LAB REPORT GUIDELINES –PHY 252

Spring 2018

TA: Joe Lesnefsky

Email: jlesnefs@asu.edu

Welcome to the laboratory component of PHY 252 – Modern Physics! This semester we will experimentally relive the exciting discoveries which indicated that, classically at least, all was not well with physics. Lord Kelvin lectured, at the Royal Institute of Brittan at the turn of the twentieth century (Thomson, 1901)

THE beauty and clearness of the dynamical theory, which asserts heat and light to be modes of motion, is at present obscured by two clouds. I. The first came into existence with the undulatory theory of light, and was dealt with by Fresnel and Dr. Thomas Young; it involved the question, How [sic] could the earth move through an elastic solid, such as essentially is the luminiferous ether ? II. The second is the Maxwell-Boltzmann doctrine regarding the partition of energy.

The resolution to I grew into the special – and subsequently general – theories of relativity, and the resolution to II would ultimately be quantum mechanics.

There is more however: you are physics majors! Given this, I would like to discuss my philosophy on the subject of the infamous "physics lab report." There are two major camps: the first is to treat these reports as a dreaded quotidian tedium where one is wont to rend garments and gnash teeth, and the second is to consider it scientific training for the glorious day where you will be published in a peer reviewed journal. Before I attained my baccalaureate degree, I had been published (Atherton, Lesnefsky, Wiggers, & Petschek, 2012) so, as second or third year students physics students it is utterly appropriate to begin practicing this skill. I see no reason why you could not have a publication before graduation either!

It is my intention to train you as budding scientists, and I will grade your lab reports as such. I will hold them to the same standard that I would a paper from any professional physicist. Given that you are not quite there yet this will be a learning experience, and the first few grades may be harsh. DO NOT BE DISCOURAGED! This is how we learn, and by the end of the semester, your scientific writing will have improved by leaps and bounds.

ATTENDANCE

Lab attendance is mandatory. Labs are not held every week. *It is your responsibility to look at the Lab Schedule in the PHYS 252 Syllabus and be in lab on the appropriate weeks*. If you are not able to make a lab, please let me know as far in advance as possible and, if your absence is approved, I will give you access to make up lab data. From this data you will be able to complete the appropriate calculations and the lab report. All error analysis will be based upon the statistical error of the provided data sets. Of course, because you working individually, you have to write the entire report yourself versus just a section as in the case of normal lab attendance.

ASSESSMENTS

There are two categories of written assessments due after performing a lab: lab reports and investigations. Lab reports are full, bona fide, writeups in the style and caliber of a scientific paper for submission to a peer reviewed journal. Investigations are more informal, homework style questions based upon the activities performed in lab. The major difference between the two is that, for experiments requiring a lab report writeup, there are a few physical quantities which are to be measured and reported in full scientific notation, complete with absolute error calculations. Labs which only require an investigation type writeup will usually have many more small sub-experiments which demonstrate physical phenomena, but full reporting of the measured values with absolute error calculations are not required.

Lab Name	**Report**	**Investigation**
Lab 1 – Complex Data Fitting	X	
Lab 2 – Gas Thermometer	X	
Lab 3 – Mechanical Equivalence of Heat	X	
Lab 4 – Gas Compression and Expansion	X	
Lab 5 – Statistical View of Entropy		X
Lab 6 – Geometric Optics	X	
Lab 7 – Microwaves		X
Lab 8 – Interference		X
Lab 9 – Spectroscopy		X
Lab 10 – Photoelectric Effect	X	

INVESTIGATIONS

In the style of a homework assignment, not a through-composed paper, a list of questions, usually found in the lab manual, will be asked. All your lab group must do is answer these questions and submit the responses the next lab period.

Lab Reports

Lab reports will be the primary focus of this course. These lab reports will be group activities, and you will co-author the report with your fellow physics students at your lab table. *We are all adults here, and I will treat you all as such*. Given this I expect every group member to contribute in an appropriate fashion. One successful method past students have used to deal with "mooching" students is "voting" someone's name off the author's list if they do not do their share of the work. If this method fails, and all attempts at self-mediation in your group fail feel free to contact me. However, if I have to babysit, I will not be happy and there is an extreme probability you will not be happy either.

Each lab report is due at the beginning of the next lab period, which is usually, but not always, the following week. Please feel free to email me at any time with questions about the lab write-up, or come to my office hours, which are still TBD.

Remark*: *The primary reason for students loosing points on lab reports is not following the Lab Report Grading Criteria. Read these carefully; heed these carefully.

Lab Report Grading Criteria

Below is the breakdown for lab report grading. Each report will be out of 100 points.

Title and Authors	5 pts
Abstract	15 pts
Introduction	20 pts
Procedure	20 pts
Results	20 pts
Discussion	25 pts
Conclusion	15 pts
Acknowledgements, Works Cited, Appendix	5 pts
Style and Detail	10 pts

Only typeset reports will be accepted: this includes equation now. You are physics majors! There are many programs which are utilized for scientific writing, but the community favorite seems to utilize the Latex markup language for equation typesetting and PDF generation. I write my papers in LyX (https://www.lyx.org) or Mathematica (which is available for students in the ASU software repository https://myapps.asu.edu/home).

