of science that will be used to solve the problem.

Rubrics

Content	Points
Description of the study (problem, solution, method)	18
Background or significance of the study	12
Format	
Font: Times New Roman size 12	1
Line Spacing: Double	1
Margins: 1.5 in, left; 1 in, top, bottom, right	1
Paper: clean, A4	1
Paper Submitted on Time	1
TOTAL	35

Submission: July 1-5, 2013

STATEMENT OF THE PROBLEM

This part of the investigative project paper describes what you are trying to find out and what will be your subjects or objects of study. It consists of a general problem statement followed by specific problem statements as shown in the example below.

Example:

The purpose of this study is to design and construct a balloon-powered car that works on the principle of Newton's laws of motions and would run fast and cover a long distance. In this study, the researchers sought the answers to the following questions:

**General
problem
statement**

1. What factors affect the maximum speed and displacement of a moving object?
2. What laws of motion must be considered in the design and construction of the car?
3. What materials can be used in the construction of the balloon-powered car that would run fast and cover a long distance?

**Specific
problem
statements**

OBJECTIVES

The investigative project objectives must be paralleled to the problem statements. This consists of a general objective followed by specific objectives as shown below.

Example:

With the desire to design and construct a balloon-powered car that works on the principles of Newton's laws of motion and that would run fast and cover a long distance, the researchers will:

**General
objective**

1. Identify the factors that will affect the maximum distance covered by the balloon-powered car.
2. Explain how Newton's laws of motion are applied in the operation of the balloon-powered car.
3. Identify the materials that can be used in the construction of the balloon-powered car.

**Specific
objectives**

HYPOTHESIS

A hypothesis is a tentative answer to the research question. It states the condition and predictions in the experiment. It must be testable within a reasonable amount of time and the variables properly stated in easy to measure terms. More importantly, a hypothesis should be falsifiable. The hypothesis may be stated in three ways namely;

1. A hypothesis in the null form states that there is no significant difference between the results of two conditions being tested.

Example:

There is no significant difference between the effects of horse manure and urea on the following variables: average height per plant; time of flowering per plant, etc.

2. A hypothesis in alternative form states that there is a significant difference between the results of the two conditions being tested.

Example:

There is a significant difference between the effects of horse manure and urea on the following variables: average height per plant; time of flowering per plant, etc.

3. A cause and effect statement states that if a certain condition (cause) is true, then a supporting observation (effect) occurs.

Example:

If there is a significant difference between the effects of horse manure and urea, then the growth of the plants will differ significantly in terms of average height per plant; time of flowering per plant, etc.

In the example below, the dependent and independent variables are measurable and explicitly stated. There should be at least three specific hypotheses.

Example:

To attain the primary purpose of this study of designing and constructing a balloon-powered car, the researchers believe that:

1. If the diameter of the balloon used is increased, then the car would travel faster and cover a long distance.
2. If the wheels have bigger diameter, then the car would travel faster and cover a longer distance.
3. If the surface of the wheel is rough, then it would have greater friction on the ground, so the car would travel faster and cover a longer distance.
4. If the straw is longer, then it will generate more force, so the car would travel faster and cover a longer distance.

REVIEW OF RELATED LITERATURE

The review of related literature is an essential part of your investigative project. It discusses the relevance of your study to several concepts, theories and arguments. Specifically, it should explain;

- why your investigative project needs to be carried out
- how you came to choose certain methodologies and theories to work with
- how your study contributes to the experimental studies done by others on the same topic

The presentation of the literature should be divided into three parts namely; Introduction, Body and Conclusion as shown in the examples that follow.

Introduction

This is where you define or identify the general topic, issue, or area of concern, and let the reader understand the context for reviewing the literature.

The country's effort is currently focused on the propagation of *Jatropha curcas* L. in response to the call of the Department of Energy (DOE) to increase the use of alternative fuels as means to achieve its goal of "self-sufficiency in 2010" (Department of Energy Philippines, 2006). In the same way, the Commission on Higher Education (CHED) includes the intensive research on alternative energy source in the top list of its research agenda. Thus, the need to continually explore on alternative energy resources becomes imperative and poses an urgent challenge to scientists.

Source: Librea, 2007

- Point out overall trends in what has been published about the topic, or conflicts in theory, methodology, evidence and conclusions, or gaps in research, or a single problem or new perspective of immediate interest.

