How to Write a Good Lab Report

By Dr John Soo

The main aim of a physics lab report is to tell the reader all he/she should know about the experiment you just did – what is it about, what have you done, what went wrong, and what have you achieved. Writing a good lab report is in fact not difficult: all you need is to follow certain rules below, and you should be able to meet the target.

A lab report has a few important sections: the **abstract, theory, experimental methodology, results (data and analysis), discussion, conclusion,** and **references.** In this document, I'll break down the important things you need take note for each section, with simple **dos & don'ts** analogies.

Abstract

An abstract is always placed at the beginning of the document. It is meant to be **short** and **concise** (usually < 250 words), telling the reader what this experiment is about, and what are the important findings and results. The abstract is there to attract the interest of the reader, in which once captured, the reader will continue reading the report for further details.

Dos	Don'ts
✓ *Include the title of the experiment.* This goes without saying! But I'm surprised how many students end up diving into it without even mentioning what the experiment is about! ✓ *Write the aim of the experiment.* Why you are doing this experiment, and what are you trying to prove? These are important things to put in the abstract. ✓ *List down the important results.* Write down what you **found**, not what you **expect**. Be quantitative about your results, e.g. 'the Planck constant is estimated to be $(6.184 \pm 0.003) \times 10^{-34}$ J s , accurate within 10% percentage discrepancy'.	× *Write multiple paragraphs.* The abstract is meant to be a short single-paragraph description of your experiment, not an essay! × *List down procedures of what you did.* Here we are interested in what you **achieved** (e.g. 'estimated value of Planck constant', or 'A is proportional to B'), and not what you **did** (e.g. 'a graph has been plotted' or 'data is recorded using an ammeter'). × *Write the theory of this experiment.* You can leave this for the theory section!

Theory

This is the section where you tell the reader the required background knowledge to understand your experiment. You are allowed to copy passages from your lab manual, but if you do so, you shouldn't expect us to give you high marks. Try to synthesise the results and write it in your own way.

Dos	Don'ts
✓ *Explain the basic theory of the experiment.* Is the experiment about photoelectric effect? Then define what photoelectric effect is, together with equations, constants and implications. Extra marks are given for graphs and diagrams! ✓ *Write down the important equations to explain the results.* If you are asked to find the gradient of a graph in the experiment, write this equation down, and tell us what this gradient represents! ✓ *Make sure that every section is explained.* Some experiments have multiple sections, make sure you provide theory information for each section (e.g. equations, expected shape of graph etc).	× *Write about the history.* The reader (i.e. your lecturer) probably knows more about this than you do! Please don't spend time writing about how Einstein came up with the photoelectric effect and etc… This is no place for stories: get straight into the equations! × *Copy the entire lab manual's introduction section.* Guess what: we'll also copy the same marks for everyone and give it back to you! × *Write in instructive form.* Do not use instructive words like "recall that", "remember that" or "note that". You're merely reporting; not writing this to educate someone!

Experimental Methodology

This is the part where you tell us what you did. In a few paragraphs, summarise how the experiment is setup to achieve your experimental goal.

Dos	Don'ts
✓ *Summarise your methodology.* Write down the important steps you took to do your experiment. Make it concise, use phrases like 'the experiment is then repeated by replacing x with y' to shorten your report. Schematic diagrams would help too! ✓ *Write your methodology all in one place.* Some experiments may have multiple sections, but remember that you are writing a single report for this experiment. Write them all in one place, separate the description for each section by paragraphs if needed. ✓ *Tell us what you did to the data.* Other than listing down the steps to get the data, write something like 'x is then estimated from the data by using equation y' to tell us what you did to the data. This is also the place where you write sentences like 'a graph of x against y is plotted / a linear least square line is plotted / the gradient and y-intercept are recorded' etc.	× *Write the methodology in point form.* You are not writing a lab manual; you are writing a report! × *Write the procedure instead of methodology.* Procedures are written in **active sentences** (do this, do that) to instruct you what to do, but methodologies are to be written in **passive sentences** (this was done, that was done) to tell your lecturer what you have done. Don't mix them up! × *Copy everything you see in the lab manual.* Please don't list down information like which direction you turn your knob to calibrate your ammeter… If we were interested in all the detailed steps, we would have read the lab manual instead! × *List down all the equipment.* We really don't need to know how many power cables and banana plugs you used… but a **figure** of the apparatus setup would be nice to have!

Data & Analysis

This is the most important part of the report. This section is where all your data tables, graphs and calculations belong.