Microsoft Word's Equation editor has gotten much better in recent years, which makes this program much more viable for scientific writing (Microsoft Office is available in the ASU software repository as well https://myapps.asu.edu/home). For collaborations using Latex, I have also seen ShareLatex (https://www.sharelatex.com/) used. This is not, by any means, an exhaustive list of programs to use.

TITLE AND AUTHORS – 5 POINTS

An appropriate title summarizing the main results of the experiment: think how this would catch a busy physicists attention in a journal. Why should they want to read your article? Include authors, institution and address and corresponding author.

ABSTRACT – 15 POINTS

Your abstract is a concise summary of your findings in the experiment. It should be no more than a few sentences, and explain why what you did is important and novel, method used, results that you found either experimentally or through analysis, and how you experiment is valuable to the field of study / and or future study.

Essentially, someone should be able to pick up your lab report, read the abstract, and know what is you've done to revolutionize the world of physics—before getting bored.

One way to write a good abstract is to write a single sentence for each section of the paper: so a sentence summarizing the introduction, one for the procedure, one or two for the results, one or two for the discussion and one for the conclusion

Remember high school essay writing? You should tell the reader what you are going to say, tell it to them, and then tell them again what you just told them. The "tell the reader what you are going to say" is the abstract and the "tell them again what you just told them" is the conclusion.

INTRODUCTION – 20 POINTS

The introduction is tricky. It should contain enough information to build a foundation for the experiment, but can easily get out of control. Try to avoid stringing together every piece of information related to the subject that you can think of, and instead ask yourself, "okay, what is it that a reader needs to know in order to understand what it is we are doing and why".

Note that you are writing for a particular community, and try to conform to community standards of what is "common knowledge" and what might be belittling or patronizing. This is incredibly difficult to do and takes much

practice. If you feel it necessary to include something that would "break up the flow" of the paper, consider mentioning a pertinent fact and moving the longer explanation to the appendix.

Include proper citations if necessary!

Some key elements the introduction should contain:

- Purpose or goal of conducting the experiment
- Background information on the physics needed to understand experiment, as well as the physics being tested
- Equations used in the experiment and the analysis, their significance, and labeled variables (while some situations will call for a *brief* derivation of an equation from a different form, every equation does not need to be derived from scratch – think community standards)

PROCEDURE – 20 POINTS

The procedure is a vital (though not very glamorous) part of the lab write up. If someone cannot reproduce your results through following your directions in the procedure, it wouldn't matter if you

found that photons were actually tiny massless gummy bears—it's only an anomaly if it cannot be reproduced!

A description of the set up should be included (diagrams are a plus), as well as a step by step walkthrough of the important elements the experiment.

Additionally, include a brief overview of what you plan to do with the data collected, which normally is insert it into a computer algebra system such as logger pro, Mathematica, Matlab, etc . . . and describe how you are going to process / fit the raw data and what derived quantity you would like to find. Save the actual equations and example calculations for the Discussion section

Additionally, I will require that at least one Figure depecting the experimental apparatus / setup / etc . . . be included. This can be a Solidworks (if you are so inclined), Photoshop, MS paint, hand-drawn, or even a cell-phone photo important parts of the setup.

Note that this must be in your own words, simply changing the tense of the lab guide procedure or copy/pasting it will be considered academic dishonesty.

I have zero patience or tolerance for academic dishonesty whatsoever, and I will do everything in my power to have anyone who violates the Arizona State University Academic Integrity Policy (Arizona State University, 2017) *removed from the class with an XE grade.*

RESULTS – 20 POINTS

A clear, non-ambiguous reporting of the quantities of interest, with units, in scientific notation, with significant figures, with appropriate error bounds. Remember error propagation? Note that not all measured quantities need to be reported, just the pertinent ones.

Relevant plots, values, and tables should be included. Depending on the volume of data, measured values may or may not be placed in this section. For example, if only a handful of measurements were made for each section of the lab, it may be appropriate to place in this section—pages and pages of raw data would not. All plots must have a title. All plots must have axes labeled with appropriate units. All plots must have a key, legend, description or caption.

Keep in mind this is solely a section for results, interpretation and analysis of the results will be in the Discussion section.

DISCUSSION – 25 POINTS

This section will analyze and discuss the findings of the experiment; where you will interpret the results. You will compare the outcome of your experiments with your expectations/theory. *Justify consistency with numbers and statistics, not personal opinion*[1]. If the findings were off—by how much were they off? Why were they off?

Keep in mind that stating "human error" is not an acceptable response. Is the error consistent with statistically random error or some sort of systematic error. If the error is systematic, what could be done to reduce, eliminate it: what is this systematic error telling us able the laboratory apparti or procedures? If an element of error was introduced via experimenters, specify exactly what that error might have been; for example, "it was difficult to tell between the black and the slightly darker black when sorting". Discuss how this error might be reduced? For

[1] I would argue that at this level demanding that you construct and asymptotic LRT to guarantee a UMVUE statistic while bounding type I error at a particular acceptable α level is excessive, but you need more justification than "ennggggh those numbers look kinda close"

more information on error analysis, please see my *Error Analysis Primer for PHYS 252*, (Lesnefsky, 2018) which is posted on the Blackboard site.

