# PHYSICS 122 LABORATORY
# (Winter, 2015)

**COURSE GOALS**

1. Learn how to perform scientific experiments.
2. Learn tricks to identify, estimate and control errors.
3. Learn how to write a good scientific report.

**PROFESSORS**:


| | | | |
|---|---|---|---|
| Tony Tyson | 514 Physics | tyson@physics.ucdavis.edu | 752-3830 |
| Xiangdong Zhu | 235 Physics | zhu@physics.ucdavis.edu | 752-4689 |


**TEACHING ASSISTANTS**:


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|---|---|---|
| Andrew Bradshaw | 518 Physics | akbradshaw@ucdavis.edu |
| Bret Stenger | 221 Physics | stenger@ms.physics.ucdavis.edu |


**MEETING SCHEDULE**:

TuTh 2:10 – 6:00 pm, 154 & 156 Roessler
Labs (via room 156) will be kept open Monday through Friday, 9 AM – 5:00 PM

**EXPERIMENT WEB PAGES AND LABORATORY MANUALS**:

Available on Web at http://122.physics.ucdavis.edu
Login/Password sent to every registered student via email.

*REQUIRED* AND RECOMMENDED **TEXTS (see below for *required* AMPAD lab book)**:

1. **Philip R. Bevington and D. Keith Robinson, *Data Reduction and Error Analysis For the Physical Sciences***, 3rd edition, McGraw-Hill, 2003. [HIGHLY RECOMMENDED]
2. ***Adrian C. Melissinos, Experiments in Modern Physics, Academic Press, 2003.*** [REQUIRED] (Old 1966 edition: UCD Library call number: QC33 M52)
3. W. R. Leo, *Techniques for Nuclear and Particle Physics Experiments*, Springer-Verlag, 2nd Edition. (UCD Library call number: QC793.46 L46)
4. D. W. Preston and E. R. Dietz, *The Art of Experimental Physics*, Wiley, 1991.
5. J.H. More, E.C. Davis, M.A. Caplan, Building Scientific Apparatus, 4$^{th}$ ed., Cambridge, 2009.

**SOLID-STATE EXPERIMENTS**

***Ferroelectricity (Zhu - Stenger)***
***Hall Effect in Germanium (Zhu - Stenger)***
***Fundamental Noise (Tyson – Bradshaw)***
***Continuous-Wave Nuclear Magnetic Resonance (Zhu - Stenger)***
***Pulsed Nuclear Magnetic Resonance (Zhu - Stenger )***

**ATOMIC, NUCLEAR, HIGH ENERGY EXPERIMENTS**

***Zeeman Effect (Zhu - Stenger)***
***Optical Pumping (Zhu - Stenger)***
***Balmer Series (Tyson - Bradshaw)***
***Muon Lifetime (Tyson – Bradshaw)***
***$\gamma$-Ray Spectroscopy (Tyson - Bradshaw)***
***Rutherford Scattering (Tyson - Bradshaw)***

**COURSE DESCRIPTION: (Prerequisites: Physics 9 labs, 104A, 105A, 110AB, 115A, 112)**

Statistics problems assigned from Bevington. Counting statistics experiment (one week) followed by Electronics Lab (one week). TWO major experiments (3 weeks per experiment) to be completed over the quarter. Based on availability and preference, you will be assigned two diverse experiments. A student may perform experiments with up to two partners. Still each student writes his/her own lab report and does his/her own analysis. ***You own your experiment.***

Pre-Lab write-ups are due at the beginning of class. Pre-Labs generally require a day of work or more. Lab reports are due on dates as shown the Lab Calendar below at the beginning of class. They should be written in the general style of a journal article, with ***Abstract, Introduction, Theoretical background, Experimental method, Results and Analysis, Discussion, and Conclusion*** (see the detailed description below and on the 122 web page).

**GRADING POLICY**

The counting statistics experiment is worth 10 points; and each of the two main experiments is worth 40 points. **NO LATE REPORTS WILL BE COLLECTED.** Finally, 10 points of your grade will be based on an in-class closed book exam and your lab notebook. Letter grade will be partially based on in class performance including teamwork.