Dos	Don'ts
✓ *Take multiple readings.* When you take multiple readings, you increase the **precision** of your data collected by taking an average value of it. Besides, the **standard deviation** of your data can be used as the **error** (±) for your readings! ✓ *Format your tables and graphs nicely.* Label them appropriately (e.g. Figure 1, Table 1 etc), label the axes, use different markers for different lines, draw **error bars**, write the equation of the best fit line etc. Draw smooth curves when appropriate. ✓ *Present your answers with errors.* Your final estimated value must come with errors, and with the **percentage discrepancy** from the theoretical value. E.g. 'The estimated value of the Planck's constant is $(6.184 \pm 0.003) \times 10^{-34}$ J s, within a 6.7% percentage discrepancy from the theoretical value'. Make sure to use the correct units too! ✓ *Use correct significant figures.* Do not use more decimal digits than the maximum precision of your equipment when doing calculations. Only the highest non-zero digit of your error is significant, and your estimated value follows suit (e.g. note that the example above showed 6.184 ± 0.003 but not 6.1843 ± 0.0028).	× *Show your results without any explanation.* As this is part of a report, you are required to describe your tables, equations, graphs and calculations. Especially graphs, write down what does the shape imply (proportional, linear, plateau etc), and if it agrees with theory. × *Attach pages full of workings.* While I appreciate your effort, many of the workings in these experiments can be calculated using your calculator or Microsoft Excel. You only need to show the important regression formulas you used, but you don't need to show all the $\sum x$, $\sum xy$ and $\sum y^2$ that you calculated. × *Draw best-fit straight lines 'by eye'.* As you are no longer a secondary school student, please use the available statistical tools (MS Excel's **LINEST function** or your calculator) to find the least-square regression line. Also, please use the **correlation coefficient *r*** to tell us how well your line fits the data.

Discussion & Conclusion

Now that you have completed your experiment, collected your data and worked out the answers, we are now interested to know what you think of your results. Is it satisfactory? Could the results be improved? Is there anything extra that you can do with your results? Let us know!

Dos	Don'ts
✓ *Write your discussions in one place.* Your experiment may be divided into several parts, but some parts share similar discussions, so you should discuss all of them together at one place. ✓ *Evaluate your results using numbers and statistics.* Percentage discrepancies larger than 30% with theory are questionable. Correlation coefficients lower than 0.8 are rather weak relationships. **Fractional errors** tell us how precise the calculation was (e.g. estimated Planck constant of 6.184 ± 0.003 has a fractional error of $\frac{0.003}{6.184} = 0.05\%$, which is extremely precise!). Use these numbers to explain how well your experiment went! ✓ *Explain the factors affecting your results.* If your estimated results have high percentage discrepancies, something must have gone wrong. Try to list down some factors that may have caused these discrepancies, or point out the few **outlier data points** in your graph that may be the culprits. If there are many factors, compare them and write down which one affected the results the most. ✓ *Push one step further!* What else can you do with your results? If the objective was only to calculate the gradient of the line, but you noticed that the *y*-intercept may contain other information, why not tell us about it too? What does it represent? Or how can this experiment be modified to determine other things? All these add into bonus marks for your report! ✓ *Answer the objectives in your conclusion.* If there are 3 objectives, make sure that your conclusion will answer all 3 of them. ✓ *Create a separate heading for the conclusion.* Try not to mix your conclusion and discussions together.	× *List down all precautions of the experiment.* Precautions are good viva questions, but in the report, you really don't need to explain how not to burn your hand when using the equipment. Remember: the discussion is meant to explain why your results turned out so bad / so good, and suggestions to improve your results. Thus, write only a few important precautions that are directly tied the imperfect results you obtained. × *Write the phrase 'objective has been achieved' in every conclusion point.* Just write down your conclusions in normal sentences, it is always understood that you have achieved your objectives. However, in the worst-case scenario where you messed up everything, you should mention how much your results deviate from theory deviate from it. E.g. suppose the expected conclusion is that the stopping potential for all 3 graphs plotted should remain unchanged (0.7 V), but you got results of 0.7 V, 0.8 V and 0.9 V. You can conclude by saying 'the stopping potential has remained unchanged, within 30% uncertainty' $\left(\frac{0.9-0.7}{0.7} \approx 30\%\right)$.

References

If you have used any external material, or used figures from external sources, do remember to use proper citations, e.g. Soo et al. (2008) in the text, and later write them in the references below. There are many online resources that could teach you how to do citations the right way, so I'll leave you to find out. I don't expect many citations in a lab report, but when you start to write your thesis in the future, you can try to use Zotero, a free and powerful citation software that could speed up your citation process.

Good luck in your report-writing! :)

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