Pre-Lab Notebook Rubric Experiment: Author:

Category	Far below threshold (1)	Below the threshold (2)	Meets the threshold (3)	Exceeds the threshold (4)	Score
Abstract/ Hypothesis	Does not include background or previous work. Does not identify the purpose, the project, the main question(s) or issue being addressed.	Gives very little background or information. May include the main question(s) or issue but does not identify the purpose for addressing them.	Gives a listing of the facts and previous work but does not tie them together and show how they lead to the purpose of the present work and the questions being addressed. It does have the question(s) being addressed and some motivation for doing them.	Briefly presents the background information and previous work that directly leads into the question(s) being addressed and the purpose of the research.	
Formulas	Key formulas or expected constants are missing or incorrect.	There are major holes in the derivation of key formulas and/or the relationship between these formulas and the graphs unclear.	There are minor holes in the derivation of key formulas or the key formulas are not related to each graph with a least squares fit.	Key formulas are fully derived and related to the graphed results for easy determination of what the slope of the graph equals.	
Background/ Introduction	Key background information is missing (or incorrect) to understand the purpose of the lab.	Minor background information is missing to understand the purpose of the lab. (See next rubric for ideas on figure expectations. It's for the post lab but you might want to go ahead and do now.)	Includes at least one diagram of the experiment and/or concepts. Background information to understand the purpose of the lab is presented.	Includes at least one diagram of both the experiment and important concepts. Background information to understand the purpose of the lab is presented expertly.	
Procedure	The procedure is missing or is the same as the procedure listed in the experimental description.	While in their own words, the procedure does not really add anything useful beyond what is provided in the exp. description.	The procedure is in their own words and expanded in parts based on what was learned from working with the sample data analysis.	The procedure is written out in their own words and it is very clear how they will collect the data and analyze it.	
Data Visibility (Easy Points!)	Some important graphs or tables are missing.	Sample data graphs and/or axes are too small. It can only be too big if it no longer fits on the page!	A small percentage of data, tables or graphs are too small to easily read. **Make it big!**	All graphs, graph axes, axis numbering and tables are very big, but not too big to fit on one page.	
Data & Results Understandability	Figures are missing information or are inaccurate. Captions or figure numbers are absent or inaccurately/ incompletely describe the figures.	Data appear accurate, but figures are difficult to understand. Captions do not clearly and completely describe figures.	Data is accurate and presented in a clear fashion. Captions clearly and completely describe figures.	The figures contain all the information needed to understand the data. All the figures flow in a clear and understandable fashion.	
Uncertainty Discussion	Multiple aspects of the discussion of uncertainty are missing, not explained or very poorly explained.	Either two measurement uncertainty, slope uncertainty or propagation of errors is missing or one and one not explained.	Either one of measurement uncertainty, slope uncertainty, or propagation of errors are not given or one is not adequately explained.	Measurement uncertainty, slope uncertainty, and propagation of errors are all given and adequately explained (FH has no propagation).	
Uncertainty Values of the Sample Data	Major parts of the uncertainty of the sample data are missing	Some parts of the uncertainty of the sample data are missing	All aspects of uncertainty possible from the provided sample data are presented	All aspects of uncertainty possible from the provided sample data are presented clearly and in context with what is expected	
Conclusion Based on Sample Data	This is no real discussion of the sample data findings.	Some of the sample data findings are discussed.	The sample data findings including uncertainties are given. Reasonable significant figures are used.	The sample data findings and uncertainties are summarized. You discuss whether the sample data agrees with the expected values within the error discussed.	
	F: 0-7 (0-1.8)	C: 15-21 (2.1-2.4) D: 8-14 (1.8-2.1)	A: 30-36 (2.7-3.0) B: 22-29 (2.4-2.7)	**Total Score**	

Post-Lab Notebook Rubric Experiment: Author:

