### Science Lab Report Guideline

\*\*\* The following guideline is to be used in all of Mr. La Monica’s science and physics classes. \*\*\*

***Other teacher’s may have a different report structure***.

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**Acknowledgment**

The citation information found in section 8.0 of this guideline has been taken or adapted from Mr. Henri van Bemmel’s Lab Report Guideline that he gives to his students. Mr. van Bemmel is a teacher at Marc Garneau Collegiate. I would like to take this time to thank Mr. van Bemmel for allowing me to use some of the material in his guideline so that I didn’t have to reinvent the wheel.

**1.0 Introduction**

Science and Philosophy are often confused. This is because both are very similar is some respects. However, science has one major difference. Science is thinking that is verified through experimentation and/or observation. Science constantly strives to correct itself by proving or disproving hypotheses, becoming more powerful in the process. One way to do this is through experimentation. In order to communicate the results of an experiment, scientists have created a lab report. The exact appearance of a lab report can change remarkably form region-to-region and school-to-school. But, the fundamental structure is the same. It is important to learn early on in your scientific career the way to communicate your scientific findings in a way that is acceptable to the scientific community. The purpose of this guideline is to educate you in the art and science (no pun intended) of scientific writing. If you follow the instructions in this guideline, you will produce very professional, well-thought out, and well-laid out lab reports similar to papers written by actual scientists. For those of you who intend to take science at the post-secondary level, this is a mandatory skill. The early you master scientific writing, the better off you will be in your post-secondary studies. If science is not you intend destination, the skills you learn are not wasted. Scientific writing has many other benefits besides conveying scientific information. Organization, critical thinking, problem solving, and the ability to communicate your thoughts are just a few of the important skills you will learn in writing lab reports. These skills are applicable to any field of study or occupation.

**2.0 Evaluation**

Lab experiments will evaluate three categories of your overall course mark – Communication, Thinking, and Application – and thus consist of three separate evaluations. The first is a lab quiz. The quiz will consist of 10 – 15 multiple-choice questions and evaluate the thinking and communication components of the lab experiment. You will be allowed to use your lab report and textbook for the quiz, however you will do the quiz individually without discussing the answers to the lab quiz with anyone. Therefore it is imperative that all members of the lab group contribute equally to the lab experiment and to producing the lab report. The second item that will evaluate your lab experiment is the lab report. This report will evaluate the Application part of the lab mark. A rubric will be the evaluation method used to evaluate your lab report. The actual rubric is in section 9.0 of this guide. **All members of the lab group will receive the same mark for the lab report, unless one student is found to have contributed little or no work to the lab report. In this case, that student only will receive a reduced mark or a mark of zero (0) for the lab report component.** It is important to note that, in an indirect way, failing to contribute to the lab report may also affect the mark on the lab quiz. So, failing to contribute to any part of the lab, may affect both evaluations. Together the lab report and lab quiz will make up the lab experiment mark.

**3.0 Lab Report Format**

Each lab report for investigations or experiments conducted in this class will have the following sections. Any missing or incomplete section(s) will result in an overall deduction in the lab experiments communication mark.

a. Title Page

b. Abstract

c. Theory

d. Method

e. Data

f. Analysis

g. Sources of Error

h. Conclusion

i. Sources

3.1 Title Page

The title page is the covering page at the front of the lab report. It must contain the title of the lab. Never use “Lab 1” as a title. The title should explain what the lab is about. For example “Motion down an Inclined Plane” or “Double Slit Diffraction” are some good examples of lab report titles. Never place pictures, Clipart or any other graphics on the title page. Remember, your goal is to produce a professional looking lab report. This starts with the title page. Near the bottom of the page on the right hand side must be the names of the group members, your teacher’s name, and the room number of the teacher.

3.2 Abstract

An abstract is used to summarize the results in a lab so that the person reading the lab can decide if the information is relevant to their interests. Hundreds of thousands of reports are written each year. Professional scientists, business executives and managers do not have the time to read an entire lab report in order to determine if they need the information. An abstract provides a brief summary of the significant findings, allowing the reader to decide whether or not to read the entire lab report. As a result, abstracts are never more that one paragraph in length. The first sentence concisely explains what was done. The results are explained in the next two to three sentences. Don’t forget to include the uncertainties of all results. The final sentences compare all experimental results with the theoretical values predicted by the theory that the lab is based upon. **DO NOT RAMBLE ON**. The abstract is a brief yet concise summary of the lab results. Abstracts are the first sections to appear in lab reports, however they are always written last. The conclusion is always used to write the abstract.