**LAB CALENDAR**

Starting dates of the three experiments are as indicated. Lab report due dates: underlined **bold**.

| Week | Dates | Activity |
|---|---|---|
| 1 | January 6 | Introduction. ***Lecture on Data and Errors Analysis.*** ***Intro to Test equipment.*** Homework 1 assigned. |
| 1 | January 8 | Start ***Nuclear Counting Experiment*** Homework 1 due. Homework 2 assigned. |
| 2 | January 13 | Homework 2 due. |
| | 15 | ***Electronics lab*** |
| 3 | **January 20** | Experiments with pulses. **Nuclear counting report due**. |
| | January 22 | *Quiz*. Start ***1st Elective experiment*** |
| 4 | January 29 | ***Lecture on Systematic Error*** |
| 6 | **February10** | **Final draft of 1st elective experiment report due.** |
| 7 | **February 17** | **1st elective experiment report due.** Start ***2nd Elective experiment*** |
| 11 | **March 16** | **2nd elective experiment report due Monday at 4 PM.** |

**LAB NOTEBOOK: (the book will be checked regularly and graded)**

You are required to have a special lab notebook. The lab notebook is available at UCD Bookstore: AMPAD Computation Book, 4x4 quad ruled, 9-1/4 11-3/4 in., spiral bound, numbered pages. In the lab notebook, you will record (1) detailed description of YOUR experimental set-up (everything!); (2) procedures that YOU use to obtain the data; (3) YOUR data; (4) symbolic and numerical analysis of the data including the relevant theory and equations. For data acquired by a computer, you may paste or staple tables or plots into the notebook. Aim for at least 20 pages per experiment.

The objective is to have all of the important information written down so that (a) the experiment can be reproduced if desired; (b) you can identify mistakes made during design, execution and analysis, and potential sources of errors; (c) you can learn why you are successful and why you fail; (4) you may later realize that you have made an important discovery. MAKE ENTRIES IN PEN ONLY. You can cross out mistakes.

**PREPARING THE REPORT ON YOUR EXPERIMENT:**

Your laboratory report should be as professional as possible. Use the supplied Physical Review article format. Examples of good reports (on other experiments) will be available. A colleague of yours, new to this course, reading your report should be able to understand your experiment and carry it out based on your report. Do not write a cook book ("do this, then do that"), rather outline the physics question, the experiment design, your procedure, error analysis, data analysis, results, and conclusions. In particular, your report should contain in essence the following sections in addition to a brief descriptive title:

(1) (**5 points**) *Abstract:* a brief summary of the experiment and the results (including statistical and systematic error estimates) obtained.

(2) (**20 points**) *Introduction:* stating the motivation for doing the work and spelling out the goal of the work to be performed, and then describing in some detail the theoretical background behind the experiment.

(3) (**20 points**) *Experimental setup and procedure*: clearly stating why they are adequate for the proposed goal of the experiment, sufficient for another student to understand what you have done. Explain hardware method of signal detection and error reduction (experiment design.) List data collection runs or procedures.

(4) (**35 points, 15 points designated to error analysis**) *Results and Analysis:* displaying the processed data that are essential to the goal of the experiment, stating briefly how the original data are processed or analyzed before being displayed, and importantly, making comparison of the processed data with the theoretical expectation as partly outlined in the *introduction* section. Be sure to include error analysis of the data, and show error bars on graphs. (don't display the unprocessed raw data--those should be in your lab notebook! All graphs need axes, tick marks, units, and descriptive captions.)

(5) (**15 points**) *Discussion*: From the results obtained, have you achieved the goal set in *introduction* section? Explain. Do the results support the understanding of the subject within experimental uncertainties? Again, explain. Suggest possible improved experiments which could result in greater precision.

(6) (**5 points**) *Conclusion*.

(7) *References.* Published journal articles, books, etc. relevant to this experiment, including experimental techniques, electronics, data analysis, and statistics. Full author, title, etc.

The figures, with *fully descriptive captions*, should be inserted in the text. Make your own figures. Use of the work of others, without attribution, is scientific misconduct. The Physical Review style is recommended, and may result in a higher grade. You may use either Tex or Word, single spacing. See the 122 web page for examples and a style file.

Physics 122 Lab sign-up Sheet

*Chose experiments from both 122A and 122B groups*

| **Experiment Preference** | **1st** | **2nd** | **3rd** |
|---|---|---|---|
| *Ferroelectricity* | | | |
| *Hall Effect in Germanium* | | | |
| *Fundamental Noise* | | | |
| *CW Nuclear magnetic resonance (NMR)* | | | |
| *Pulsed NMR* | | | |
| *Zeeman Effect of Atomic Spectrum* | | | |
| *Balmer Series of Hydrogen Atoms* | | | |
| *Optical Pumping* | | | |
| *$\gamma$-Ray Spectroscopy* | | | |
| *Rutherford Scattering* | | | |
| *Muon Lifetime* | | | |