Physics 322  
Physical Measurements Laboratory

The teaching staff wants all of you to learn about how experimental physicists overcome research problems and obtain important results by doing three relatively sophisticated experiments during the course of the semester. These experiments are not canned experiments written up in cook-book fashion which work properly each time they are set up. In these experiments, many of which resulted in Nobel prizes, important physical principles are explored. Their successful completion depends upon proper selection of equipment, the solution to immediate unexpected problems, and careful data collection, much the way the original research proceeded. Final reports can outline new experiment designs, equipment modification and fresh new ideas about how to make the measurements better. These are precisely the type of problems and/or opportunities facing scientists in the real research world. Students should attempt to work as independently as possible and feel free to discuss opportunities for change and/or improvements as the experiment proceeds, integrating these into your written and oral presentations.

I. Lab Participation
Each student will receive a grade for class preparation, attendance and for their demonstration of independence and ingenuity in their work carried out in the laboratory. Students are expected to be in the lab from 1:00-4:50 pm. If a student needs to miss a class or leave early for interviews, etc., they need to let the instructor know ahead of time. All students have after hours access to the lab.

II. Data Notebooks
Data notebooks are diaries of the work done in the lab. They should contain a record of experimental setup, all parameters used on the equipment and all data taken. Since they are the only source of original data, all notebooks should be neat enough, and contain enough information, that a similarly qualified researcher can reproduce the results from the notebook alone and arrive at conclusions similar to those at which you arrive. One notebook will be kept and turned in per group per experiment.

III. Oral Presentations
An important part of scientific research is communicating your results to the scientific community. Often the first method of reporting important new scientific findings is in oral presentations at scientific conferences. The oral presentations in Physics 322 are meant to simulate a scientific presentation at a conference. They are to be brief (~10 minutes), concise and informative. In Physics 322 these will differ from conference papers in that they will be: (1) preliminary in the sense that both staff and other students can make suggestions that can be incorporated for better results; (2) each presentation will be 10 minutes plus 2 minutes for questions; (3) one student will give the talk. Oral presentations should make use of computer presentation or overhead projectors for clarity and efficiency of presentation. Students should practice the talks ahead of time to ensure
they can deliver their talk in the allotted 10 minutes making sure that they give plenty of time to the results and discussion section of their talk. Grading will be determined by:

   a) staying within the 10 minute time limit
   b) organization of talk
   c) clarity of speaking and quality of slides
   d) level of understanding of content and subject
   e) quality of discussion of results and conclusions

IV. Research Papers and Peer Review

The final result of physics research is publication in an appropriate journal. In Physics 322 you are asked to prepare a document following the general format of a Physical Review, Science, Review of Scientific Instruments or other similar publication. This document uses your data notebook as the only source of raw data. Information included in referenced articles may supply supporting information and theoretical models. Research papers should be prepared on word processors with references, figures and tables included as appropriate. As in scientific publications, all experimental data should be carefully analyzed and thoroughly checked. All experimental uncertainties, both systematic and random must be included in the results with the expected precision reflected in the number of significant digits shown. You should properly propagate errors through all stages of computation. See Theory of Error Propagation handout for details.

In the final section of the paper, point out problem areas and make recommendations for improving the experiment.

In addition to handing in a paper copy of your publication, a pdf copy of your publication must be emailed to phys322@physics.wustl.edu. If you have trouble making a pdf copy of your publication ask the AI or instructor for help.

For each of the three periods we will utilize a formal peer review process where students read each other’s work and prepare a clearly written review of the work. The students will then use this feedback to revise and resubmit their papers.

For all three periods:

   First presentation day:
   1) each group will hand in two copies of their first draft to be exchanged with fellow students for reviewing
   2) one member of the group will give an oral presentation (half the groups present)

   Second presentation day
   1) the reviewed papers will be turned in and handed back to the respective group
   2) one member of the remaining groups will present their oral presentation
One week later (from second presentation day)
1) final publication and lab notebooks will be turned in for grading

V. Grades
The grades for Physics 322 will be based upon two nearly equally weighted parts. One part is derived from an evaluation of the lab notebook, the quality and independence of the work actually carried out in the laboratory, and whether the experimental workspace is left in a tidy state. The other part is a combination of the oral presentations and the joint papers produced. The following section explicitly states the grading rubric. The staff will attempt to provide constructive feedback during and after the oral presentations to help the students prepare their written reports.
VI. Grading Breakdown

1) **Lab Participation (individual grades)**
   1. **Preparation for experiment**  30pts
      Read the lab write-up and literature documents *before* starting the experiment
   2. **Quality, ingenuity and independence of the work carried out in the lab**  30pts
   3. **Presence in the lab during class time**  30pts
      a) Class is from 1:00-4:50 pm Tuesday and Thursday
      b) If you have to miss a class period you must notify your lab instructor and partner
      c) You must make up the time missed outside of class time
   4. **The experimental workspace must be left in a tidy state**  10pts

2) **Lab book (combined grades)**
   1. **Evidence of critical analysis**  25pts
      This includes relevant notes during the experiment and brief analysis of results at the end of each day.
   2. **Is Procedure Reproducible?**  25pts
      You should keep your notebook in the form of a journal, with an entry for each day you are in the lab, even if not much happened. You should write your notes assuming that someone is going to repeat your work with the same apparatus. Be sure to note everything that could have affected your results or caused problems.
   3. **Is documentation concise?**  10pts
      You don’t need to write too much background or details that may not be needed. Write down everything relevant that happens each day, using clear language.
   4. **Proper presentation of data**  15pts
      This includes clear presentation of tables, as well as reporting units and error estimates on all data. If you are calculating a quantity or converting measured values to something else, show an example of the full calculation once.
   5. **Error Analysis**  20pts
      This includes both physical estimates and quantitative results when applicable. Some experiments will require a propagation of error calculation, and some will rely on physical estimates such as averaging or noting the spread in measurements. If a propagation calculation is needed, you should show the calculation.
   6. **Clarity of work**  5pts
      Your work should be legible and well organized. Always use a pen. Never completely eradicate a mistake. Just cross it out so that it is still legible. It may be useful to see what the mistake was, or it may not be a mistake after all.
3) **Presentation (individual grades)**
   1. **Total time limit 10 minutes** 10pts
      Practice talks…make sure you have enough time for results
   2. **Organization** 25pts
   3. **Clarity** 25pts
      a) Speaking
      b) Slides
   4. **Content/Subject Knowledge** 25pts
   5. **Good discussion of Results and Conclusions** 15pts

4) **Publication (combined grades)**
   1. **Title, Author List and Affiliation**
   2. **Abstract** 5pts
   3. **Introduction** 15pts
      a) Objective/Goal
      b) Theory/review
   4. **Methods/Procedures** 15pts
      a) Outline of procedure/Specific measurement details
      b) Apparatus figures/diagrams
   5. **Results** 30pts
      a) Analysis
      b) Tables/Graphs
      c) Uncertainties
   6. **Discussion** 30pts
      a) Comparison of experimental results to predicted results
      b) What went wrong?
      c) How to improve?
   7. **References** 5pts
      Cited in the text, numbered in order of appearance in text

5) **Peer Review (individual grades)**
   1. **Overall quality and depth of the peer review**. 50 pts
      Understanding of the critical aspects of the paper and recommending improvements.