Syllabus – Intermediate Lab – Physics 265

Instructor: Keith Bonin, Olin 310, x4962, email: bonin@wfu.edu

The intent of this course is two-fold: to illustrate the concepts of Modern Physics in the laboratory and to extend your laboratory experience in physics to more advanced techniques (instrumentation, computer interfacing, data collection software, and data analysis). Toward these ends, the class consists of a series of labs that you will carry out each week in teams of two. You and your lab partner will be responsible for reading the laboratory write-up in advance, for setting up the equipment to carry out the data-taking segment, for disconnecting the equipment to put it back in its original state, to analyze the results, and to write up your results in a neat report to be handed in each week for grading. Each student must hand in their own individual report. You are allowed to share data with your partner, but the phrases, sentences, and paragraphs in your report must be your own work.

The schedule of labs is listed at the end of this syllabus. The second section of this syllabus is a rather detailed outline of what is expected of your lab report. The first report you submit will be very carefully graded, with lots of feedback to calibrate you about what is expected in a good laboratory write-up. Lab write-ups are due each week at the beginning of lab. Late lab reports are accepted, but you will lose 10 points for being late up to a week, 20 points will be lost if you hand in your report between 1-2 weeks late, etc.

Laboratory meetings: Labs are every Tuesday from 2:00-4:30 PM in Olin room 203.

Grades: Each lab is worth equal weight toward your final grade. The final grade will simply be the average of all your reports.

Office Hours: I have an open door policy – if my door is open then I am available for questions. In addition, I frequently check my email and will respond to your questions as promptly as I can.

Resources: Detailed descriptions of each lab are available at my website as pdf files. You are welcome to download and print the lab descriptions. Bringing the descriptions to lab will be of great benefit when you get stuck or have a question about the lab.

Teaching Assistants: There are three laboratory Teaching Assistants who will assist me during the laboratory period, and they will also grade many of the labs. The TAs will each be assigned to answer questions about specific labs (and grade specific labs), while I will circulate and answer questions about all the labs.

Emergency Contingency Plan: students will be responsible for reading each laboratory write-up, and handing in an electronic or paper copy of their lab report. Since the lab equipment will be inaccessible, the instructor will electronically send you data that he/she collected using the apparatus, and the students will use this data for the analysis presented in their reports. Weekly typewritten reports will be due 1 week after you receive the data.
Format of Lab Reports – Intermediate Lab (Phys 265)

Keith Bonin

Your lab reports should follow the following structure:

0) Title of Experiment and Names of Lab Team Members
1) Abstract
2) Introduction
3) Theory/Basic Physics
4) Experimental Method/Procedure
5) Results & Analysis
6) Discussion/ Answer Questions
7) Conclusion/Summary

The purpose of adopting this structure is to get you more used to the style of writing that is used in published scientific literature. This format, with modest variations, is used to report research in nearly all peer-reviewed articles. At your level, your goal should be to write so your lab partner, or another physics undergraduate, can understand your report.

Detailed tips for each section of the report:

1) Abstract: The abstract should briefly describe what you did, why you it, and what was the main result. (1-2 sentences)

2) Introduction: Here you should give background information and put the experiment in context. Why is such a measurement important? Convince the reader of its significance in simple language, with a very brief description of a lingering question or problem it is trying to solve, or a new phenomenon that was observed, etc. (1 paragraph, no more than 5-6 sentences)

3) Theory/Basic Physics. In this section, the basic physics that describes the experimental behavior should be summarized. The reader should not be given detailed derivations, but physical arguments must be sketched and backed up with equations that model the physical behavior. The key is to give the educated reader enough physics so they will understand the results and your analysis of the results. The reader should be able to understand the physics underlying your experiment without having to consult a
textbook or other source. Note that all equations should be sequentially numbered (by hand if necessary). In some of the labs, 2 & 3 can be combined. (Try to limit it to no more than half a page).