Studies showed that *J. curcas* together with *Pongamia pinnata*, more commonly known as Pongam, proved to have the oil most suitable for conversion to biodiesel (BDF) (Patil 2003, Pramanik 2002). In other species like *Pittosporum resiniferum*, resinous substance is found to contain „crude petroleum” (Perry, 1980) and resin ducts accompanied by vascular tissue and bordered with tabular shaped cells were reported in the mesocarp of the fruit (Tolentino, 2002). Despite the reports on seed oil extracts of *Jatropha* as possible source of biodiesel (Ratree 2004; Henning 2002; Del Greco 2005; Rockefeller Foundation & Scientific & Industrial Research 1998; Becker & Francis 2005), limited studies have been done on its morphology and anatomy. Hence, the study will attempt to screen the tissues of fruits and seeds for presence of oil cell, characterize its anatomical features and differentiate it from other cells.

Source: Librea, 2007

- Explain the criteria that you used in analyzing and comparing literature and the organization of the review. When necessary, explain why certain literature is or is not included.

The review of related literature will focus on the presence, location, distribution and development of oil cell at different developmental stages of fruits and seeds of *J. curcas* in different locations. Extraction and chemical testing of the oil composition will not be included in this review since the focus of the study is anatomical study of *J. Curcas*.

Source: Librea, 2007

Body

In the body, organize your review according to a specific criterion to make the flow of your discussion coherent.

Anatomy and Function of Oil Secretory Structures

Secretory structures vary in location in a plant body. They are either external or internal cells (Esau 1967). Furthermore, they are classified according to the structure, function and ...

Location and Distribution of Oil Cells in Different Organs of Plants

Known occurrences of oil cell in plants are in vascular and ground tissues of stem and leaf (Esau 1977). In the leaf of *Tasmania lanceolata* (Winteracea), oil cells are dispersed in the mesophyll...

Development of Oil Cells

According to West (1969), and Mariani et al., (1989) oil cell development is characterized by lysigenous development, formation of tripartite wall and "cupule" attaching the oil sac to the wall. The...

Source: Librea, 2007

Instead of jumping immediately to the next topic, put topic titles/topic organizers to signal to the reader that you are now moving on to the next topic.

- Discuss in detail the theoretical underpinnings on which your research is based on.

Development of Oil Cells

According to West (1969), and Mariani et al., (1989) oil cell development is characterized by lysigenous development, formation of tripartite wall and “cupule” attaching the oil sac to the wall. The early stages of oil cell development in species of various families of Magnoliaceae, Lauraceae, Anonaceae, Hernandaceae, and Liliciaceae, are similar in characteristic. The oil cells initials (OIC) increase in size, become larger and have better stain affinity than the surrounding parenchyma cells (West 1969; Tucker 1976; Postek & Tucker 1983; Mariani et al., 1989). As OIC enlarges, adjacent cells are pushed to the side.

Source: Librea, 2007

- Discuss also the major findings of other researchers who did a similar study. More importantly, write your own comments to the studies that the researchers did.

Oil cell development has been investigated in different species of plants such as *Magnolia grandiflora* (Postek & Tucker 1983), *Persea americana* (Platt et al., 1983; Platt and Thomson 1981), species of woody Ranales (West 1969), *Crombe* sp (Smith 1974), *Laurus nobilis* (Maron & Fahn 1979), *Eupatorium rugosum* (Curtis and Lersten 1986) and *Saururus cernuus* (Tucker 1976) and *Liriodendron tulipifera* (Mariani et al., 1989). Normal ontogeny of oil cells in woody Ranales is characterized by the development of lysigenous cavity, formation of oil sac and stalk-like attachment or cupule and complex cell wall (West 1969). In the fruit of *P. americana*, Platt, et al., (1983) concluded that formation of complex cell wall and localization of oil accumulation characterized development of idioblastic oil cells. Furthermore, Esau (1977) noted that secretions of oil cells in avocado are confined in oil sacs with cellulosic wall.

Source: Librea, 2007

Conclusion

End your review with a summary of the contributions of significant studies and articles to the topic under review.

- Evaluate present knowledge of the topic, pointing out major flaws or gaps in research, inconsistencies in theory and findings, and issues pertinent to your study.

Despite the promising alternative fuel source of *J. curcas*, very limited studies on the anatomical characterization have been done.

- End your review by giving an insight into how the topic being reviewed is related to a larger field of study.

