PHYSICS 2510
LABORATORY

Instructors:
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Lab Coordinator: Jerry Leigh

Lecture 1
January 15, 2008

SCOPE OF THE COURSE

- This is your experimental introduction to modern physics!
- “Modern” in this case means roughly the 20th Century
- Your goals:
  - Learn how to take data efficiently and precisely
  - Learn proper use of uncertainties/error analysis
  - Learn how to present your results in writing and graphic form

INSTRUCTOR CONTACT INFORMATION

- Instructors
  - Prof. Noel Clark (noel.clark@colorado.edu)
    - Office hours: by appointment
  - Prof. James G. Smith (jgsmith@pizero.colorado.edu)
    - Office hours: by appointment
  - Prof. Eric D. Zimmerman (edz@colorado.edu)
    - Office: Duane F-435, x5-5338
    - Office hours: Mondays, 9:30-11:30
- Lab coordinator:
  - Jerry Leigh
  - Office: Duane G2B78A, x2-7368

REQUIREMENTS

- PRE/CO-REQUISITES
  - Have completed PHYS 1140
  - Are taking / have taken PHYS 2170 or 2130
  - Familiarity with numerical calculation program (Mathcad, etc.)
- SUPPLIES
  - Syllabus (handout; on WWW)
  - Lab manual (handout)
  - Lab notebook with carbon duplicate pages (1 per student supplied)
  - Error analysis pamphlet (handout)
  - Radioactive material handling training (handout)
  - Textbook: Taylor, “An Introduction to Error Analysis” (required)

SECTION ENROLLMENT

- The Tuesday afternoon section is VERY crowded. This will be unpleasant for everyone and limits your choice of experiments.
- No other section is more than half full.
- If you are signed up for Tuesday afternoons and can take another section instead, please try to switch!

COURSE SCHEDULE: LECTURES

- Lectures are Tuesdays, 4:00-4:50, through February 11.

- PLEASE READ THE APPROPRIATE CHAPTERS IN TAYLOR BEFORE EACH LECTURE!

- Lecture 1 (January 15):
  - Review of syllabus
  - Tour of lab room
  - Error introduction

- Lecture 2 (January 22): read Taylor Chapter 5
  - Statistical and systematic uncertainty
  - Gaussian distributions, mean, standard deviation
  - Tips for your first lab report

COURSE SCHEDULE: LECTURES / HOMEWORK

- Lecture 3 (January 29): read Taylor Chapters 6, 7
  - Rejection of data
  - Weighted averages

- Lecture 4 (February 4): read Taylor Chapter 8
  - Least squares analysis
  - Feedback from first lab reports

- Lecture 5 (February 11): read Taylor Chapters 9, 11
  - Correlation analysis
  - Poisson statistics

- Homework: One assignment, worth about 1 lab (assigned after lectures)

COURSE SCHEDULE: LABS

- Signup:
  - Sign up for experiments on the door pages in the lab.
  - Sign up one week in advance; don't sign up for the whole semester at once.
- You must do six labs; at least 2 "advanced" (see syllabus). Do not start with an advanced lab.
- Lab partners:
  - You may work alone or with one partner
  - You may not have the same partner for more than two labs.
- Most labs are 2 weeks; two are 3 weeks.
- The 3-week labs are not required, but accrue bonus points.

COURSE SCHEDULE: REPORTS

- First reports are due Thursday, January 31.
- Subsequent due dates will be Fridays.
- Common due date for all sections and reports: these are staggered to allow you to do up to two 3-week labs.
- You are encouraged to manage your time well and turn in reports as soon as possible after your section, so you are not working on the previous report while doing the next experiment.
- Late reports are penalized. See the syllabus for details.

LAB NOTEBOOK

- You will be issued a lab notebook, with duplicate pages.
- Everything must be recorded in your lab book!
  - Record in ink; do not erase. Correct mistakes by crossing out items, leaving them legible.
  - Use the carbon paper to produce a copy onto the yellow pages, which you will hand in.
  - Do not remove the white pages.
- Number and date all pages in your book, and be sure they show up on the yellow page.

LAB SAFETY

- Some experiments use radioactive materials. You must complete the on-line radioactive handling course.
- The biggest hazards in the lab are high voltage (enough current capacity for an unpleasant shock!) and trips/falls. Never touch energized electrical components, and always look out where you are going!
- Treat the equipment with care. The modern equipment is expensive (and parts can have a long delivery time). Some of the classic instruments cannot be replaced.

GRADING

- Grades will be based mostly on the lab reports, with the homework assignment worth about one lab report.
- Labs will be graded out of 10 points, with up to three bonus points available for 3-week labs.

YOUR LAB REPORT

- You must turn in the yellow pages from your lab notebook with your lab report. Add any computer-generated work (Mathcad output, etc.) separately.
- You are strongly encouraged to use a good word processor to write your lab report. A professional presentation is important.

YOUR LAB REPORT: FORMAT

- Experiment title
- Objective: 1-2 sentence description of scientific goal (not “to learn about….”)
- Technique: A couple of paragraphs explaining the basic idea behind the measurement: what is being measured, and how?
- Apparatus: Explanation of equipment. Diagrams strongly encouraged!

YOUR LAB REPORT: FORMAT

- Procedure:
  - Summary of process, including unexpected occurrences. What did YOU do?
  - Discuss problems and how they were resolved
  - Include details! Should be sufficient for someone else to do the experiment
- Data:
  - Include the complete data set, either printout or raw data tables from your notebook

YOUR LAB REPORT: FORMAT

- Data Analysis:
  - Analysis of data and results.
  - Include sample calculations
  - Tables are a great way to organize information
  - Make data plots, including axis labels and error bars
  - Estimate all uncertainties — statistical, systematic

YOUR LAB REPORT: FORMAT

- Conclusions
  - Short discussion summarizing results (give the final result again here)
  - Further comment on uncertainties: explain basis of assigning them, possible hidden errors, etc.
  - Compare results to accepted value: what is level of agreement based on your error estimate?
  - Stick to scientific conclusions! No opinions, no personal comments.
- **READ THE SYLLABUS FOR DOS/DON'TS ON YOUR LAB REPORT!**

UNCERTAINTY

- As used by physicists, “error” is a synonym of “uncertainty.” It is distinct from “discrepancy” or “mistake.”
- A result is meaningless without an uncertainty. ALL results should be quoted with an error!
- The uncertainty can result from inaccurate equipment, limited statistics, or other factors beyond your control
- Uncertainties should have 1-2 significant digits (generally 1 if the first digit is 4 or more). The measurement result (“central value”) should have the same final digit as the uncertainty:

GOOD	BAD
1.41 ± 0.07	1.408 ± 0.07
6.7 ± 1.3	6.7 ± 1
0.1006 ± 0.0022	0.1006 ± 0.00225