4) Experimental Method. Discuss your setup and method so that an educated undergraduate can understand what you did. You can cut and paste helpful figures from the lab write-ups, but everything else must be in your own words. Figures must be credited. For example, at the end of your figure caption for a figure that you did not draw, but that you used from the write-up, you should type ‘taken from the lab write-up for Lab XXXX’. All figures in your report must include a figure caption. (Limit the text part to half a page).

5) Results and Analysis: It is critical to neatly summarize your data in tables and in graphs (where appropriate). In most cases you should include error bars (at least in the entries for a table). For graphs containing few points, error bars are usually given for each point. For graphs containing much data, usually only one data point is given an error bar – to be representative of the fractional error for the whole graph. The analysis part should explain how you treated errors (propagation of errors, the largest sources of error, etc) as well as any curve-fitting that was performed on the data. If curve fitting is discussed, a $\chi^2$ analysis should be briefly described.

6) Discussion/Answer Questions. For experiments where a physical constant is measured, compare your results with accepted values. Then analyze the result compared to the error (both systematic and statistical). Finally, make a connection to the theoretical value of your quantity, if appropriate. Some of the labs have questions interspersed throughout the lab description – answer these questions in this section. (Limit it to no more than half a page)

7) Conclusions. Summarize the main result and main conclusion from your discussion section. (~2 sentences)

Final Comments: A well-written lab report will be strong in both content and style, and it will be tightly edited. A well-executed lab is critical, but so is your ability to communicate and explain your results to others. Hence you should strive for good organization, correct syntax and grammar, and lucid explanations.
<table>
<thead>
<tr>
<th>Lab Title</th>
<th>September</th>
<th>October</th>
<th>November</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability, errors, curve fitting</td>
<td>ALL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge $e$ of the electron (RR Millikan, two weeks) Setup 1</td>
<td>a b c d e f g h i</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge $e$ of the electron (RR Millikan, two weeks) Setup 2</td>
<td>a b c d e f g h i</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$e/m$ for the electron (JJ Thomsen)</td>
<td></td>
<td>b c d e f g h i a</td>
<td></td>
</tr>
<tr>
<td>Photoelectric effect (H Hertz, A Einstein)</td>
<td></td>
<td>c d e f g h i a b</td>
<td></td>
</tr>
<tr>
<td>Balmer spectrum of hydrogen atom (J Balmer)</td>
<td></td>
<td>d e f g h i a b c</td>
<td></td>
</tr>
<tr>
<td>X-ray emission spectrum of Cu (Roentgen, Moseley)</td>
<td></td>
<td>e f g h i a b c d</td>
<td></td>
</tr>
<tr>
<td>Bragg's Law (with microwaves)(WL Bragg)</td>
<td></td>
<td>f g h i a b c d e</td>
<td></td>
</tr>
<tr>
<td>Quantization of electronic energy levels of atoms (Franck-Hertz)</td>
<td></td>
<td>g h i a b c d e f</td>
<td></td>
</tr>
<tr>
<td>Wavelength of the electron (L de Broglie)</td>
<td></td>
<td>h i a b c d e f g</td>
<td></td>
</tr>
<tr>
<td>Hall effect: measuring $B$(EH effect)</td>
<td></td>
<td>i a b c d e f g h</td>
<td></td>
</tr>
<tr>
<td>Nuclear Magnetic Resonance</td>
<td></td>
<td>a b c d e f g h i</td>
<td></td>
</tr>
</tbody>
</table>

Group a = Eliot Conwill & Martus Gn
Group b = Brian Shoemaker & Richard Carney
Group c = Eric Voyles & Patrick Donelan
Group d = Matthew Snyder & Victor Yu
Group e = Cameron Zinchuk & Bradley Hicks
Group f = Jon Powers & Martins Ayoola-Adeola
Group g = Timothy Thomas & Daniel Johnson
Group h = Zac Christ & Tyler Jackson
Group i = Derek Fogel & Michael McCarthy