Physics 331 Lab Report Grading standards September 24, 2015

A maximum of **50 points** will be allocated to each Lab Report. Detailed guidelines can be found at this Link: http://courses.washington.edu/phys331/lab_practice_and_report.pdf

General guideline: Read experimental instructions and plan your lab report ahead. You will see that most of part 1, 2, 3, and some part of 4 of lab reports can be done during the lab section, which will save you a lot time and also help you to achieve a successful experiment.

Please label each section

1. **Title** (1 pts): Name of experiment, date of the experiment, your name, and all names of your partners. (This part can be done before come to the lab).

2. (4 pts) **Motivation and Objective***:* state the purpose of the experiment in one or a few sentences. The purpose of the experiment is distinct from the method or apparatus used, rather it is the overall goal(s) or motivation. (This section can be done before you come to the lab).

3. (5 pts) **Experimental Methods**: describe the method(s) used to carry out the measurements in a general way (the description should not go into trivial details). Plot Diagram of apparatus. Parameters should be defined. For example in SoL parameters would be *A*, *B*, *D*, focal lengths, rotation speed, and spot displacement. (This section can be done during the experiment).

4. (30 pts) **Results and Analysis**: should state the main results of the experiment, including all important numerical results *(Please refer to in-class notes and data for detail)*. This should include

- Graphs with axes labeled and a title or caption.
- Formulas: Refer to definitions of parameters given above. Give reference to the source of formula or derivation if original.
- Name of programs you used (include listing only if you wrote them or made major changes)

Uncertainty analysis (propagation of errors). *All records of data collection should contain an estimate of the uncertainty of the raw data if appropriate.* The usual rules apply: calculate a mean and a standard deviation.

- (5 pts) Raw Data sheet should be attached to the report. *Every report must include a copy of the raw data*. It is your responsibility to make copies of X-Y graphs, computer printouts or other data collected by the group as a whole. At least one person in the group should include the original data in his or her notebook.

5. (5 pts) **Discussion**: assess the success of the experiment itself. That means, results should be compared to literature values (if available), and systematic error should be addressed: is there a systematic error, and if so, how do you know? If systematic error is present, what do you believe it arises from, and how might you check that hypothesis?

6. There is also 5 points for the style and format. Please make sure to organize the report and keep your writing/notes neatly (at least readable), which will help TA to grade your reports.

Instructions for Lab Notebook and Reports

Notebooks

There are no formal reports in the usual sense. Experiment write-ups will be in the form of lab notebooks. Following materials are strongly recommended for the notebooks.

- Two cardboard "expansion report" covers. These are cardboard covers that allow hole-punched papers to be assembled into a bound notebook. An example purchased at the University Bookstore is the Oxford Esselte model 12905. You will need two of these covers because you will need to be able to use one of the notebooks while the other is being graded.
- One (or more) pad(s) of green or tan \engineering" paper. This is the paper that has graph ruling on the back side of each sheet. The same type of paper is used in the electronics labs (physics 334).
- A package of \insertable notebook dividers". These are the notebook dividers that have the clear plastic tabs you can slip a label into.

Your reports will consist of the notes and drawings you make in lab (on the engineering paper), computer, plotter, or oscilloscope printouts (depending on the lab) assembled into the report covers. Each lab report should be separated by one of the notebook dividers.

Each report should contain the following materials

1. In-class notes and raw data (will be included in the report for experimental methods, and Results and Analysis)

Notes: The notes taken in class should conform to proper scientific record-keeping practices. This means that

- Each page should be numbered and dated with the day on which the work was done.
- Notes should be recorded in pen. Errors should be crossed out with a line or two. Do not use white-out, and do not recopy your original notes.
- Notes should be kept neatly. Give yourself space on the page. Lay out tables with columns so that they are easy to fill in and to read.
- *Data should be recorded with proper, stated units*. Failure to follow consistent unit usage is one of the main causes of incorrect work.
- Relevant conditions pertaining to various parts of the experiment are clearly stated, for example, light source, apertures, distances, and so forth (depending on the experiment).
- Specific operations or procedures that would be different from time to time are described in a few sentences.

The above list is neither complete nor minimal: what you record and how will depend on your experiment. *The important point is to record the information one would need to reproduce your results.*

Annotated diagrams of the apparatus (For the **Experimental Methods** section): These diagrams (there may be one or more, depending on your experiment) should be *original*: drawn by you (not drawn by your partner and not copied directly from the instructions); they should clearly show all of the light paths among the various components; they should clearly indicate any physical characteristics important to the experiment. Complex sub-components of the apparatus should have their own diagrams and annotations.

Annotations are important! The annotations should be copious and indicate the use and function of the various components of the apparatus. The annotations may be written directly on the diagrams or on a separate page.

The annotated diagram serves the purpose of a description of the procedure used in the experiment. Do not write a step-by-step procedure that mimics the steps given in the instructions. However, it is OK to write a few sentences on the overall operation of the experimental apparatus.

2. Analysis of results (Results and Analysis section in the report)

It is a good idea to run quick preliminary analysis of your data while you do the experiment. This helps prevent major errors in data recording as well as making clear any calibrations that may need to be done. Preliminary analysis should be noted as such. In general, however, most analysis will be done after data collection is over.