Since this may be a pioneering study on the ultrastructure and ontogeny of oil cell in the fruits and seeds of *J. curcas*, it hopes to contribute in the existing literature on secretory oil cell in plants. It can be used as contributory literature in the taxonomy of the species.

D. Bibliography

Attach a bibliography on a separate page. Use the Turabian citation style.

Examples:

Ameele RJ 1980. Developmental Anatomy of Secretory Cavities in the Microsporophylls of *Ginkgo biloba* L. Botanical Gazette 67(6): 912-917.

[Aiyelaagbe OO, Adesogan EK, Ekundayo O, Adeniyi BA.](#)1994. The antimicrobial activity of roots of *Jatropha podagrica* (Hook). Phytother Res. 14(1): 60-2.

Batra A. & Rajore S. 2005. Efficient Plant regeneration *via* shoot tip Explant in *Jatropha curcas* J. Plant Biochemistry and Biotechnology 14. (January):73-75.

Bhatnagar K & Kapil R. 1994. The Contribution of Embryology to the Systematics of Euphorbiaceae. *Annals of the Missouri botanical Gardens*. 18 (2): 145-159.

Becker K & Francis G. 2005. Bio-diesel from *Jatropha* plantations on degraded land. *Natural Resources Forum* 29. (December)

Beg J. & Gaskin T. 1994. *Jatropha Podagrica*. National Toxicology Group. unpublished.

Can Ake- R 2004. Bioactive Terpenoids from roots and leaves of *Jatropha gaumeri*. *Rev. Soc. Quim. Mex.* (48) 11-14

Note:

- .edu and .org sites are more preferred internet sources.
- Sources from the following are strongly discouraged: .com sites, wikipedia, yahooanswers, and about.
- Sources from the following are strongly encouraged: printed materials/books (at least 3) and science journals/monographs (at least 3)

Rubrics

Statement of the Problem	Points
The general problem statement describes what the project is all about	1
The specific problem statement	
..... is stated in question form (1 X 3)	3
..... will lead to answer the question posed in the general problem statement (1 X 3)	3
..... specifies the variables to be investigated (1 X 3)	3
Objectives	
The general objective describes the purpose of the project	1
The objectives are appropriate to the problem	1
The specific objective is SMART(1 X 3)	3
	13

Hypothesis

The hypothesis is appropriate	1
The condition is clearly stated (3 x 1)	3
The prediction is clearly stated (3 X 1)	3
The variables are measurable (3 X 1)	3

Review of Related Literature**Introduction**

.....the general topic or concern was presented	5
.....overall trends about the topic were discussed	5
.....criteria used to analyze and compare literature were explained	5

Body

.....literature was organized into specific criterion	5
.....scientific concepts are identified correctly	5
.....correct principles/concepts are discussed thoroughly	10
.....correct equations are cited and discussed	10
.....major findings of the researchers were discussed and commented on	10

Conclusion:

.....contributions of other researchers were summarized	5
.....present knowledge of the topic is evaluated	5
.....topic is related to a larger field of study	5

Sources are cited correctly	5
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Paper Submitted on Time	1
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Bibliography (at least 10 sources)	10
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Format

Font: Times New Roman size 12	1
Line Spacing: Double	1
Margins: 1.5 in (left); ; 1 in (top, bottom , right)	1
Paper: clean, A4	1

TOTAL	115
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METHODOLOGY

Planning is an essential part of your investigative project. An architect provides the design of a structure and the engineer builds it. In a scientific investigation process, an experimental design should be in place first before doing any experimentation.

The methodology is a general system that presents specific components of the investigative project such as materials, procedure, phases and techniques in order to attain the objectives.

Materials. Make a list of all the materials, tools or equipments that you need. You may visit your laboratory technicians to inquire about availability of such. In case that the materials are only available in other institutions, you may draft a request letter to the person-in-charge and ask your teacher's approval by affixing his or her signature.

The list of the materials should be written as accurately as possible. It is imperative that the following information is included:

- complete description of the item
- the quantity/unit

Example:

3 pcs	10 cm x 10 cm cardboard paper
20 mL	distilled water
1 unit	mercurial sphygmomanometer

Procedure. You are familiar with the lab manual or cookbook method of writing the procedure. For convenience, it is highly encouraged that this section is written in "past tense" which will eventually be the acceptable format in the final IP paper.

Depending on the type of investigative project and your hypotheses, the examples below show how the procedure should be stated.