Category	Far below threshold (1)	Below the threshold (2)	Meets the threshold (3)	Exceeds the threshold (4)	Score
Data & Results	Figures are missing information or are inaccurate. Some axes are not labeled with units.	Data appear accurate, but figures are difficult to understand. There is limited discussion about the findings from several figures.	Data is accurate and presented in a clear fashion. The results from the figure are discussed. Graph axes and numbers are large.	The figures contain all the information needed to understand the data. The results from the figure are well discussed near the figure (not just in conclusions).	
Figure Numbers and Captions	Many figures are missing figure captions, or they are extremely vague (such as "experimental data")	There is more than one important point that is not clear from the figure captions	Figure captions mostly explain the most important points of the figure. All fit lines are mentioned.	Figure captions completely explain the important points of the figure. All fit lines are mentioned.	
Figures Explaining the Main Physics	Only one figure is provided that relates to the background of the experiment and/or the experimental setup.	Two figures related to explaining the key concepts AND setup of the experiment. **Note that all figures should have figure captions.** **(You may request an example.)**	Three or more figures related to explaining the key concepts AND setup of the experiment. At least one focuses on the core physics occurring, but has extraneous/distracting other stuff.	Three or more figures related to explaining the key concepts AND setup of the experiment. At least one focuses on the core physics occurring and doesn't have extraneous/distracting other stuff.	
Improved Procedure	No procedure is given beyond what was given in the pre-lab. (Now that you've done the lab, you should have a better step-by-step understanding.)	Very small changes were made from what was given in the pre-lab. (Note that the pre-lab procedure was before experiments and the procedure is not step-by-step in the handout. Yours should be.)	The procedure is written out in their own words and it is very clear what experimental and procedural steps were performed for most parts. (Procedural may have been covered well in the pre-lab.)	The procedure is written out in their own words and it is very clear what experimental steps were performed for each part. If not previously thorough, updates to analysis procedure.	
Uncertainty	Multiple aspects of uncertainty are missing and not explained.	Either two measurement uncertainty, slope uncertainty or propagation of errors is missing or one and one not explained.	Either one of measurement uncertainty, slope uncertainty, or propagation of errors are not given or one is not adequately explained.	Measurement uncertainty, slope uncertainty, and propagation of errors are all given and adequately explained (FH has no propagation).	
Sig Figs	There are many places where the sig figs are way off.	There is at least one important place (such as the results) where the sig figs are way off.	There are minor places were the sig figs look pretty far off, such as a regression fit giving the slope or intercept to too many sig figs	There are no graphs or final results that are listed with unreasonable sig figs	
Troubleshooting	No discussion of whether any troubleshooting was needed is given	Discussion of troubleshooting is limited and is not clear what the problem was.	There is a clear discussion of what trouble the student ran into during the experiment.	There is a clear discussion of what trouble the student ran into during the experiment and how it was overcome.	
Experimental Improvements	There is no discussion of improvements that could be made to the experiment.	Discussion of experimental improvements is limited and it is unclear why the ideas discussed would be improvements.	There is a clear discussion of potential experimental improvements.	Not only was there discussion of how improvements could be made to the experiment, but some were already tried and discussed.	
Conclusion	An absent or illogical explanation for the findings. Does not address any of the questions or issues posed in the introduction.	Presents an incomplete or illogical explanation for the findings and only addresses a couple of the questions or issues posed in the introduction.	Presents a logical explanation for the findings and addresses some of the questions or issues posed in the provided experiment description. Reasonable sig figs used.	Presents a logical explanation for the findings and addresses the questions or issues posed in the provided experiment description. Reasonable sig figs used.	
	F: 0-7	C: 15-21 D: 8-14	A: 30-36 B: 22-29	**Total Score**	

Written Report Rubric Title: Author:

Category	Far below threshold (1)	Below the threshold (2)	Meets the threshold (3)	Exceeds the threshold (4)	Score
Title	Title is missing or misleading.	Title does not identify the topic of the paper.	Title identifies the topic of the paper.	Title clearly identifies the main research question addressed in the paper without being silly long.	
Introduction/ Motivation/ Goals	Does not include background or previous work. Does not identify the purpose, the project, the main question(s) or issue being addressed, or the results and conclusions.	Gives very little background or information. May include the main question(s) or issue but does not identify the purpose for addressing them. Does not preview the results and conclusions	Gives a listing of the facts and previous work but does not tie them together and show how they lead to the purpose of the present work and the questions being addressed. It does have the question(s) being addressed and some motivation. Previews the results and conclusions.	Presents the background information (and procedure in a concise manner) that directly leads into the question(s) being addressed and the purpose of the research **including learning goals** (oscilloscope). **Concisely previews the results and conclusions without just giving the abstract**!	
Formulas/ Constants	Key formulas or expected constants are missing.	There are major holes in the derivation of key formulas and/or the relationship between the formulas and graphs are unclear.	There are minor holes in the derivation of key formulas or the key formulas, but it is clear how the formulas relate to the graphs.	Key formulas and where they come from are fully discussed and related to the graphed results for easy determination of what the slope of the graph equals.	
Looks like a Paper	Derivations, references and data may be given, but only listed in a section that is not part of the story of the paper.	Derivations of formulas, refs and data are given, but only one of them is included the way it would be in a paper (see real papers!)	An attempt was made to include the derivations of formulas, ref #s and data into the discussion like a paper, but it didn't quite manage well.	Derivations of formulas, references #s and data not just given, but worked into the discussion of the paper as if it tells a story.	
Relation to Modern Applications	There is discussion of the relationship of the current lab to modern applications, other than maybe just "spectroscopy" or similar few word description.	The principles learned in the lab are briefly related to other applications, but not much detail is given (but more than just a couple of words).	There is a reasonable discussion of how the principles in this lab apply toward at least one application, and the link is explained.	There is a detailed discussion of how the principles in this lab apply toward more than one application, and the link is well explained.	
Data & Results	Figures are missing information and are inaccurate. Captions are absent or inaccurately/incompletely describe the figures.	Data appear accurate, but figures are difficult to understand. Captions do not clearly and completely describe figures.	Data is accurate and presented in a clear fashion. Captions clearly and completely describe figures. Figures are numbered.	The figures contain all the information needed to understand the data. All the figures flow in a clear and understandable fashion. Figures are numbered correctly.	
Uncertainty	Multiple aspects of uncertainty are missing and not explained.	Either two measurement uncertainty, slope uncertainty or propagation of errors is missing or one and one not explained.	Either one of measurement uncertainty, slope uncertainty, or propagation of errors are not given or one is not adequately explained.	Measurement uncertainty, slope uncertainty, and propagation of errors are all given and adequately explained (FH has no propagation).	
Conclusion	An absent or illogical explanation for the findings. Does not address any of the questions or issues posed in the introduction.	Presents an incomplete or illogical explanation for the findings and only addresses a couple of the questions or issues posed in the introduction.	Presents a logical explanation for the findings and addresses some of the questions or issues posed in the introduction. Reasonable sig figs used.	Presents a logical explanation for the findings and addresses the questions or issues posed in the introduction. Suggests what the next research project would be.	
Procedure/ Methods	The procedure is missing or is a numbered list. This is not how papers discuss methods. (Look at papers for examples.)	While in their own words, the procedure does not really add anything useful beyond what is provided in the exp. description.	The procedure is written out in their own words and it is very clear what experimental steps were performed for most parts.	The procedure is written out in their own words and it is very clear what experimental steps were performed for each part.	
	F: 0-7	C: 15-21 D: 8-14	A: 30-36 B: 22-29	**Total Score**	

End of Semester Talk Rubric Title: Author:

Category	Far below threshold (1)	Below the threshold (2)	Meets the threshold (3)	Exceeds the threshold (4)	Score
Delivery	Uses eye contact ineffectively. Fails to speak clearly and audibly and uses unsuitable pace.	Some eye contact, but not maintained. Speaks clearly and unclearly in different portions.	Maintains eye contact. Speaks clearly and uses suitable volume and pace.	Effectively uses eye contact. Speaks clearly, effectively and confidently using suitable volume and pace.	
Visual Presentation	Many slides look like they were done in a hurry. Possibly multiple typos. Things may be hard to read.	Most slides look good, but several have way too many words, formulas, graphs or data. There may be several typos.	Slides look mostly professional, but there are a couple slides that **way too many words**, graphs or data are presented at once. Typos minimal. References listed.	Slides look professional and not filled with multiple full sentences. You don't try to put too much on each slide. References listed on slides they appear and at the end.	
Introduction/ Motivation/ Goals	Does not include background or previous work. Does not identify the purpose, the project, the main question(s) or issue being addressed, or the results and conclusions.	Gives very little background or information. May include the main question(s) or issue but does not identify the purpose for addressing them. Does not preview the results and conclusions	Gives a listing of the facts and previous work but does not tie them together and show how they lead to the purpose of the present work and the questions being addressed. It does have the question(s) being addressed and some motivation.	Presents the background information and procedure in a concise manner that directly leads into the question(s) being addressed and the purpose of the research **including learning goals** (oscilloscope). **The results are previewed** (not abstract form).	
Physics Concepts/Key Formulas	Many errors in explanation or usage of concepts/formulas from the course that are critical to the analysis in the work. No relationship to modern work.	Some errors in explanation or usage of concepts/formulas from the course that are critical to the analysis in the work. Vague relationship to modern work.	No errors in explanation or usage of concepts/formulas from the experiments that are critical to the analysis in the work. General examples given to modern work but nothing specific.	No errors in explanation of concepts/formulas. Correct and novel application of concepts and/or techniques to a new problem. **Specific modern examples related to work.**	
Data & Results	Figures are missing information and are inaccurate. Figure descriptions are absent or inaccurately/ incompletely describe the figures.	Data appear accurate, but figures are difficult to understand. The figures are not clearly and completely described.	Data is accurate and presented in a clear fashion. Some key take away points are discussed.	The figures contain all the information needed to understand the data. Clear labeling. **The main take away(s) is/are clear**.	
Uncertainty/ Significant Figures	Error discussion is missing or inaccurate. Three or more too many significant figures are quoted. Missing error bars.	The discussion of error and uncertainty appears accurate but not clear. A couple too many significant figures are given.	A mostly clear discussion of how error and uncertainty are determined in your work. Sig. figs and error bars are reasonable.	A clear discussion of how error and uncertainty are determined in your work. Significant figures are appropriate. Error bars accurate.	
Troubleshooting /Improvements	Neither challenges/troubleshooting nor improvements are discussed.	Discussion of troubleshooting and improvements is limited to only a few word discussion of possible changes.	Either experimental challenges/ troubleshooting or improvements to the experiment are effectively discussed.	Both challenges **and** improvements are discussed and it is detailed how **exactly** you would fix them and how that would **affect the data**.	
Conclusion	An absent or illogical explanation for the findings. Does not address any of the questions or issues posed in the introduction.	Presents an incomplete or illogical explanation for the findings and only addresses a couple of the questions or issues posed in the introduction.	Presents a logical explanation for the findings and addresses some of the questions or issues posed in the introduction.	Presents a logical explanation for the findings and addresses the questions or issues posed in the introduction. Suggests what the **next research project** would be.	
Questions & Answers	Demonstrates incomplete knowledge of the topic by responding inaccurately and inappropriately to questions and feedback.	Demonstrates some knowledge of the topic by responding accurately and appropriately to questions and feedback.	Demonstrates knowledge of the topic by responding accurately and appropriately to questions and feedback.	Demonstrates extensive knowledge of the topic by responding confidently, precisely and appropriately to all audience questions and feedback.	
	F: 0-7	C: 15-21 D: 8-14	A: 30-36 B: 22-29	**Total Score**	