3.3 Theory

The theory section provides a brief yet informative summary of the theoretical background of the physics involved in the lab experiment or investigation. All equations used in the lab report must be listed and explained in this section. However, a proof of the equation is not required unless it is not one that can be found in a physics textbook or other paper on physics – i.e. it is original work that you have created (This would be extremely impressive if you were to come up with an original equation while you were at high school). Just like the abstract, the theory section is brief, but it is not restricted to a certain length. Just make sure that you are brief, but thorough. Never list an equation without explaining why, where, and when it will be used. If the equation is not commonly known, an explanation of its origin can be discussed.

3.4 Method

Most students think that the method is just the procedure of the lab written in the third person past tense. It is true, that the method is an account of what was done in the experiment, but it should not be limited to just copying the procedure and changing the tense. All good students (and scientists) are constantly trying to improve the results of an experiment either by changing the procedure in some way or by using a special method to analyse the data. You should be seeking out every opportunity to do the best work possible, not blindly following a procedure. The procedure given to you either in your textbook or as a handout is a guide to follow, not a strict recipe. This does not mean that you should take it upon yourself to modify the experiment to achieve some other goal different from the purpose of the experiment. **This can be very dangerous to yourself and others**. If you wish to change the procedure to better your results, ask your teacher before attempting any modification. If it is a change in how the data is analyzed, then you do not need your teacher’s approval. When in doubt … **ASK!**

3.5 Data

In most experiments, experimental data will be obtained. This can be numerical data, visual observations, and/or sensor output. All experimental data is displayed in a lab report in the form of a table. Never explain any analysis or study of the data. The table should merely display the results of the experiment in a neat and concise form. The table used to display the experimental results must be constructed in a specific way. See section 5.0 labelled Tables for more information on how to construct an experimental data table used to display your numerical results in this section of the lab report.

3.6 Analysis

This section is very important for drawing correct conclusions about what the data is tell you. The relationship between the data involved in the experiment can be determined. This relationship can be used to verify or confirm the theory. The most common way we determine relationships between data collected in an experiment is through regression techniques. A regression is a mathematical way of seeing how two variables are related. There are many types of regressions – linear, polynomial, and exponential are some examples of regressions. Any regression can be used with the experimental data, but there is usually only one regression that best fits the data. The best regression can then be used to confirm the theory behind the lab experiment. At the high school level, most experiments will be done to confirm a specific theory. So, if you perform a regression on a set of data points and the fit does not agree with the theory then there is a very strong possibility that your work is wrong. The only alternative is that the scientific theory is wrong. So, you are wrong or the science is wrong – you decide! If this happens it doesn’t mean that your work is useless or a waste of time. There is much to be learnt from what went wrong and how to correct it. Most professional scientists get it wrong on their first attempt; this is part of the scientific method.

This section gives you an opportunity to display your scientific talent – it is your time to shine. Your teacher will expect a great deal of insight and thought in this section. There is no restriction on the length of the analysis section so be extremely detailed in your analysis of the data and the method of explanation. Again don’t ramble on, but don’t leave out the nitty-gritty details. The analysis is arguably the most difficult part of the lab report. It is where you will draw your results used for your conclusions. Most students think that they should exclude any data that does not fit the theory – **THIS IS A MISTAKE**. All scientists must accept **all** data, not just the data that proves the theory. If certain data does not fit the theory, then an explanation as to why is needed. It is possible to get 100% on a lab report with experimental data that contradicts the theory, as long as a reasonable explanation can be give as to why.

3.7 Sources of Error

Numbers in science are dealt with very differently than in mathematics. Since numbers in science generally come from observation or experimentation, there is some uncertainty in the measured value. Take for example the measurement of the length of this page. If I were to ask you to measure the length of this page with a standard 15 cm ruler, two things would have to be done. First, since the ruler is too short it would have to be lift and set back down again. This illustrates a procedural error. Secondly, there is some uncertainty as to if the zero mark on the ruler was set exactly on the edge of the page. The other edge of the page would most likely lie in between the millimetre divisions on the ruler, so some estimation must be done. This illustrates an instrumental uncertainty.