- **Type 1. Construction**

Sample Hypothesis: Newton's Third Law can be demonstrated by using a balloon-powered car made out of discarded but still reusable materials.

Sample Procedure:

1. A hole was drilled on the center of the bottle caps...
2. Barbecue stick was inserted...

- **Type 2. Variable Testing**

Sample Hypothesis: The bigger the wheels of the car, the farther the car will go.

Sample Procedure:

1. Wheels with a diameter of 1 in were inserted into the axles.
2. The balloon was inflated to a circumference of 30 in. The car was then let go and the total displacement was measured.
3. The previous step was repeated using wheels of diameter 3 in, 5 in, 7 in, and 9 in. The mass of the car and the diameter of the balloon were kept constant.

- **Type 3. Survey**

Sample Hypothesis: About 75% of AHS senior students carry backpacks that weigh 3 kg or more.

Sample Procedure:

1. The population sample was determined using the equation...
2. X no. of students per class were asked to fill out a questionnaire regarding the type of bag and the weight of the bag they carry on a regular basis
3. Results were tabulated and a frequency table was constructed...

The procedure can still change depending on the results of your first experiment. When this happens, you should be ready to plan measures to deal with the situation and respond appropriately.

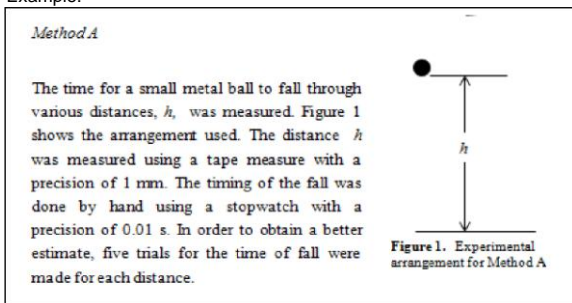
Variables and Trials

A variable is a factor that might affect the behavior of the experimental set-up. In an investigative project, there are situations when you have to change or manipulate one variable (independent variable) and observe its effect on another variable (dependent variable). In an experiment, you can only change one factor at a time.

Increasing the number of trials in an experiment increases the reliability of the result. It is therefore necessary that you can decide on a reasonable amount of trials which is dependent on the type of study that you are pursuing.

Diagram. In the procedure section, visual representations can be added. However, the figure number and the corresponding description should be included.

Example:



Source: Kirkup, Les

For construction type of project, the diagram of the prototype to be constructed is necessary. The properly labeled diagram should include the dimensions as well. This should be done on a separate sheet of paper.

DATA PRESENTATION

After gathering all the results of the experiment, your task is to communicate them in a logical way by using tables and graphs. Remember that the data can be descriptions of your observation (qualitative) or the result of your measurements (quantitative).

Data Table. The sample data table below shows the following:

- brief description of the table
- table number and title
- the label on the header rows
- units of measure used
- precision of the measured values

Method A

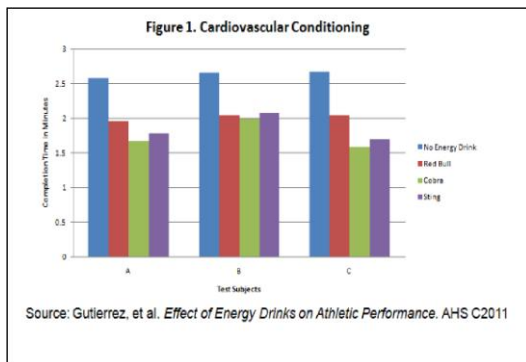
Table 1 shows the data gathered for the free fall of the ball as a function of distance. The second column of the table contains the mean of the five measurements made at each distance, h . The uncertainty in the time was calculated by dividing the range of times measured at each distance by the number of trials made.

Table 1. Time for the ball to fall various distances

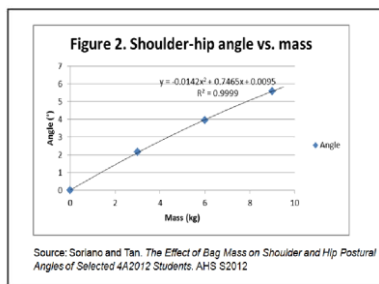
Distance, h (m) ± 0.01 m	Time (s)	Uncertainty in time
0.86	0.38	± 0.06
2.02	0.65	± 0.06
3.01	0.79	± 0.1
4.26	0.99	± 0.1

Source: Kirkup, Les

Graphs. Graphing is another way of presenting the result of your experiment. The choice of the type of graph is dependent on the kind of data that will be analyzed. Most of the time, a scatter plot is used to easily interpret the trend. However, pie graphs and bar graphs are also helpful. The bar graph below shows a figure number and title. The axes are also properly labeled.



