

## Physics 4780 Atomic and Nuclear Physics Laboratory, Fall 2010

(draft syllabus updated August 30, 2010)

Instructor: Randy Ellingson; Assistant Instructor: Mike Brown; Teaching Assistant: Greg Warrell

Lecture: Monday\* 3:00-3:50 p.m., MH 4009

Labs: Session #1: Tue. 1 pm - 5 pm. Session #2: Wed. 2 pm - 6 pm. Session #3: Thu. 1 pm – 5 pm.

\*The lecture for Monday, Sep. 6, will be included at the start of each lab session for that week.

Labs: MH 2026, 3010, 3006, 3002

### GENERAL INFORMATION

This class meets weekly for a 1-hour lecture and one 4-hour laboratory period; data analysis and write-up are to be done both inside and outside the laboratory. Each of the weekly labs require a report demonstrating a sound understanding of (a) the basic physical concepts for the experiment(s), (b) a summary and details of the measurement approach, and (c) a clear understanding of the data with discussion of the reliability, accuracy, and analysis of the data. September 6 is Labor Day (so no lecture) – the weekly lab sessions will proceed as initially planned, and the lecture introducing the lab will be worked into the beginning of each lab session. There will be no class or labs the week of October 11 (Fall Break week).

### SAFETY FIRST!!

You will be working around x-ray and radioactive sources, high voltages, and laser sources. Familiarize yourself with proper operation of each instrument, and use appropriate caution when working with potentially dangerous equipment.

**BACKGROUND:** This is a course designed to give graduate students advanced laboratory experience in conducting experiments and analyzing the resulting data with appropriate error analysis. The schedule of experiments listed may be modified over the semester due to time or equipment constraints.

**COURSE CREDIT:** PHYS 4780, Atomic and Nuclear Physics Laboratory, is a 3-credit-hour course.

**REPORTS:** With the exception of the first two labs (Introduction to LabVIEW, and Introduction to Igor Pro, which will entail shorter 2-3 page write-ups and will be worth 5 points each), each lab report will be worth 10 points per week (a 2-week lab results in a 20 point report). Each report should be complete, with a typical length of 5-7 pages (for a one-week lab) -- including graphs, data tables, and drawings. Please use font size 12, with margins of 1" on each side. Explain all physical concepts; explain the physical significance of each equation; and provide context for your answers/conclusions (do they make sense? right order of magnitude?). A typical report should follow this general structure:

- I. **Introduction** (of the experiment, including context and brief physics background) – 1 page
- II. **Experimental Method** (apparatus, schematics, etc.) – 1 page
- III. **Data and Results** (data summary) – 2-3 pages
- IV. **Error Analysis** ½ page
- V. **Discussion** of results – ½ or more page as needed

Synopsis/Full lab report grading:

Experimental data: 50%

Explanation/interpretation and error analysis: 50%

**COURSE GRADING:** The final grade will be based on a weighted average of the lab reports (85%) and the final exam (15%). For WAC section students, the final grade will be based on a weighted average of the lab reports (75%), the science history paper (10%), and the final exam (15%).

**Physics 4780**  
**Lab Schedule (subject to change)**

<u>Experiment</u>	<u>Date (week of)</u>	<u>Subject</u>
I	Aug. 23	Introduction: Laboratory session scheduling, instrument control, data acquisition, error analysis, laboratory techniques
LV	Aug. 30	Introduction to LabView virtual instrumentation (.vi) software
IP	Sep. 6	Introduction to Igor Pro graphing and analysis software
B5	Sep. 13	Alpha particle spectroscopy with surface barrier detectors
B5 cont.	Sep. 20	Alpha particle spectroscopy with surface barrier detectors
N2	Sep. 27	Gamma ray spectroscopy
N2 cont.	Oct. 4	Gamma ray spectroscopy: attenuation
Fall break	Oct. 11	No lab
CM5	Oct. 18	X-ray diffraction and crystallography
AM1	Oct. 25	Atomic spectra with diffraction grating spectrometers
AM3	Nov. 1	Raman scattering gases – linear molecules
AM-2A	Nov. 8	Interferometric spectroscopy of laser mode structure
AM-2B	Nov. 15	Plane-parallel Fabry-Perot interferometer and the Zeeman Effect
AMX-A	Nov. 22	Using the heliostat: measurement of the Sun's spectrum
AMX-B	Nov. 29	Using the heliostat: angular velocity of the Sun
Review	Dec. 6	Review and follow-up as needed.

**SCIENTIFIC and ACADEMIC HONESTY:**

When you prepare a report, it should represent your own work. In the case that you use a graphics or text from an outside source (outside of our course), be certain to cite the Reference carefully and accurately to attribute the credit for that work to that source. When one fails to properly credit the source, then you are implicitly representing the work as your own, which is plagiarism. It is understood that scientific honesty requires that the author of a scientific paper (in this case, your Lab Report) presents and analyzes his or her own data. In this regard, each lab report must have sufficient "raw" data so that the reader (in this case, the instructor) can independently analyze the data to verify that the analysis was done correctly.

- REFERENCES: Any good intermediate level modern physics textbook, for example:
- Eisberg & Resnick, *Quantum Physics of Atoms, ...*
  - Morrison, Estle, & Lane, *Quantum States of Atoms, ...*
  - Price, *Nuclear Radiation Detection*
  - Moore, Davis, & Coplan, *Building Scientific Apparatus*

OTHER MATERIALS: You will need to bring a lab notebook (NOT looseleaf), and a USB thumb drive.

EXPERIMENTS: The experiments each designed to be completed in the laboratory sessions. However, in order to be able to successfully do this, it will be necessary for you to enter the laboratory **very well prepared**. Remember that you will be working with **radioactive sources** and high (sometimes **lethal!**) voltages. Four hours goes by very quickly when you do not know what you are doing. Therefore, it will be necessary for you to have studied reference material before coming to the lab.

Lab Experiment Reports:

1. Develop good laboratory practices. Record all observations as they are made. **DO NOT** record them on scrap paper and copy them into your lab notebook. Be sure to record **everything** which seems relevant (as well as some things which don't...). You will often find when you get home that you forgot to record a crucial piece of information anyway, but if everyone follows this suggestion, maybe at least someone may have recorded it! When you discover that you made an incomplete or inaccurate measurement, **DO NOT** tear the sheet out -- merely note the error and record the new data. The old "wrong" data many times turns out to be useful to you later on.
2. Outside of the laboratory, do all reading, library research and computation necessary to understand the experiment. Record all calculations in your lab notebook -- explain clearly what you are doing. Be sure to answer all questions asked. Computers are typically an integral part of this laboratory, used to graph the data and to perform statistical analysis on the data when needed. Sometimes you will be acquiring roughly 10,000 - 20,000 data points in a lab period!! You really don't want to analyze each point by hand! This course will introduce you to Igor Pro, made by Wavemetrics. This software will be supplied by your instructor. And will enable high quality analysis and flexible graphing. As always when fitting data, please check for the appropriate number of significant digits in the fit! Your laboratory write-ups should be composed using a word processor, and submitted as a .pdf file with your last name and the lab name in the filename. The computers in the fourth floor micro-cluster are available for your use in this class.
3. It is especially important that the data of the prior week of a multi-week experiment be analyzed before returning to the lab for the following week.

**All instrument manuals must stay in the lab; please do not take them out of the room.**