The specifics of the analysis will vary according to the experiment, but the following general guidelines pertain:

Graphs should take up at least a half-page, with a plot area filling most of that space. The axes should be labeled with the specific quantity and its unit. If the quantity does not have a unit or is arbitrary, make sure that is clear. The data set should fill most of the area of the graph, unless it is important to show its relationship to some point on the coordinate axes, such as zero.

Data points should not be connected by line segments. Data points should have error bars indicating the uncertainty of the data. Any lines drawn on the data sets should represent fits to the data or theoretical predictions. If more than one thing is plotted on a graph, a legend should be provided.

Spreadsheets should contain clear column and row headings and a description of what is being calculated. Any cells outside of the main tables should be annotated so that the meaning of their contents is obvious. *Do not assume the grader can decipher your spreadsheet by reading the numbers themselves*. *Uncertainty calculations* should be clearly laid out. Indicate how you feed in various uncertainties into your calculations and whether you have chosen to ignore the uncertainty in some quantities. You will need this information when you discuss the causes of uncertainty in your written portion.

Computer programs should be printed out and included in your report. Give comments within your code or else written on the paper stating what each part of the program does. In a computer program the variable names should be short but meaningful, for example: refractionIndAir, speedLight, focalLeng2, or slitWidth3. The names should be identified with hardware components or measured or derived quantities.

Formulas that are used to calculate results with spreadsheets, programs or even by hand should be written on or near the relevant parts of the report. Any formulas should be defined: state what they are for, and define any variable that may be unclear.

Final results should be clearly placed and labeled and should be stated using correct significant digits with uncertainty and with correct units. If a result does not have units, state that it is "unitless". An effort should be made to compare your results to other results, if they may be found. You may need to run a literature search to determine whether your result agrees with a previously determined value. You are not absolved of needing to compare your results to the literature just because such values may not be stated in the experiment instructions. When you find a result to compare to, you must cite the source with enough information so that anyone could locate it. Many measurements are of known quantities (such as the speed of light), whereas other measurements may depend on apparatus specifics.

In either case, *you must assess the quality of your results and determine whether you think they are reasonable or not, based upon a coherent physical argument*.

Treat *random uncertainty* first. To start, make sure you have included all parameters in your uncertainty analysis, at least insofar as you consider whether they contribute importantly to the final value of your uncertainty, as presented in the summary abstract. Then, after you have propagated the uncertainty using the usual techniques, check your percentage uncertainty against the percentage uncertainty of each of the parts that went into this final value, and determine the most important contributors. Finally, discuss why these factors are the most important. (It may be useful to make a table of the various contributors to your uncertainty to help you sort them out, but this should not appear in your written discussion.)

Systematic error should be addressed. A systematic error certainly exists if the expected value of what you measure lies outside the range of accepted values of well-known quantities, although there may be other indicators of systematic errors. It should be clear whether your result more than about 2 sigma away from what you wanted. If this is true, then you need to decide what aspect of the apparatus or method could cause this effect. Be qualitative in your discussion first, for example, could a change in the gain of some amp or a shift in a calibration factor account for the discrepancy? Then be quantitative: how much of a change in that parameter is necessary to cause the change in the result that you see? Is such a change a reasonable possibility? If it is, you have a good candidate for a "source of systematic uncertainty"; if not, you should keep looking.

The discussion of uncertainty should be a critical assessment of the sources of uncertainty in your results. You need to provide a sensible, logical, physical argument based upon your own experiment, not unsupported speculation. In other words, do not cite a source of uncertainty that you cannot prove is evident in your results.

Academic Honesty

Students working together are encouraged to discuss their analysis and results with each other (and with other students) but must independently generate their own written reports.

The way in which you estimate your uncertainties must ALWAYS be clearly shown. If you copy text from the lab instructions, you are wasting space. You are asked to give a brief statement in the introduction; this means in YOUR words.

When you quote a result that is not in many optics or physics texts, you need to give a citation, whether you obtain the results from the Internet, a book, or a friend. Best of all is to show how you got the result.

For example, the definition of reduced mass needed for experiment 2 is in many texts, but how you use the wavelength splitting you measure to deduce the mass ratio of deuterium to hydrogen is something that needs to be explained. If you copy something from the Internet, give the complete link for the source. If you copy from a book, give the author(s), title, and year published. Plagiarism is an offense punishable by expulsion from the university. If you don't know the meaning of the word plagiarism you might wish to look at http://depts.washington.edu/grading/issue1/honesty.htm or http://www.engr.washington.edu/org/processes/miscpolicy.htm

To quote from the second:

ALWAYS make very clear reference to the source of the material you use and put the material taken in "quotation marks," no matter where you find it. This is perfectly acceptable and legitimate. DO NOT try to rewrite or change another person's work and pass it off as your own this is very difficult to do and is easily detected. You can always use published writings as long as you give a formal reference and acknowledgment of the source. If the information comes from a conversation with a professor or another student, give their name and recognition that it is their thought.