The scatter plot that follow shows the figure number and title. The axes are labeled correctly with the corresponding unit. The equation of the trendline and the R-squared value (reliability) are displayed on the chart. The R-squared value represents the goodness of fit of the trendline that is constructed for a scatter plot. A perfect fit has an R-squared value of 1.



Whenever an equation is derived, a brief description of the derivation, the equation on a separate paragraph and the equation number should be included. Long derivations should be included as part of the Appendix.

The graph above shows that there is a quadratic relationship between the weight of the bag and the angle formed by the shoulders of the individual and the horizontal. The equation of the trendline is:

$$y = -0.01x^2 + 0.7587x + 0.02 \quad (1)$$

where y is the angle and x is the weight of the bag. The R^2 value of the graph is 0.9993; therefore, the fit of the trendline is almost perfect.

Statistics. Statistics is a systematic approach of collecting, presenting and analyzing a set of data in order to make reasonable answers to a particular problem.

There are a number of statistical tools available. However, there is a need to determine which tool is applicable to your experimental design. Some of the tools are enumerated below.

- frequency distribution (i.e. cumulative frequency curve or ogive, Lorenz curve)
- measures of central tendency (i.e. mean, median, mode)
- measures of dispersion (i.e. standard deviation)
- correlation and regression (i.e. linear and non-linear)

Some of the tools may not sound familiar to you. Part of the objective is to give you an overview of these statistical tools which you will later encounter in college. Please visit <http://ahsphysics.weebly.com> for assistance.

ANALYSIS OF DATA

This is the section of the investigative project where results are thoroughly analyzed and discussed. The results of the experimentation are explained using scientific concepts and principles. Specifically, the following should be included in the interpretation of results.

- major trends are pointed out
- relationship between quantities are identified and equations are clearly stated
- results of the experiments are explained using sound scientific theories
- sources of error are identified and explained
- an insight about the problem being studied is included

Example:

DISCUSSION	
Values for the acceleration due to gravity, determined using both methods, are consistent with those published elsewhere (Rocke, 1984).	} Result is compared with established values
However, the method using the pendulum is superior in so far as the 'best' value obtained is close to those reported by other workers and the uncertainties in the value of g are less than that of the first method, that is, Method B is both more precise and more accurate than Method A. In both methods, the main source of uncertainty is in the timing of the events. However, in the case of the pendulum, the reaction time was a small fraction of the total time measured, whereas in Method A, the reaction time was a large fraction of each timing. An electromechanical or optical means of synchronizing the beginning and end of the motion of the ball with the timing instrument is required if Method A is to provide a more accurate value for g .	
	} Major findings are pointed out
	} Source of error is discussed
	} Recommendation to improve the experiment is given

Source: Kirkup, Les

Rubrics

Methodology	Points
materials are appropriate and complete (5 x 3)	15
procedure is complete, logical and clear (15 x 3)	45
diagrams have dimensions and labels (if applicable)	5
Data Presentation	
data are complete and accurate	15
data tables have appropriate titles and labels	5
graphs are appropriate to the data	5
correct statistical tools are used (if applicable)	5
Analysis of Data	
results are explained using scientific principles	15
major trends are pointed out	5
sources of error are identified	5
recommendations to improve study are given	5
TOTAL	125

CONCLUSION

Based on the analysis of data, you are now ready to state the results of the experiment. This includes conclusive statements to that will determine whether the data agrees with established scientific principles, concepts or values.

Example:

CONCLUSION

When the weight carried in a messenger bag increases, so does the amount of postural change. Based on the data collected, the shoulder of a person carrying a messenger bag will lean forward and sideward in proportion to the weight of the bag. In relation to the weight of the bag (x), the angle the shoulders form with the horizontal is given by the equation $y = -0.01x^2 + 0.7587x + 0.02$. The angle formed one shoulder, the hip and the vertical is given by the equation $y = -0.0142x^2 + 0.7465x + 0.0095$. It was also found that although the direct relationship is consistent across all test subject masses, the proportion constantly changes. The heavier the individual, the less their posture is affected by the weight of the bag. When the bag has a mass of 12 kilograms, the angle the shoulders form with the horizontal is given by $y = -0.0266x + 9.0897$, where x is the mass of the individual. The angle formed by the shoulder, hip and vertical is then given by $y = -0.0346x + 10.37$.

