PHYSICS 2150 LABORATORY

Instructors:
John P. Cumalat
Adam Light
Lab Coordinators: Jerry Leigh, Scott Pinegar

Lecture 1
January 11, 2011

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. John P. Cumalat (john.p.cumalat@colorado.edu)
    - Office hours: by appointment or just drop by
    - Office: Duane F-321, 303-492-8604
  - Adam Light (adam.light@colorado.edu)
    - Office: Duane G323, 303-492-2010
    - Office hours: by appointment of just drop by
- Lab coordinators:
  - Jerry Leigh
  - Office: Duane G2B78A, x2-7368

  Scott Pinegar

  Duane G2B87

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-hep.colorado.edu/~jcumalat/2150)
  - Lab manual (handout)
  - Error analysis pamphlet (handout)
  - Radioactive material handling training (handout)
  - Textbook: Taylor, “An Introduction to Error Analysis” (required)

COURSE SCHEDULE
LECTURES

- Lectures are Tuesdays 4:00-4:50pm in Ramaley N1B23
- Please read appropriate chapters in Taylor before the lectures.
- Lecture 1
- Review Syllabus
- Tour of Lab
- Error Introduction
- Systematic and Statistical Uncertainty
- Read Chapter 5 in Taylor for the Second Lecture

COURSE SCHEDULE: LECTURES / HOMEWORK

- Lec. 3: read Taylor, Chapters 6,7
- ~Rejection of Data; ~Weighted Averages
- Lec. 4: read Taylor, Chapter
- ~Least Squares; ~Feedback on first reports
- Lec. 5: read Taylor, Chapters 9,11
- ~Correlation; ~Poisson Statistics
- Homework Assignment ~ equivalent to 10% of your grade

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 one lab.
- 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 Friday, January 28.
- Subsequent due dates will be on Fridays, except for the final report on Monday.
- 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.
- Everything must be recorded in your lab notebook!
  - Record in ink; do not erase. Correct mistakes by crossing out items, leaving them legible.
  - Do not remove pages from your book.
- Number and date all pages in your book.

LAB NOTEBOOK -1rst page

- All grading information should be on the first page so it is easy to track your progress.
- Table of Contents
- Have 5 columns for your each of your six experiments. List each experiment you performed; dates data taken, pages in book, partner name(s), and leave the last column for grading.
- Edge of the lab and cover should have your name, the lab section, and your TAs name.

LAB SAFETY

- Some experiments use radioactive materials. You must complete a CAPA 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 20 points, with up to five bonus points available for 3-week labs (ie Compton Effect and Millikan Oil Drop.)
- An average score is typically 15/20.
- Late labs will be penalized at a rate of 1 point per weekday. Labs which are two weeks late will not be accepted! If you forsee a conflict, then check with your TA as soon as possible.

YOUR LAB REPORT

- You should add any computer-generated work (Mathcad output, etc.) separately.
- You can write the report in your lab notebook or you can use a good word processor to write your lab report. If you use a word processor, then be sure to submit the report and your notebook for grading.

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 (MathCad printout is very useful.)
  - 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**