If the experiment turned out as expected, explain why it turned out that way. Refer to equations, tables, and figures by appropriate reference numbers: this is another place where you can learn to utilize a reference system in your chosen composition program.

This section should be at the very upmost absolute minimum least a page in length.

CONCLUSION – 15 PTS

Consider this you ESPN highlight reel of your paper. After just having performed an experiment, what are the biggest items you want your reader to take away?

Briefly summarize the findings and their significance. If this particular experiment were your field of study, how would you modify this experiment to learn more from it or make the results more accurate? *Do NOT introduce new information!* You are winding down and wrapping up your paper, not adding new, riveting information, getting your reader even more excited.

Discuss why this particular experimental result is interesting to your field. What would this result imply about open questions in the field? Are these findings contradictory to any other well known or well cited papers? What does this mean? What are the next logical steps? What further research would you perform?

ACKNOWLEDGEMENTS, WORKS CITED, APPENDIX – 5 POINTS

At the end of the report, there are quite a few categories of final remarks which may or may not be included as they are appropriate. However, science is a collaborate effort, and it is always nice to acknowledge people, organizations, or *grant money* a propos your research. It is especially imperative to include any grants that funded your research, if applicable. If you don't really have any acknowledgements, you can always mention me!

If any citations were necessary in the paper, include a works cited page. Use whatever major citation style you are most comfortable with.

Remark: *I – Joe Lesnefsky – DID NOT write the lab manuals. Given this, DO NOT attribute me as the author of these in your works cited or you WILL LOOSE POINTS. An improperly researched bibliography undermines your scholasticism, erudition, and integrity as a researcher. In fact, it begins the slippery slope to plagiarism. If you feel the need the cite the lab manual, and please do, attribute authorship to ASU Physics Instructional Resource Team (PIRT) (Arizona State University Physics Instructional Research Team, 2018).*

Attach any extraneous plots, tables, additional explanations, or data that you feel should be contained in the report but were not appropriate for the results section in one or more appendices. *ATTACH THE RAW DATA WITH MY SIGNATURE IN THIS SECTION.*

Overall Style and Attention to Detail – 10 points

My subjective opinion of the overall appearance, organization, swagger, etc. of your lab report is scored here. If your lab report wows me it will be reflected here!

In my opinion, attention to detail is often the subtle difference between success and failure.

Remark: ***I reiterate, the primary reason for students loosing points on lab reports is not following these aforementioned directions. I give no quarter to my red pen. If you have any questions / comments / concerns on these do not hesitate to ask!***

Grades

As stated in the PHYS 252 Syllabus the lab component is worth 40% of the final PHYS 252 grade. The final lab score is out of 1000 points as summarized in the following table

Assessment	**Multiplicity**	**Total**
Single Lab – 135 pts	$\times 6$	810
Single Investigation – 47 pts	$\times 4$	188
Bonus Points	$\times 1$	2
Total		1000

I reserve the right to give or not to give appropriate extra credit assignments to the class as a whole – not just to individual students – as I see fit. Extra credit will be added on *a posterior* to the grand total of 1000 points after grades are calculated.

I reserve the right to renormalize (curve) or not to renormalize final grades as necessary, utilizing any statistical method I see fit.

ACADEMIC INTEGRITY

As stated in the course syllabus, academic integrity must be maintained. I will state this again:

> *I have zero patience or tolerance for academic dishonesty whatsoever, and I will do everything in my power to have anyone who violates the Arizona State University Academic Integrity Policy* (Arizona State University, 2017) *removed from the class with an XE (failure for an academic integrity violation) grade.*

I highly recommend that all students at ASU familiarize themselves with the Academic Integrity Policy https://provost.asu.edu/academic-integrity.

ACKNOWLEDGEMENTS

I would like to acknowledge the previous TA for this class, Scott Sherman for the general outline and copious blurbs of text which I have edited and / or reproduced in full or in part.

WORKS CITED

Arizona State University. (2017, August 23). *Office of the University Provost - Academic Integrity*. Retrieved from Arizona State University: https://provost.asu.edu/academic-integrity

Arizona State University Physics Instructional Research Team. (2018, Jan 12). *Physics Instructional Resource Team*. Retrieved from Arizona State University Physics: https://physics.asu.edu/resources/pirt

Atherton, T. J., Lesnefsky, J. E., Wiggers, G. A., & Petschek, R. G. (2012). Maximizing the hyperpolarizability poorly determines the potential. *Journal of the Optical Society of America B, 29*(3), 513. doi:10.1364/JOSAB.29.000513

Lesnefsky, J. E. (2018). Error Analysis Primer for PHYS 252. *Unpublished*.

Thomson, W. (1901). Nineteenth century clouds over the dynamical theory of heat and light. *Philosophical Magazine Series 6, 2*(7), 1-40. doi:10.1080/14786440109462664