Source: Soriano and Tan, AHSS2012

RECOMMENDATION

The recommendation part of the investigative project is an opportunity to evaluate your own work in many aspects. Specifically, it is with the assumption that future researchers can possibly consider pursuing the same study and focus on your recommendations.

Below are some of the things that can be included in your recommendations.

- ways to improve the study
- difficulties encountered in conducting the study
- better steps to avoid difficulties encountered
- applications of the study in real life

Example:

RECOMMENDATIONS	
1.	Provide a better method of marking the joints since experimenters had difficulty in maintaining the accuracy of marking them in the PAG.
2.	Use a more accurate measuring device than the meterstick (i.e. meter tape).
3.	Measure the weights of the subjects in kg instead of lbs. to maintain uniformity of units.

Source: Soriano and Tan, AHSS2012

Abstract

The abstract is a summary for the reader stating the reason for study, techniques/methodology used, major findings and its significance. It should be limited to 50-150 words or approximately four sentences.

<i>Advances in the applications of the superconducting ceramic material $YBa_2Cu_3O_{7-x}$ have been restricted due to the difficulty of making good electrical connections to this material. In the investigation reported here, cathodoluminescence was used to analyze the surface of the ceramic at points where electrical connections are made. The study offers strong evidence that barium carbonate forms at the surface when the ceramic is exposed to the atmosphere. The barium carbonate forms an insulating layer detrimental to the formation of good electrical connections.</i>	Problem/Reason For the Study
	Methodology Used
	Major Findings/Results
	Significance/Explains why

Source: Kirkup, Les

Writing the IP Final Paper

Overview

Cover Page	Methodology
Abstract	Data Presentation
Introduction	Analysis of Data
Statement of the Problem	Conclusions
Objectives	Recommendations
Hypothesis	References
Review of Related Literature	Appendix

Format for Abstract

Line spacing: single

Heading: ABSTRACT (bold, uppercase, centered)

Body: Three line spaces after the heading, italicized, justified

Example

ABSTRACT

The destruction that flooding can cause has been witnessed by the whole country time and time again especially during the most recent and disastrous one, Ondoy. Although most houses in private villages have several precautions and safety measures to avoid flooding, the majority of the Philippine population, which are the middle and lower classes, are the ones that suffer due to poor drainage and sewage systems in very poorly developed and rural areas. In this investigation, different drainage designs were made to determine which type of drainage system could help lessen water in a flood scenario for the average middle class house. The study offers extensive findings on how efficient some drainage designs can be in comparison to others. This may greatly help in building simple but efficient drainage systems for the middle and lower class households which are usually built in very small, tight, and poorly developed land areas.

Source: Adviento, et al. Design and Construction of a Drainage System as Flood Control for Households. AHS H2011

Heading: uppercase bold, centered

At least three line spaces

Body: single-spaced, italicized, justified

- Cover Page

Title Page	THE DESIGN AND CONSTRUCTION OF A BALLOON-POWERED CAR	
	An Investigatory Project Presented to	Title 7 spaces
	Teacher's Name Physics Teacher Ateneo de Manila High School Science Subject Area	7 spaces
	In Partial Fulfillment of the Requirements in High School Physics	7 spaces
	Submitted by: Surname, First Name MI Year-Section Surname, First Name MI Year-Section Surname, First Name MI Year-Section Surname, First Name MI Year-Section	7 spaces
	January 4, 2013	28

- IP Title

The title should be brief (5 – 15 words) and informative. Below are examples of investigative project titles.

Could Be Better (Vague and Lacking in Information Title):

A Study of the Insulating Properties of Some Materials

Better (More Informative Title):

A Comparison of the Thermal Insulating Properties of Styrofoam and Fiberglass

References

The reference section gives the reader access to information concerning the background of the study, details of experimental techniques, theoretical information, etc. For this investigative project, use Turabian citation style. Make sure that you include only the references used in this project.

Example:

BIBLIOGRAPHY

Bonino, F., C.A. Vincent, et al. Modern Batteries: An introduction to electrochemical power resources. 1984.

Department of Energy of the United States of America. NEWTON. "Magnetic Flux". <http://www.newton.dep.anl.gov/asksci/phy99/phy99184.htm>, (accessed August 12, 2010).