Poster Rubric Title: Author:

Category	Far below threshold (1)	Below the threshold (2)	Meets the threshold (3)	Exceeds the threshold (4)	Score
Grammar / Mechanics	Numerous and distracting errors in punctuation, capitalization and spelling.	Many errors in punctuation, capitalization and spelling.	Almost no errors in punctuation, capitalization and spelling.	No errors in punctuation, capitalization and spelling.	
Visual Presentation	Poster looks like it was done in a hurry. Possibly multiple typos. Things may be hard to read.	Most of the poster looks good, but some sections have way too many words, formulas, graphs or data. There may be several typos.	Poster looks mostly professional, but there are a few sections that have way too many words, graphs or data. Typos minimal. References listed.	Poster looks professional and not filled with multiple full sentences. You don't try to put too much on each slide. References listed **where used and** at the end.	
Introduction/ Motivation/ Goals	Does not include background or previous work. Does not identify the purpose, the project, the main question(s) or issue being addressed, or the results and conclusions.	Gives very little background or information. May include the main question(s) or issue but does not identify the purpose for addressing them. Does not preview the results and conclusions	Gives a listing of the facts and previous work but does not tie them together and show how they lead to the purpose of the present work and the questions being addressed. It does have the question(s) being addressed and some motivation.	Presents the background information and procedure in a concise manner that directly leads into the question(s) being addressed and the purpose of the research **including learning goals** (oscilloscope). **Why is this important beyond this lab?**	
Physics Concepts/Key Formulas/ Modern Connection	Many errors in explanation or usage of concepts/formulas from the course that are critical to the analysis in the work. Formulas may look sloppy. It is not discussed why this lab is related to any modern application or modern research.	Some errors in explanation or usage of concepts from the course that are critical to the analysis in the work. At least a brief link of the experiment is mentioned in relation to modern experiments or applications.	No errors in explanation or usage of concepts/formulas from the experiments that are critical to the analysis in the work. There are pictures and brief text showing how the principles in this lab apply toward **one modern application**.	No errors in explanation of concepts/formulas. There are pictures showing how the principles in this lab apply toward **more than one modern application** and the main findings are directly linked to properties used/found.	
Data & Results	Figures are missing information and are inaccurate. Figure descriptions are absent or inaccurately/ incompletely describe the figures.	Data appear accurate, but figures are difficult to understand. The figures are not clearly and completely described.	Data is accurate and presented in a clear fashion. Some key take away points are discussed, but should not be made as figure captions.	The figures contain all the information needed to understand the data. Clear labeling. **The main take away(s) is/are clear**.	
Uncertainty/ Significant Figures	Error discussion is missing or inaccurate. Three or more too many significant figures are quoted. Missing error bars.	The discussion of error and uncertainty appears accurate but not clear. A couple too many significant figures are given.	A mostly clear discussion of how error and uncertainty are determined in your work. Sig. figs and error bars are reasonable.	A clear discussion of how error and uncertainty are determined in your work. Significant figures are appropriate. Error bars accurate.	
Troubleshooting /Improvements	Neither challenges/troubleshooting nor improvements are discussed.	Discussion of troubleshooting and improvements is limited to only a few word discussion of possible changes.	Either experimental challenges/ troubleshooting or improvements to the experiment are effectively discussed.	Both challenges **and** improvements are discussed and it is detailed how **exactly** you would fix them and how that would **affect the data**.	
Conclusion	An absent or illogical explanation for the findings. Does not address any of the questions or issues posed in the introduction.	Presents an incomplete or illogical explanation for the findings and only addresses a couple of the questions or issues posed in the introduction.	Presents a logical explanation for the findings and addresses some of the questions or issues posed in the introduction.	Presents a logical explanation for the findings and addresses the questions or issues posed in the introduction. Suggests what the **next research project** would be.	
Questions & Answers	Demonstrates incomplete knowledge of the topic by responding inaccurately and inappropriately to questions and feedback.	Demonstrates some knowledge of the topic by responding accurately and appropriately to questions and feedback.	Demonstrates knowledge of the topic by responding accurately and appropriately to questions and feedback.	Demonstrates extensive knowledge of the topic by responding confidently, precisely and appropriately to all audience questions and feedback.	
	F: 0-7	C: 15-21 D: 8-14	A: 30-36 B: 22-29	**Total Score**	