Procedure and instrumental uncertainty are the two “errors” that occur in science. Do not confuse errors and mistakes. In science 2 x 2 = 3 is not an error, it is a mistake. Errors are generally not your fault. They are limitations due to the equipment or procedure that you use. There are ways to minimize these errors, but they cannot be eliminated. If you were to use a longer ruler to measure the length of this page, you can minimize the procedural uncertainty. Or if you were to use a calliper instead of a ruler, you can minimize the instrumental uncertainty. All scientists must strive to reduce their uncertainty in their results. However all scientist are restricted to the equipment that they can use. You must make the best of what you have. Making suggestions to use equipment that is too expensive or not found in a high school science lab are useless. Keep this in mind when you try to minimize your uncertainty in your labs.

When stating a measured value with its error, the following method will be used:

*The length of the page was found to be (28.0 + 0.1) cm*

Notice the error is only one significant digit and the measure value and are written within round brackets.

Uncertainties must be included in every measured quantity in your lab report, including tables. See the table section below for more details.

There are specific rules when dealing with calculations involving data. Your textbook has more information on how to handle data when computations are done.

3.8 Conclusion

This is the most important section of you lab report. All the results of the experiment are list here in order of importance. It is a common mistake to not include numerical results in the conclusion. All supporting evidence, including numerical results, must be stated. An explanation of how the evidence and results prove your conclusions is necessary. All comparisons between the expected values that the theory predicts and your experimental results must also be done in the conclusion. Percent deviation is the best way to compare experimental results and theoretical results. The conclusion does not have to explain what was done, like in the abstract. It should be results focused. The conclusion also differs from the abstract in that the conclusion is very detailed. No length restrictions are placed on the conclusion, but like always, don’t ramble on.

3.9 Sources

The last section of your report should list any sources that were used. All sources are list with the author’s name first and in alphabetical order. The title of the sources comes next, followed by the publisher and year of publication. Below are some examples:

*LaMonica, D., The “E”-lite Physicist, DAL Press,* 1998 Print

*van Bemmel, H.,* [*www.interlog.com/~hmvb/lc.html*](http://www.interlog.com/~hmvb/lc.html)*, 2000*

**4.0 Grammar and Spelling**

In a lab report, you are trying to produce a professional account of your work. It is self-evident that if your report contains grammatical and spelling errors, or consists of poorly chosen words, it will detract from the professionalism of the report. As part of the mark for the lab experiment, you are evaluated on your ability to communicate what you have learned. Clearly grammar, spelling, sentence structure, and vocabulary all affect how you communicate. Always have your lab report proof read by someone else. If you have to proof read your lab report yourself, never proof read it immediately after you have written it. It is always best to proof read your report in the morning and not after a few hours of intense physics problems.

**5.0 Tables**

Tables are the optimum way to display the results of an experiment. This is because large amounts of data and the relationship between independent and dependent variables can be viewed at once. Students think that the construction of their data tables is straightforward, however some common problems always seem to appear throughout the many years I’ve been teaching science and physics courses. Below are some rules for your tables that you should follow in every lab report that you write.

1. All tables must have a caption. A caption is a brief paragraph written below the table that

describes what data the table is conveying. Captions for tables are identified with a unique

number so that references throughout the lab report can be made.

2. Do not title your tables; the caption takes the place of the title. Titles on tables are

unprofessional.

3. The independent variable appears in the leftmost column of the table. Some scientists like to

index their tables, so the index appears in the leftmost column followed by the independent

variable.

4. The heading of each column should contain three things; the name of the variable in the

column, the units of the variable, and the uncertainty assigned to the variable. If the uncertainty is not consistent in the column, then the individual uncertainty for each data point is specified beside the data point and not in the heading of the column.