Extreme Circuits. "USB Powered Mobile Phone Battery Charger". <http://www.extremecircuits.net/2010/02/usb-powered-mobile-phone-battery.html> (accessed August 12, 2010).

Galbraith, Kate and Jad Mouawad. The New York Times. "Plugged-In Age Feeds A Hunger in Electricity". 2009. http://www.nytimes.com/2009/09/20/business/energy-environment/20efficiency.html?_r=2 (accessed August 12, 2010).

Hochman, Paul. Fast Company. "Wireless Electricity is Here (Seriously)". 2009. <http://www.fastcompany.com/magazine/132/brilliant.html#RH7> (accessed August 12, 2010).

Source: Parafina and Villacastin. *An Investigation on the Possibility of Inducing Voltage from the Changing Electromagnetic Fields Emitted by Home Appliances*. AHS S2011

Callouts:

- Heading: Uppercase bold, centered
- 1 line space per entry
- Hanging indent
- Single Space between lines
- Alphabetized entries

Appendix

The appendix usually contains the very long derivations, comprehensive data, transcripts of interviews, computer programs used in the project. For the purpose of documentation, include the photos of the actual experimentation and the previous reports you have submitted, especially the data reports.

Format Guidelines

- **Specifications**

Use A4 size bond paper

Margins: 1.5 in on the left side, 1 in for the rest of the sides
Font: Times New Roman, size 12

Line Spacing: double

Page numbers: bottom right

- **Pagination**

Front: Title page

Page i: Abstract

Pages 1 – n: Main Report

Page n+1: Bibliography

Page n+2: Appendix (optional)

- **Use past tense, passive voice**

(Except for the theoretical part of the report and when inferring general relationships from the data)

Example:

Measurements were made of the length of the copper rod as a function of the temperature. The graph of the data shown in figure 1 indicates that the increase in length of the rod is directly proportional to the temperature rise.

- **Use the third person point of view**

Example:

The pressure was measured at time intervals of 30 s.

Not:

I measured the pressure at time intervals of 30 s.

- **Keep sentences short**

Could Be Better (1 long sentence):

The contact resistance was measured by attaching two current leads to the sample through which a current of 1 mA was provided by a constant current source and two voltage leads which were connected to a high input impedance voltmeter as shown in figure 1.

Better (3 short sentences):

To measure the contact resistance, two current leads and two voltage leads were attached to the sample as shown in figure 1. The voltage leads were connected to a high impedance voltmeter. The current leads were connected to a constant current source which provided a current of 1 mA.

- **Explain abbreviations fully the first time they are used**

Example:

The Scanning Electron Microscope or SEM was used to... X-Ray Diffraction (XRD) is a breakthrough method in...

FINAL INVESTIGATIVE PROJECT PAPER Rubrics

Section	Points
General Instructions	10
Title	5
Abstract	10
Introduction	5
Problems, Objectives & Hypotheses	10
Review of Related Literature	10
Methodology	10
Results	15
Discussion	15
Conclusion	10
Recommendations	5
References	10
Appendix	5
TOTAL	120

ORAL DEFENSE

Class: _____

Group No. _____

CN & Names _____

Title: _____

Rubrics

Descriptor		Points	Score
Objectivity	<ul style="list-style-type: none"> The researchers were dependent on facts (based on actual data gathered) 	3	
Resourcefulness	<ul style="list-style-type: none"> The researchers used all possible available materials such as books, newspapers, multimedia and other forms of materials 	2	
Mastery	<ul style="list-style-type: none"> The researchers demonstrated understanding of their work The researchers were able to answer correctly all the inquiries of the panel 	3 4	
Relevance	<ul style="list-style-type: none"> The researchers communicated the significance of their study and linked its relevance to the current situation 	2	
Presentation	<ul style="list-style-type: none"> The presentation is well-organized and smooth, with a clear and coherent flow The researchers were able to communicate with certainty in a clear and appropriate volume 	4 2	
TOTAL: 20 points			

Adopted from AHS Integrated Sciences Oral Defense Rubric

REFERENCES:

Kirkup, Les. *Experimental Methods: An Introduction to the Analysis and Presentation of Data*
 Librea, Milarosa L. 2007. *Anatomical Study of J. Curcas. Pan-Asian Pacific Conference on Microbiology; Seoul, S.Korea.*