A Few Common Challenges

When error bars are too small to be visible on your graphs, it is the student's responsibility to identify the error bars in some other fashion. One example would be a table of the data with the error bars. In the caption, it should **also** be noted that the error bars are too small to see.

When it is not obvious how error should be defined: The photoelectric effect, charge to mass and ESR labs all have one important variable (two in the last part of charge to mass) where the uncertainty in it is not obvious how to define. In many other labs, the uncertainty can be easily related to a full width half max, or something else reasonably obvious. You can use a variation of FWHM in ESR actually, but it is not as obvious as you might expect. In real research, it is not always obvious how to define error in a variable. Thus, it is important to be very clear (with words and diagrams) about how you define that error. In the last part of **charge to mass**, for example, you'll be looking for what values of E and B result in a straight-ish line. Your error for E and B is then how much can you move it before it is no longer straight-ish. People might have different opinions on what straight-ish is, and that's ok. But, it's very important that you document your decision. You'll want to at minimum take a picture of what the boundary of straight-ish looks like. Another example is the **photoelectric** effect lab. In this lab, the measurement error would give you WAAAAAY too small of an error for the stopping potential. The manual suggests a particular method to find the stopping potential, but it is pretty hard to define an error with this method. Thus, I recommend that you use two different methods of approximating the stopping potential; come up with your own ideas, but I'm happy to discuss ideas with you if you need it. The difference between these two methods should be a pretty good estimation of the error on the stopping potential. Note that the error will be different for each LED. Like any non-obvious error approach, you really need to do a good job at explaining in words and with diagrams/graphs what your two methods are. You should show these two methods on **at least** two of your LED graphs. (Another note about the photoelectric effect lab: watch out for detector saturation. If you catch it early, you can figure out how to prevent it from happening. If you catch it late, you'll have to throw out some points and might require you to redo a measurement if it is too many points.)

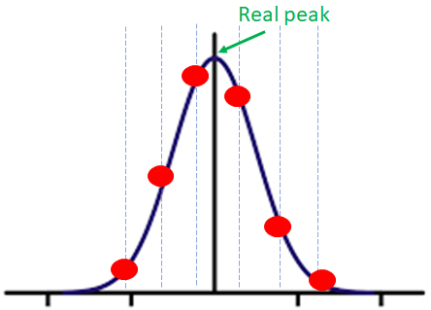

Figure 1: Generic illustration that picking the highest point is going to give you a poor answer for your peak position, particularly when you have few or noisy data points. (Axes purposefully unlabeled since it applies to many different situations.) The dashed blue vertical lines signify where a measurement is taken. Red dots are measurements. The black Gaussian curve is the expected actual curve.

Documentation is also a very important part of your labs. I find it is not uncommon for students to forget to include some information, such as graphs from oscilloscopes or trajectory lines from charge to mass. At minimum, take a picture with your phone and include it in your lab notebooks and lab reports. On oscilloscopes, you can even collect the data with a flash drive; I recommend this as it will allow you to analyze your data more accurately.

Franck-Hertz: This lab is probably the easiest lab conceptually; thus, I am extra harsh on making sure you document your data and how you determine the peaks and error. If you only list the peaks and error without showing me how you determined that, you will lose points. How you find your peaks should NOT just be the voltage with the highest intensity. (Similarly for **atomic spectroscopy**, the highest intensity spot is not necessarily the peak location. See the figure to make this clear.) Also in the Franck-Hertz experiment, you will notice that you have peaks on an increasing background. I suggest you think about how to approximately subtract that background so that you don't accidentally skew your results.