5. Never break tables across pages in your report. This is very unprofessional and sloppy.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | Time (t)  (±.1 s) | Distance (d)  (±.01 m) | Speed (v)  (m/s) | Energy (EK)  (J) |
| 1 | 1.2 | 1.00 | 0.83 ± .02 | 0.7 ± .1 |
| 2 | 1.8 | 2.03 | 1.13 ± .03 | 1.28 ± .09 |
| 3 | 2.1 | 3.06 | 1.46 ± .04 | 2.13 ± .08 |
| 4 | 2.9 | 3.68 | 1.27 ± .03 | 1.6 ± .1 |
| 5 | 3.6 | 4.44 | 1.23 ± .03 | 1.51 ± .09 |

Table 1: The results of the experiment showing the three dependent variables studied in the investigations.

**6.0 Graphs**

Just like with tables, there are some very specific rules on how to construct graphs for your lab report. Graphs are very important because from them you can determine the relationship between the dependent and independent variable.

1. Never title your graphs. Again, the caption provides the necessary information.

2. All graphs require a caption.

3. The independent variable always appears on the horizontal axis.

4. The axes of the graph must be labelled. Units and direction (if necessary) must also be indicated on the axes. All text and numbers must be clear and legible.

5. Do not use colour other that Black and different shades of grey

6. All regressions must be done using a computer program. Do not attempt to fake the curve or line of best fit using the draw program on the word processor you are using.

7. If you are plotting more than one set of data points, a legend is required.

8. Grid lines are acceptable but must be done in a shade of grey that does not dominate the graph.

9. Data points should be circles that are not filled in. They should range in size from 3 to 5 points. All data points must have error bars in two dimensions.

10. Never bold the line or curve of best fit to make it stand you. This is unprofessional.



Graph 1: The impulse of the rocket as measured for a duration of 7 seconds. The fits chosen

was an inverse relation yielding a correlation of .9930.

**7.0 Equations**

Most of the equations found in a lab report are introduced in the theory section. However, equations can appear anywhere in the lab report. Never place equations within sentences. The must always appear on there own line and they are always numbered. They are always centre justified. The variables of the equation are defined only when the equation is first introduced. Subsequent appearances of the equation do not have the variables defined. The following are examples of how equations are to appear in a lab report:

 … [1]

where Erest is the rest energy in J

m is the mass in kg

c is the speed of light

or

 …[2]

When referring to an equation in your lab report, you simply state the number of the equation. For example: “In Eq [1] we see that the rest energy is proportional to the speed of light squared.”

Never hand write equations, it may seen tedious, but you should learn to us an equation editor. Microsoft Word, has an equation editor built in, however in must be installed. Remember, your are being evaluated on your professionalism.

**8.0 Citations**

In a science paper the text is written in third person past tense.

“I measured the water temperature” - 1st person past

“He measured the water temperature” – 2nd person past

“The water temperature was measured” – 3rd person past tense 🡸 This is what we want!

If the name of a person must be mentioned to distinguish two observations etc, then it should be written with a first initial and the surname. There should be no easy way to determine the sex of the individual.

For example,

Two teams effected observations of the water pH. A. Smith was probe manager of the first team and produced better calibrations than those by T. Jones.

Science papers are ideas. Ideas come from people. Any idea you use in your report that has come from some reference must be cited. Failure to do so is very poor professional practise. A scientific citation is different from a footnote. Footnotes however useful are rarely used in scientific papers. A citation indicates the author and the data of publication. More detail on a reference can be found in the sources of a paper at the end of the section.

There are two types of citations. The first is when the author’s work is given as a subject or object of the sentence.

“Work by van Bemmel (1997) led to the first observation of diffraction fringes by an asteroid.”

The second is when a fact has been given that comes directly from the work of others.

“The use of advanced placement courses at MGCI has increased student retention rates at university. (McMaster, 2000).”

If your group has two or three members then all names are given.

(van Bemmel and McMaster, 2001)

or

(McMaster, van Bemmel and Lang, 2001)

However citations that are longer than this are unwieldy and are abbreviated using the following form (van Bemmel et al, 2001). The Latin “et al” means “and others”. Much modern collaboration has a hundred or more scientists included. Therefore, this abbreviation is necessary.

**9.0 Lab Report Evaluation Rubric**

On the following page is the lab report rubric which will be used to evaluate your lab report.

